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An assessment framework for the implementation of a smart grid system in the municipality of Groningen

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Preface

In front of you lies the final version of my master thesis, which marks the end of the master Environmental and Infrastructure Planning (EIP). Throughout the bachelor Human Geography and Urban and regional planning, I noticed that my interests in infrastructural projects have increased. Especially projects within the energy sector, I experienced as an interesting, informative and challenging study during the Master EIP. This is mainly due to the content, the fellow students and the open-minded staff of the Faculty of Spatial Sciences. I think the master EIP contains a good balance between theory and practical assignments and field trips.

First of all, I would like to thank my supervisor from the Faculty of Spatial Sciences: dr. F.M.G. (Ferry) van Kann. Thanks to several courses during the bachelor, I already had the pleasure to know him. I experienced the cooperation with Ferry as very pleasant, mainly because your informal way of consulting. Ferry, thanks a lot for your help and feedback!

In addition, I want to thank the interviewees Marlous van der Veen, Han Slootweg and Anne Venema for their time to provide the information and input to complete the research. Without your vision from the practice, I was not able to link the theory with the practical examples.

Last, but definitely not least, I want to thank my friends and family for endlessly supporting me in the whole process of writing my master thesis. Chris and Douwe, I want to thank you in particular for giving your critical feedback in the final part of the process. Studying this subject in relation to Environmental and Infrastructure planning was not easy, but in the end, I am satisfied with the master thesis I realized.

Finalizing this monologue, I want to wish you great joy while reading this master thesis.

Jense Steffen van der Veen
Groningen, 16th of August 2019

Abstract

In 2010, the total electricity consumption in the Netherlands was about 119 billion kWh. In the next 30 years, the expectations are that this number will be double. This enormous increase of demand for electricity will cause many problems, i.e. the increasing number of peak moments in the electricity grid. One of the best-known ways to deal with these issues is to implement a smart grid. A smart grid is an electrical grid, which includes a variety of operational (communications, control) and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficiency resources. The goal of this study is to develop an assessment framework 'Quick scan' for the choice between strengthening the electricity grid or applying flexibility (smart grids). The case study is the municipality of Groningen and the main question of this thesis is: *"How can a smart grid system contribute to solve the problems of the increasing demand for electricity?".*

Due to some constraining factors, i.e. the lack of sufficient sustainable energy, still no large-scale smart grid system is realized in the municipality of Groningen. This study presents an assessment framework 'Quick scan' to support by making a choice for the best solution. This assessment framework consists of several, relevant criteria and can be seen as a combination of a checklist and a multi-criteria analysis (MCA). The 9-cell approach of De Roo & De Voogd (2019) is mainly used as an analytical tool and consists of three main concepts. First the material aspect, then the organizational aspect and the third and final concept is the institutional aspect. Implementing smart grids is a complex planning issue and the 9-cell model could help by splitting the issue into (three) different concepts. The evaluation of the assessment framework in this study shows that another institutional design is needed for the framework to function properly. Some small pilots are already going on in Groningen, i.e. the application of smart meters. Also in the future, several projects concerning smart grid are planned to be realized, but these are on a smaller scale and it is still unknown when these projects will take place. At this moment, the principle "Strengthen, unless…" is the leading slogan in almost all projects, even when the outcome of the assessment framework is to apply flexibility.

This master thesis contributes to planning theory by putting the implementation of a smart grid in the current planning debate. Furthermore, this thesis contributes to planning theory by using the 9-cells model. Using the 9-cells model have contributed to the determination of the criteria for the assessment framework 'Quick scan'. With the help of the 9-cells model, the issues in the implementation of smart grids can be made clearer. Implementing smart grids is a complex planning issue (according to this study) and the 9-cell model could help by splitting the issue into different (three) concepts.

Keywords: Smart grid; Flexibility; Energy transition; Qualitative research; multi-level perspective; Smart grid management; institutional design.

List of abbreviations

Abbreviation	Full
CAPEX	Capital expenditures
CO2	Carbon dioxide
COPEX	Operational costs
DSM	Demand Side Management
EU	European Union
GW	Giga Watt
GWh	Giga Watt hours
i.e.	Id est (in other words)
kW	Kilo Watt
MCA	Multi-criteria analysis
OER	Office of Energy Regulation
PV	Photovoltaic system
RNO	Regional network operators
SG	Smart Grid

List of translations

English	Dutch
Crisis and recovery law	Crisis- en herstelwet
Energy supplier	Energieleverancier
Housing Act	Woningwet
Network operator	Netbeheerder
Network reinforcement	Netverzwaring
Utility	Energie centrale

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1.Introduction

1.1 Increasing demand for electricity

Modern life would almost not be possible without the presence of electricity. Electricity is one of the most important types of energy and it continues to be one of the fastest-growing form of end-use energy consumption (Corbett et al., 2018). According to the Dutch Minister of Economic Affairs and Climate policy, Eric Wiebes, electricity is a primary necessity of life (Bouma, 2017). That means everyone is entitled to electricity and energy suppliers cannot just shut down defaulters and they must deliver to all households. The increasing number of devices dependent of electricity is mainly the cause of a growing demand for electricity. In 2010, the total electricity consumption in the Netherlands was about 119 billion kWh (CBS, 2015). In 2050, this number will be doubled according to an expectation of Yang et al. (2011). Also the global demand for electricity is projected to increase about 1.4% annually to 2040 (EIA, 2016). This results in a substantial increase of the use of the current electricity grid and this can cause some big planning issues in the energy sector. Beyond simply meeting increasing demands, the electricity sector has much work to do in order to achieve the sustainable development goals (SDGs), particularly in relation to climate change and sustainability (Corbett et al., 2018).

The Dutch government decided to phase out gas production in the Groninger gas field by 2030 (van den Berg, 2018). The major reason for this decision is to reduce the earthquakes in the province of Groningen. This phase out process will stimulate the Dutch citizens to reduce gas use and switch to non-gas heating systems. Using heat pumps is one of the most popular replacement options of the gas consumption but has one significant disadvantage. A heat pump is a device that uses a relatively small amount of electricity to move cold or hot air into another location (Cowan & Sennebogen, 2018). Unlike other energy resources, electricity has to be used when it is generated, because production of large storages in still lacking (Rodriquez et al., 2018). A better regulation of the electricity consumption is needed, since the utility companies have to deal with the increasing demand for electricity and the bigger peak moments in current networks. Also an adjustment in the laws and legislation (institutional design) is needed, since the current laws and legislation is based on the old electricity grid. An improved institutional design might contribute to the development of the energy sector by giving more space for flexibility. A solution to absorb the disruptions is needed and the existing electricity grid cannot handle it (Rodriguez et al., 2018). These disruptions, or blackouts, occur when the supply is incapable of meeting the demand, which can be solved by reducing the demand for electricity. Another option to solve is investing in new power plants and transmission lines (Rodriquez et al., 2018).

Nowadays, the Netherlands relies for more than 90% on natural gas combustion in boilers for the supply of the building-related thermal demand (Energypost, 2017). For the electrical energy demand, 84% is produced by natural gas and coal combustion. Due to recent low prices of coal, the share of coal increased in recent years which also led to an increase of the related CO2 production. The remaining part of the electrical energy demand is supplied by waste co-generation plants, wind turbines and solar PV (Energypost, 2017). For the next few decades, the increasing electrical energy demand needs more devices, and can cause obstacles due to excessive use the network.

In order to accurately allocate investments and research efforts, it is important to forecast electricity demand patterns on the long term (Hyndman & Fan, 2008). A way to get an overview of these patterns and to relieve the current electricity grid to be able to reduce the peak demand is to make use of the demand side management (DSM) and control systems (Rodriquez et al., 2018). DSM is a collection of strategies and techniques aimed at altering "customer's electricity consumption patterns to produce the desired changes in the load shapes of power distribution systems" (Logenthiran et al., 2012 : p. 1245).

Demand side management

Since the end of the Second World war, the demand for electricity in The Netherlands has increased overall (fig. 1), especially during the peak moments (CBS, 2018). This high demand has been driven mainly by growth in population, urbanization, higher standards of living, and cross-sectorial economic growth (Yahya et al., 2018). The increasing electricity consumption has a huge economic impact because of extra budget items for building new power plants, extra primary energy (oil, gas) required to fuel the new plants (Yahya et al., 2018).

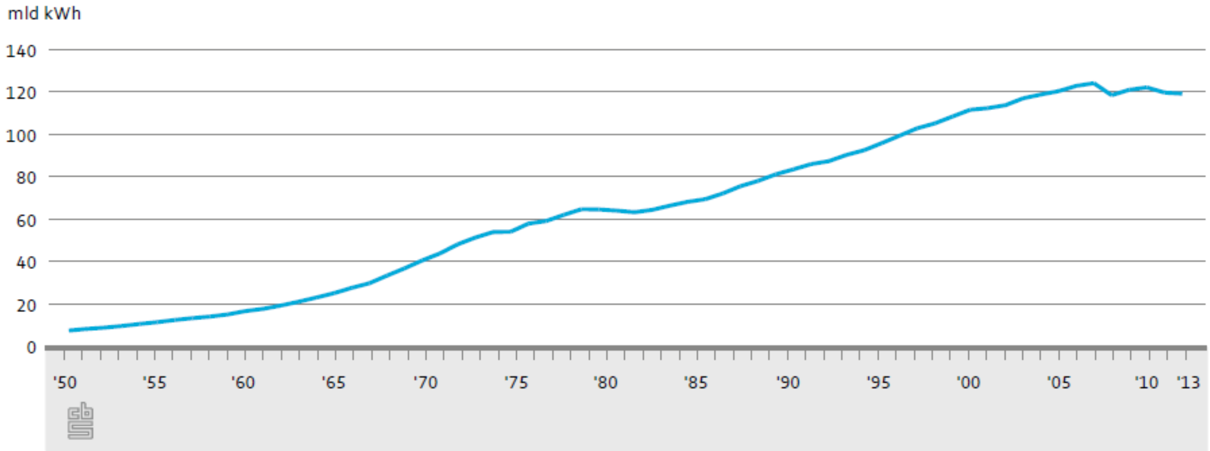

Figure 1: increasing demand for electricity in the Netherlands 1950-2013. Source: CBS, 2018.

All of the utilities want to reduce their expenditure to meet the total electricity demand. A simple solution is using the existing grid. According to Masters (2013) and Rodriguez et al. (2018), a way to manage the consumers' consumption is to implement a so-called demand side management (DSM). The main aims of DSM implementation can be listed as, (1) to reduce the cost of electricity by managing energy consumption, (2) social and environmental improvement, (3) to increase reliability and (4) to reduce the network issues (Kakran & Chanana, 2018). Consumption of electricity can be reduced by directly controlling the load by utility (Kakran & Chanana, 2018). DSM can be divided into passive DSM and active DSM (Corbett et al., 2018). Passive DSM involves attempts to permanently reduce the overall demand for electricity, without considering short-term fluctuations in demand, while active DSM techniques are more proactive as they seek to alter short-term demand in anticipation of changes in peak loads (Corbett et al., 2018 : 253). Both categories are helpful in reducing the peak moments of the demand for electricity. The two categories are also stimulating factors for the consumers to reduce their electricity consumption during the day. Some clear examples of DSM strategies are education and (financial) incentives.

Contradictory, a problem which occurs when implementing a demand side management, is the consumer's privacy. Utility uses variable prices based on demand variation. It regularly conveys the electricity price information to the consumer through smart devices and the consumer manages their load in response of the price (Kakran & Chanana, 2018). This means the consumer is connected with the utility through a two-way communication network (Amin & Wollenberg, 2006). In the consumer load management strategy (mainly for the residential consumers) utility aims to reduce the consumption of electricity and to shift the peak hours demand to off peak hours (ECCRR, 2006). Figure 2 shows the different load shape techniques.

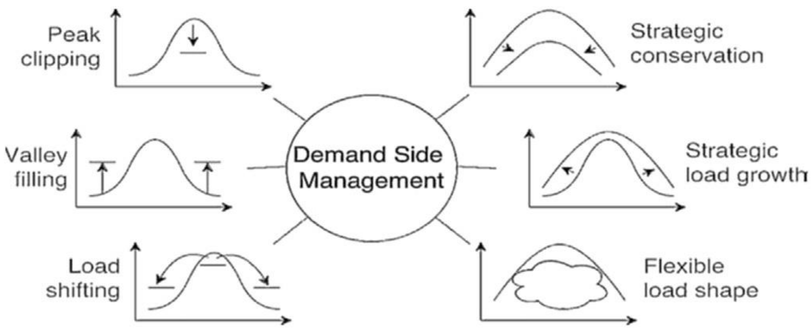

Figure 2: Different load shaping techniques. Source: Gellings (1985).

The different load shaping techniques contribute to a stabilization of the daily and seasonal electricity demand. DSM can be distinguished into six different techniques: Peak clipping, valley filling, load shifting, strategic conservation, strategic load growth and flexible load shape (Gellings, 1985). Load shifting is an original form of load management and the most important one within this study. Within the energy sector, load shifting is a relatively new method of operating.

A tool for that might be useful in the energy sector is the use of an assessment framework. An assessment framework contains several, relevant criteria (including safety, duration and financial aspects). Finally, the assessment framework can help by choosing the right option.

Direct load control is used to reduce the peak moments in the electricity grid. Direct load control is most commonly practiced by direct utility control of customers appliances (Gellings, 1985 : p. 1468). It can also be used to lower the operating cost and dependence on critical fuels by economic dispatch (Gellings, 1985). Direct utility control of customer’s appliances can be done by smart meters, an appliance which consists both communication and metering (fig. 3). The communication component of a smart grid consists of wireless communication or wireline methods (Kabalci, 2016).

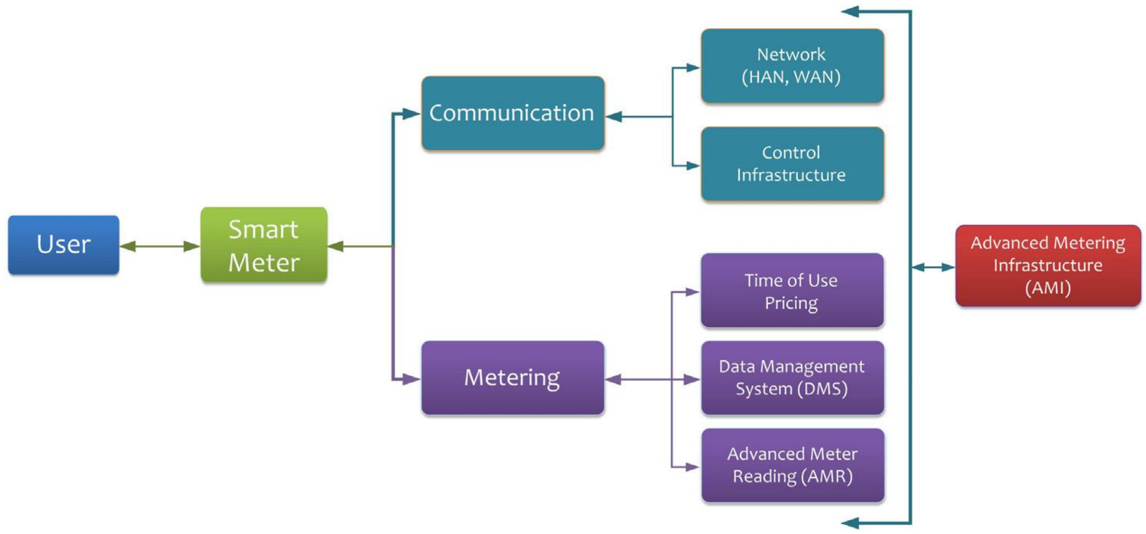

Figure 3: A smart grid perspective with all components. Source: Kabalci (2016).

1.2 Research questions

The main question of this thesis is: *"How can a smart grid system contribute to solve the problems of the increasing demand for electricity?"*

The following sub-research questions are underlying the main research question:

1. *What is a smart grid?*
2. *What are the constraining and stimulating factors in the development of a smart grid system?*
3. *How can an assessment framework help by the development of implementing smart grids?*
4. *How can flexibility play a role in the implementation of a smart grid?*
5. *Which actors and stakeholders are involved in a smart grid initiative in the municipality of Groningen?*

1.3 Thesis outline

This thesis consists of eight chapters and is set up as follows. Chapter one contains the introduction of this study, including the research questions. It elaborates why there is a need for smart grids. The first part of chapter two further explains what smart grid actually is. The second part of chapter two is the literature review, which is divided into several concepts: 1) the regulation on smart grids, 2) incentives for consumers, 3) cooperation between stakeholders and 4) flexibility within the electricity grid. The final part of this chapter elaborates the concept institutional design and how that is related to the implementation of a smart grid. Within this section, the '9-cells approach' (De Roo & De Voogd, 2019) will be connected to smart grids and the question how this approach contributes to clarify the issue. Chapter two ends with the conceptual framework made by the author. It provides insight into how the issue could be examined empirically.

Chapter three contains the methodology of this study. The first part of this chapter elaborates the research strategy of this study. The research strategy consists 4 steps: 1) background information, 2) literature study, 3) developing an assessment framework and 4) presenting results and discussion.
After that, the research methods are explained. The data will be gathered by doing desk research, studying policy documents and conducting semi structured interviews. Chapter three finishes with the section 'towards an assessment framework', to introduce the concept 'assessment framework'. Chapter four consists the development of the assessment framework 'Quick scan'. This is done by using an explanation of the three concepts of the 9-cell model (De Roo & De Voogd, 2019): material, organizational and institutional. The goal of this study is to develop an assessment framework and the 9 cell-model (De Roo & De Voogd, 2019) can be seen as an analysis tool. The second part of chapter 4 is about the fact that the three concepts can be seen as multi-level (macro, meso and micro) and the interconnection between these levels. This will finally lead to the result of this study: an assessment framework 'Quick scan'. This assessment framework consists of several, relevant criteria and can be seen as a combination of a checklist and a multi-criteria analysis (MCA). Furthermore, the assessment framework of this study could help to make the choice between strengthening the electricity grid and the use other (sustainable) solutions. Chapter 5 contains an evaluation of the assessment framework 'quick scan' presented in chapter 4 of this study. In addition, the chapter contains an evaluation of the implementation of smart grids, including opportunities and disadvantages. The final part of chapter 5 contains the evaluation of the assessment framework 'Quick scan' while focusing on the municipality of Groningen. Chapter 6 contains the conclusion of this study, including the answer on the main research question of this study. Chapter 7 is the reflection on this study and contains the contribution for the planning practice and planning theory. Also recommendations for further research is elaborated in this chapter. Chapter 8 contains the literature used in this research.

2. Literature review

2.1 What is a smart grid?

It is well known that day to day increasing demand is overloading the current electrical grids and conventional solution techniques are increasing the complexity of existing networks (Kakran & Chanana, 2018). Our current electricity grid was conceived more than 100 years ago, when the electricity needs were simple and clear. Power generation was localized and built around communities. Most homes had only small energy demands. The grid was designed to deliver electricity to consumers' homes and is called a one-way interaction. That makes it difficult for the grid to respond to changing and rising demand in the beginning of the 21st century (Sakran & Chanana, 2018). According to Yeang & Jung (2013), a solution for this can be the implementation of a smart grid system. A smart grid is an electrical grid, which includes a variety of operational (communications, control) and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficiency resources (Yahya et al., 2018). A smart grid introduces a two-way dialogue where both electricity and information can be exchanged between the producer and its customers. It is a developing network of communications, controls, computers, new technologies and tools working together to make the grid more efficient, more reliable, more secure and greener. This smart grid enables new technologies to be integrated such as wind, solar energy production and plug in electric vehicle charging. Ardito et al. (2013) states a definition of smart grid this thesis refers to:

> "A smart grid is an energy network (electricity, heat, gas etc.) that can intelligently integrate the actions of all users connected to it – generators, consumers, operators and those that do both – in order to efficiently deliver sustainable, economic and secure energy supplies. A smart grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies (Ardito et al., 2013)".

Figure 4 shows an example of how a smart grid model can be. As mentioned in section 1.1, the increasing demand for energy can cause a lot of issues in the electricity system (i.e. overloads). Under which conditions can a smart grid system contribute to solve these problems?

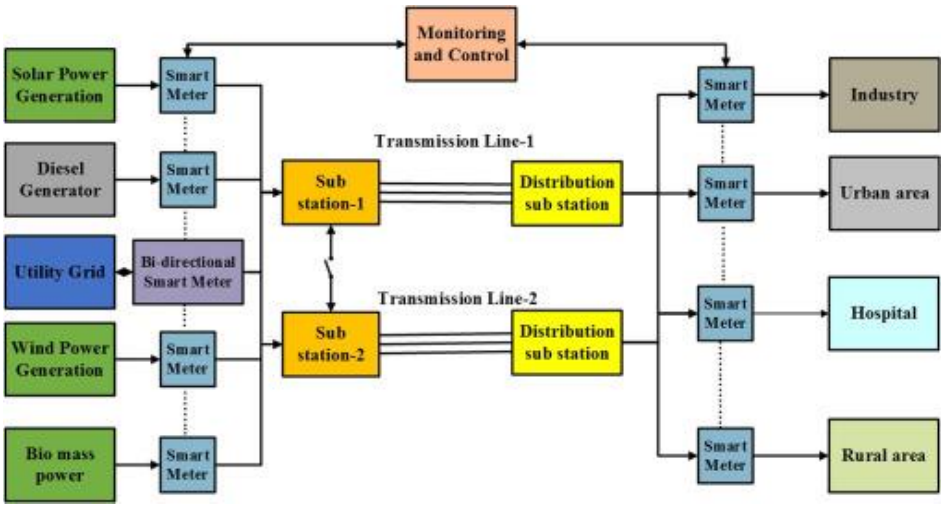

Figure 4: Smart grid model. Source: Kakran & Chanana (2018).

Electricity smart meters are part of the smart grid system and the best-known example of a smart appliance. Electricity smart meters are electronic devices that are deployed by utilities to measure the electricity consumption of consumers at frequent intervals (Razavi & Gharipour, 2018). They provide a two-way communication link for transmitting meter readings to the utility provider and receiving control and configuration commands. The introduction and deployment of such meters have prominently transformed the utility market for both electricity providers and consumers. In the United States (U.S.) alone, electric providers had installed 65 million smart meters, as of 2015, which accounts for more than half of the U.S. households (Meadowcroft et al., 2018). The deployment is expected to exceed 90 million units by 2020 (Meadowcroft et al., 2018).

According to Ma et al. (2018), different reasons for the implementation of smart grid facilities in the current infrastructure are clear. First, the growing population has brought about higher demands for the existing smart grids, in addition to the sustainability, security and reliable problems. Furthermore, the increasing demand for electricity and growing data. Mutual response is therefore of great necessity for the expansion of present smart grid facilities. Accordingly, many smart grid technologies including power generation grid, transmission grid and distribution grid have been developed for lots of electricity consumers (Ma et al., 2018). According to D'Hulst et al., (2018), another reason for implementing a smart grid is the stagnation or even decrease of the number of traditional controllable power plants. All these reasons for implementing a smart grid can be seen as multi-level (macro-, meso- and micro level). This ensures the implementation of a smart grid system is not easy and even complex. The complexity of (planning) issues increases as they move into several social domains with different processes and structures.

Yet, it is well known that the overused fossil fuels have given rise to global warming, climate change, infrastructural insecurity and some other serious problems, which rival the environmentally friendly policy. Therefore, a smarter grid is necessary for processing renewable generation at both large and small scales, plugging electric vehicle and motivating the enthusiasm for consumers' participation in this process (D'Hulst et al., 2018). Compared with the old traditional ones, smart grid has many advantages. In terms of power quality, it is considered as a suitable solution for outages, blackouts, early fault sensing, distributed energy integration and energy management. With regard to information and communication, the sensing ability, virtual computing capacity, energy monitoring and controlling, dynamic pricing are all considered (D'Hulst et al., 2018). In this way, smart grid is more competitive and warmly welcomed to meet consumers' needs. The emergence of smart grid together with applicable technologies is of great practical significance and brings hope to the electrical grid in all aspects. In addition to the participation of power generation, both power transmission and distribution suitable communication also greatly contribute to the success of smart grid. Together with load control power management, information data processing, smart meters and sensors, smart grid creates more opportunities. This can be achieved through machine-to-machine communications and distributed energy delivery network.

Furthermore, scalable technology has become increasingly important in smart grid development as well (Gungor et al, 2011). Accelerating progress in electricity, data processing and mutual response are needed for the expansion of current smart grid facilities. Recent emerging progress in smart grid renders scalability a worthwhile project to invest. However, some economic problems as well as economic benefits including maintenance and deployment costs both make the design and use of scalability challenging, especially the application of smart grid in larger situations (Gungor et al, 2011). Herein, a modular approach was proposed, and smart grid scalability would start from individual islands. Extensive innovative plans accompanied with the emergence of smart grid have been devoted to improving scalability.

Basically, a smart grid is an electrical grid, which includes a variety of operational (communications, control) and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficiency resources. A smart grid involves the application of digital technology, monitoring, easier operation and maintenance and finally data communication networks to the electric grid to enable automation (Yahya et al., 2018). Within a smart grid, the electricity storage can accommodate peak shifting (fig. 5). The biggest challenges of implementing electricity storages are the bad influences on the environment and the fact that it is expensive to realize (Mulder et al., 2010).

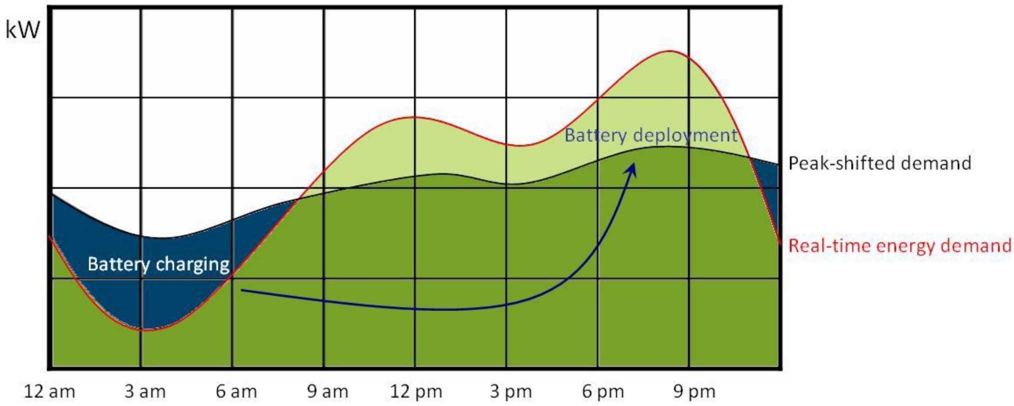

Figure 5: Shifting peak moments. Source: Greensmith (2012).

The smart home is also a part of the smart grid system and communicates with the grid. It enables consumers to manage their electricity usage. By measuring homes electricity consumption more frequently through a smart meter, energy suppliers can provide their customer with more information to manage their electricity bills. Table 1 shows the active parties within the energy sector, including their roles and tasks.

Party	Role	Tasks
Enexis/ Aliander	Network operator/ manager	The installation and maintenance of the electricity grid in the Netherlands. In addition, a network operator takes care of the transport of energy. They transport energy from the power plant or gas station to a home.
Municipality of Groningen	Multiple roles: producer, supplier, director, network operator/ manager	The municipality performs several roles and tasks. Their most important role is to negotiate and consult with all involved actors and determine where certain projects (experiments) can take place.
TenneT	Transmission network manager	TenneT is the independent manager of the national high-voltage grid. Most regional

		networks are supplied with electricity from this network. TenneT also makes the connection with foreign electricity networks. The company is 100% owned by the Dutch government.
Ministry of Economic affairs	Legislator	They determine the laws and regulations in the Netherlands and the development of smart grid implementation is (largely) dependent of those regulations.

Table 1: An oversight of the active parties within the energy sector.

Inside the home, a home area network (HAN) connects smart appliances, thermostats and other electric devices to an energy management system. Smart appliances and devices will adjust their run schedule to reduce electricity demand on the grid at critical times and lower consumer energy bills. These smart devices can be controlled and scheduled over the web or even over a television.

Renewable resources, such as wind and solar, are sustainable and growing sources for electric power. However, renewable power sources are variable by nature and add complexity to normal grid operations. This is one of the constraining factors of implementing a smart grid system into the existing grid. The smart grid provides the data and automation needed to enable solar panels and wind farms to put energy onto the grid and optimize its use. To keep up with constantly changing energy demands, power stations must turn power plants on and off depending on the amount of power needed at certain times of the day. A smart grid system is characterized with a direct flow of information back to the generation (Zame et al., 2018). This results in a real-time demand within the energy generator and supply will meet the demand more accurately at any given time (Zame et al., 2018).

The cost to deliver the power depends on the time of day it is used. Electricity is costlier to deliver at peak times because often less efficient power plants must run to meet the higher demand. This will enable network operators to manage and moderate electricity usage with the cooperation of their customers, especially during peak demand times. As a result, utilities will be able to reduce their operating costs by deferring electricity usage away from peak hours and having appliances and devices running at other times. Electricity production is more evenly distributed over a day. The power being used right now was generated less than a second ago many miles away. At each instance the amount of electricity generated must equal the consumption across the entire grid.

Smart grid technologies provide detailed information that enables grid operators to see and manage electricity consumption in real time. This greater insight and control reduce outages and lowers the need for peak power. In the United States, smart grid technologies could reduce overall electricity consumption by 6% and peak demand by as much as 27% (Mosella, 2015). Reductions in peak demand alone would save between $175 billion and $332 billion over 20 years (Morsella, 2015).

The distribution system routes power from the power station to residential and commercial customers through power line transformers. Utilities typically rely on complex power distribution schemes and manual switching to keep power flowing to their customers. Any break in this system caused by storms or sudden changes in electricity demand can lead to outages. The smart grid distribution intelligence counters these energy fluctuations and outages by automatically identifying problems and rerouting and restoring power delivery. Utilities can further use distribution intelligence to predict electricity usage with the cooperation of their customers.

2.2 Regulation on Smart grid

The integration of smart grid technologies in the current energy system might lead to a major challenge talking about a change in that system. According to Slootweg (2019), professor of smart grid at the university of Eindhoven, the implementation of a smart grid system is prevented by the current Dutch electricity law. The Dutch government seeks to motivate organisations and citizens to become more sustainable and focus on renewable energy. With all the different procedures, which generally take a lot of time, it is not easy to realize that. The regulation on Smart grids blocks its own development, i.e. it may be unclear what scope the existing laws and regulations offer for experiments and projects (Akkerboom et al., 2011).

In the presence of distributed generation and smart appliances, smart meters could enable load balancing through demand response and dynamic protection reconfiguration (Asghar et al., 2017 : 2820). The data collected by these smart appliances, such as a smart meter, may also disturb the consumers' privacy. According to Buttarelli (2012), research has pointed out personal data, such as economic status and household occupancy, can be demonstrated via electricity consumption. Data collected by smart appliances is linked to a couple of privacy regulations. Asghar et al. (2017) identify five security requirements that during the process of smart grid management arise (see table 2).

Requirements	Meaning
Confidentiality	Meter data should not be exposed to unauthorized individuals or processes during transmission (data-in-transit), storage (data-at-rest) and computing (data-in-use). Ensuring confidentiality of data-in-transit, data-at-rest and data-in-use is necessary for achieving cryptographic privacy.
Integrity	The accuracy and correctness of the meter data should be maintained during transmission, storage and computing, and any changes made to the data should be detectable.
Authenticity	The receiver of the meter data should be able to verify the source of the data.
Non-repudiation	The source of the meter data should not be able to deny that it originated the data. It implies integrity and authenticity.
Auditability	It should be possible to verify whether the response to a request (meter data or computation on meter data) is correct.

Table 2: Five requirements during process of smart metering. Based on Asghar et al. (2017).

It is not fully clear what will happen with the personal data after it is collected and therefore it will be a major challenge to achieve the requirements mentioned in table 2. In the U.S., there is still no federal regulation on the privacy of smart meter data, only in some States there is regulation in place (Asghar et al., 2017). In the European Union, there is another regulation on smart grids in contrast to the US regulation. To make it even more complicated, different regulations within the countries of the

European Union are applicable (Salverda, 2017). Various European laws and regulations have been created to encourage the use of Smart meter that may be relevant for the municipality to consider.

The history in the Dutch legislation has led to some discussion. In the bill from the House of Representatives in 2008, the placement of smart meters would become mandatory (Salverda, 2017). However, the Senate decided that the introduction should take place on a voluntary basis. In 2014, Minister Kamp of Economic Affairs announced in a parliamentary letter that the introduction of smart meters would start, so in December 2020 the Netherlands would meet the European requirement that at least 80 % of the connections have a smart meter. Nowadays, about 5 million Dutch households own a smart meter (Netbeheer Nederland, 2019). The European rules on Smart meters already state that smart meters and data traffic must be protected, and that the privacy of the consumer must be protected (art. 9 section 2 sub b energy efficiency directive). Since May 2018, the General Data Protection Regulation (GDPR) must be used for the application of privacy rules for smart meters.

2.3 Incentives for consumers

The United States of America were one of the first countries that invested lots of money in the implementation of a smart grid. This project is called: the American recovery and reinvestment Act of 2009. In this program, 4,5 billion dollars were provided to optimize the existing electricity grid. This program in the USA can be seen as a successful project stimulating a smart grid system.

Furthermore, most of the EU-member states invested around a total amount of 1.8 billion euro in smart energy innovations in the same period. The implementation of those innovations was not a successful project like it was in the USA. The EU commission only funded 35% of the total amount needed for the innovations. Focusing on the Netherlands, the subsidies for these future oriented innovations comes from mainly the EU commission and also from other actors, such as the national government (Giordano et al., 2011). Financial injections are great opportunities for countries to make investments in ‘smarter’ energy. Most of those subsidies are reserved for pilot projects and development in the smart grid technologies. Municipalities receive money to facilitate those projects and to allow energy companies to act.

The role of the customers becomes more important over the years. So-called smart meters and other ‘smart devices’ will be installed in their houses and track their energy activities. Consumers must be motivated or triggered by external factors to contribute to the use of a smart grid system, i.e. receiving financial compensations. The contribution of consumers consists of using a smart meter and the release of personal information. This means these consumers make use of the electricity grid for a lower price, when using their devices at a certain moment during the day. This immediately raises the following question: ‘What does the amount of the compensation need to be in case customers will participate?’. Inherent to these incentives is the use of flexibility. A smart grid system is one of the solutions to create that flexibility of the energy system (Middelweerd, 2018). The current electricity grid already shows some flexibility, but that is mainly within the high voltage network. Chapter 4 will elaborate the role of flexibility in the implementation of Smart appliances and how to use the so-called assessment framework.

2.4 Cooperation between stakeholders

Within complex projects with a lot of different actors, such as the implementation of a smart grid, there is a strong need for a smooth cooperation between the different stakeholders (table 3). This differs from the micro level (consumers, municipality) to the macro level (European Union). These levels are imaginary, modelling levels (Geels & Kemp, 2000). The purpose of using these three levels is to simplify the explanation of the involved stakeholders.
Obviously, most of the stakeholders in a smart grid are multi-level. This is due to the fact that planning issues are often not isolated at one particular level (De Roo & De Voogd, 2019). In most planning issues, the European Union states the rules and the other, lower levels must follow and do what they are instructed to do. This also holds for the implementation of smart appliances. Yet, within the same level, a lot of cooperation takes place. For example, all network operators are member of 'network management Netherlands', which is a platform within the energy sector.
The network operators manage the electricity infrastructure in a certain area and fall outside the liberalization of the market. They do not have to compete. To prevent abuse of this monopoly situation, maximum tariffs set by network operators are implemented. Within the energy sector in the Netherlands, the tariffs that network operators may charge to a maximum are set by the Office of Energy Regulation (OER) on behalf of the government.

Stakeholder	Level
European Union	Macro level
National government	Macro level
Network operators	Meso level
Energy suppliers	Meso level
Municipality of Groningen	Micro level
Consumers	Micro level

Table 3: Different stakeholders in the process of implement a smart grid.

2.5 Flexibility within the electricity grid

The section focuses on using flexibility in the electricity grid and its contribution to the development of implementing smart grids. When focusing on the Netherlands, the SER Energy agreement for sustainable growth sets out an ambitious growth path for the development of sustainable energy up to 2023 (Afman, 2019). This is used for large-scale realization and integration of wind and solar PV. The electricity production of these resources depends on the weather conditions and therefore has large fluctuations. The share of renewable energy also has to continue developing after 2023 if the Netherlands wants to meet the future environmental goals. Various existing and new applications, centralized and decentralized, for temporary extra supply and demand for electricity can meet a need for flexible electrical power. The existing frameworks for market design and regulation form the framework conditions in the short term within these flexibility options have to be realized. In the long term, this framework can be adjusted where necessary to facilitate the market under new circumstances. In this thesis, flexibility is considered to entail: *the ability of the electricity system to* *maintain the balance between demand for and supply of electricity, all within the limits of the distribution and transmission system with controllable, flexibly deployable resources in the short term.*

The increasing need for flexibility will present itself at different time scales and at different locations. From the perspective of operational planning in the electricity system, this flexibility requirement will manifest globally in three related operational domains (fig. 6), namely:

- **Supply of electricity** (commodity);

  Supply of electricity refers to the week-to-day forecasting and planning of producers, suppliers and users, followed by adjustments until the moment of delivery. It also refers to the realization of production to meet the aggregate demand.

- **Balance enforcement** (imbalance);

  Balance enforcement relates to the need to maintain a balance in supply and demand on short time scales. The stakeholders involved are responsible for constantly keeping their supply, trade and production in balance on the basis of their program responsibility. Deviations in balance can arise due to deviations from the forecast of demand, limited controllable production and controllable production. Imbalance in supply and demand leads to frequency deviations with possible disruptions and even power outages. Flexibility is already used to decrease voltage deviations in the electricity grid, caused by both increased consumption and local production (D'Hulst et al., 2014). Adjustments of supply for balance sheet maintenance at the time of realization is centrally organized by the Dutch system administrator (TenneT).

- **Network congestion** (transport capacity);

  Network congestion relates to the balance between feeding and consumption of electricity on the network within the limits of the available transmission capacity. If the demand for transmission capacity is higher than the available transmission capacity, congestion can occur, and the network components can become overloaded. This situation can arise if the sum of local production and electricity demand exceeds the local available transmission capacity.

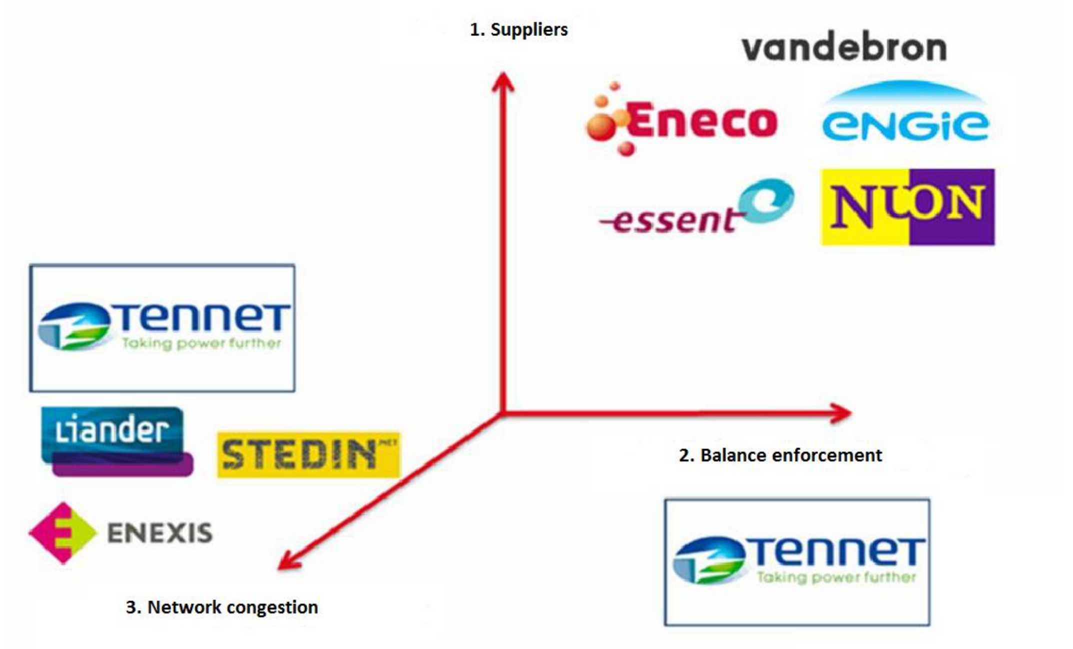

Figure 6: Dimensions of possible operational flexibility requirement. Source: Afman (2019), modified by author.

Based on the prospects for wind and solar energy, a significant increase in flexibility needs is expected. For example, the need for peak power in 2023 could rise up to 5 GW (that is a 30 % increase compared to 2013) and the need for balance power up to 1.2 GW, which is more than 40% increase compared to 2013 (Afman, 2019). In addition, it is conceivable that network congestion may arise in the future, as a result of which an additional need for flexibility in short-term can arise up to 0.5 GW in low-voltage networks, 1.2 GW on medium-voltage networks and 1.3 GW on high-voltage networks (Afman, 2019). Kobus et al. (2015) have done a pilot test with smart washing machines combined with dynamic tariffs. They claim the smart appliances, such as the smart washing machine, were only used for 14% of the time (Kobus et al., 2015). This raises the question whether this number could be increased by using a different reward for offering flexibility, i.e. different than the dynamic tariff incentive (D'Hulst et al., 2015). The study of Kobus et al. (2015) also showed that an increased use of smart appliances can be realized, by using a capacity fee or another way of flexibility.

Nevertheless, several constraining factors occur when discussing the use of flexibility in the electricity grid. Therefore, the existing structure of the electricity markets and the regulatory framework may hinder the use of certain options. The constraining factors can be divided into two different parts. First, the barriers due to market design. The complexity of the electricity markets requires high-quality knowledge and competence in the field of electricity trading, operational requirements for active trading and technical requirements for the use of flexibility in various submarkets. Secondly, constraining factors occur among flexibility and regulation. The current connection- and transport obligations limit the possibilities for the use of flexibility in network congestion (Afman, 2019). In addition, the current structure of transport tariffs is not designed to accommodate demand control.

Therefore, it is difficult to determine when to use flexibility within the electricity grid. In this study, the focus is on two solutions that are able to help the overloads: 1) strengthen the electricity grid and 2) congestion management. Chapter 4 consists the development of the assessment framework 'Quick scan'. This is done by using an explanation of the three concepts of the 9-cell model (material, organizational and institutional), which can be seen as an analysis tool. This assessment framework 'Quick scan' provides an overview of the assessment criteria of the different options and might be helpful for dealing with planning issues in the future.

2.6 Institutional design

The concept institutional design is used to formulate both formal and informal rules (Gupte et al., 2009). In this study, the focus will be mainly on the formal rules (law and legislation). According to the existing literature, the current institutional design does not fit with the latest developments of smart grids. This is largely due to the fact that laws and regulations were drafted at a time when smart grids did not exist. Also the zoning plan may indicate that a sustainable residential area may be realized, but that specific requirements may not be laid down. Legislation on spatial planning and housing law prevent this development (Akerboom et al., 2011). Especially article 122 of the Housing Act imposes restrictions. They may not contract on cases regulated by the Housing Act and the regulations based on this. A solution could be found in the operation of the crisis and recovery law.

There are several reasons for institutional (re-)design (Koppejan & Groenewegen, 2015). First, new systems need new institutional arrangements. Secondly, the current systems produce unwanted outcomes or became inefficient (public services: privatization). The third reason is the fact that the existing systems do not have the right scale. As mentioned before (chapter 1.2), the implementation of a smart grid system covers multiple levels and probably need another institutional design.

The current legislation in the implementation of a smart grid system still contains several constraining factors. Therefore, a need for a new institutional design is desirable. According to Koppejan & Groenewegen (2005), institutions provide predictability and stability and are therefore hard to change. Institutions are also robust, but they continuously change in relation to environmental processes and institutions at other levels in which they are embedded (Koppejan & Groenewegen, 2015).

The 9-cells approach

According to De Roo & De Voogd (2019), complex planning issues can be explained by the 9-cell approach. This approach connects the 'what'-question with the 'who'-question by merging three main concepts with a multi-level perspective. The three main concepts in this approach are 'material', 'organizational' and 'institutional' and they all can be divided into three different levels: macro, meso and micro (De Roo & De Voogd, 2019). The 9-cells approach can used as an analysis tool and can contribute to gain a better understanding of the development of smart grids. Then, this understanding can contribute to solve complex planning issues, such as energy issues. These characteristics can be merged together in one figure (figure 7).

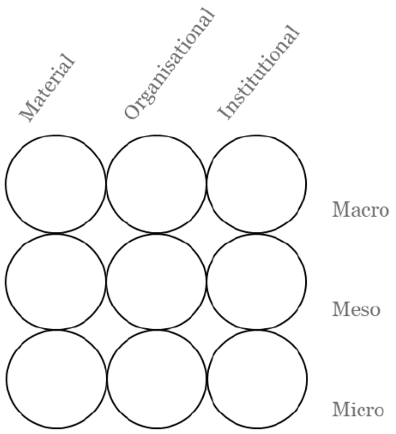

Figure 7: ‘Nine cells’ according to De Roo & De Voogd (2019).

The ‘material’ environment focuses on the functionality and accessibility of a smart grid system. How can smart grids be connected to and assessable with its environment on every level (De Roo & De Voogd, 2019)? The organizational part explains how the involved actors are connected within the energy sector. How is the cooperation between the different stakeholders organized? The third and final concept is the institutional design. Does the institutional aspect need adjustments in the current design to create more flexibility and therefore more accessible for the implementation of smart grids? The concepts ‘material’, ‘organizational’ and ‘institutional’ naturally do not occur on one specific level, but they can be seen as multi-level (macro, meso, micro). These concepts will be explained in chapter 4 of this study.

2.7 Conceptual framework

The conceptual framework of this thesis is shown in figure 8 and raises both the questions and sub questions. The main question of this study is as follows:

> *"How can a smart grid system contribute to solve the problems of the increasing demand for electricity?".*

The following sub-research questions are underlying the main research question:

1. *Wat is a smart grid?*
2. *What are the constraining and stimulating factors in the development of a smart grid system?*
3. *How can an assessment framework help by the development of implementing smart grids?*
4. *How can flexibility play a role in the implementation of a smart grid?*
5. *Which actors and stakeholders are involved in a smart grid initiative in the municipality of Groningen?*

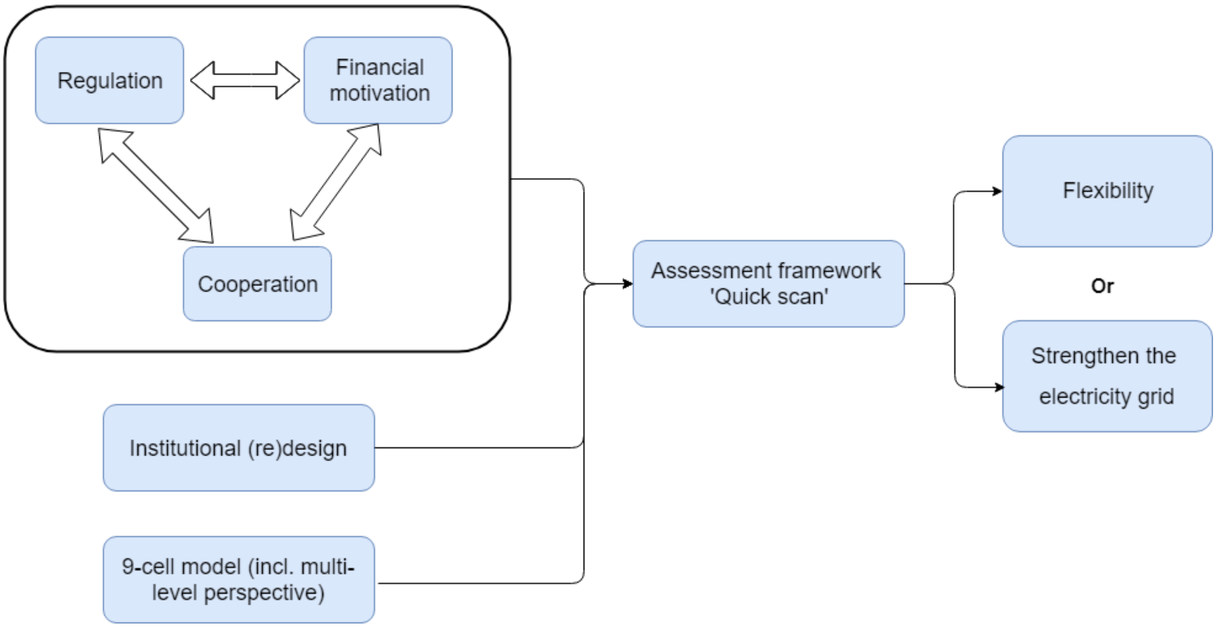

Figure 8: Conceptual framework. Source: Author.

3. Methodology

The goal or research objective of this study is to develop an assessment framework and hopefully this framework will be used in the future. The development of the assessment framework 'Quick scan' is based on the analysis of the current energy system plus the use of the '9-cell approach'. Having established the research questions and the theoretical framework, this chapter explains the steps of the research process that are needed to provide insight into the development of the implementation of smart grid. Thereafter, a section presents the research methods used in this study. The final part of this chapter contains an explanation and criteria of the assessment framework.

3.1 Research strategy

This section explains the steps of the research process that are needed to make the development of smart grids transparent. The research is subdivided into four steps. The first step consists of a background research of smart grids, using document analyses, exploratory research and analyzing reports. The reasoning for choosing this case study (the municipality of Groningen) is also explained in the first step. The second step contains a combination of the literature study and semi structured interviews with experts. The combination of the expertise of the experts on smart grids with the literature study and the document analyses, provided sufficient information and knowledge about the opportunities and constraining factor of implementing smart grids. The third step of this study is the development of an assessment framework. The assessment framework in this study can be seen as a checklist combined with a multi-criteria analysis (MCA). A MCA is a scientific evaluation method to make a rational choice between various discrete alternatives based on multiple distinction criterion (Janssen, 2001). The development of an assessment framework is the main goal of this study and the 9 cell-model can be used as an analysis tool. The fourth and final step of the research strategy is an outcome of the first three steps and contains the results, discussion and recommendations of this study. The reflection of this study, including shortcomings, relevance for planning theory and planning practice, and recommendations for further research are part of step 4 as well. The four steps form the body structure of this study (fig. 9).

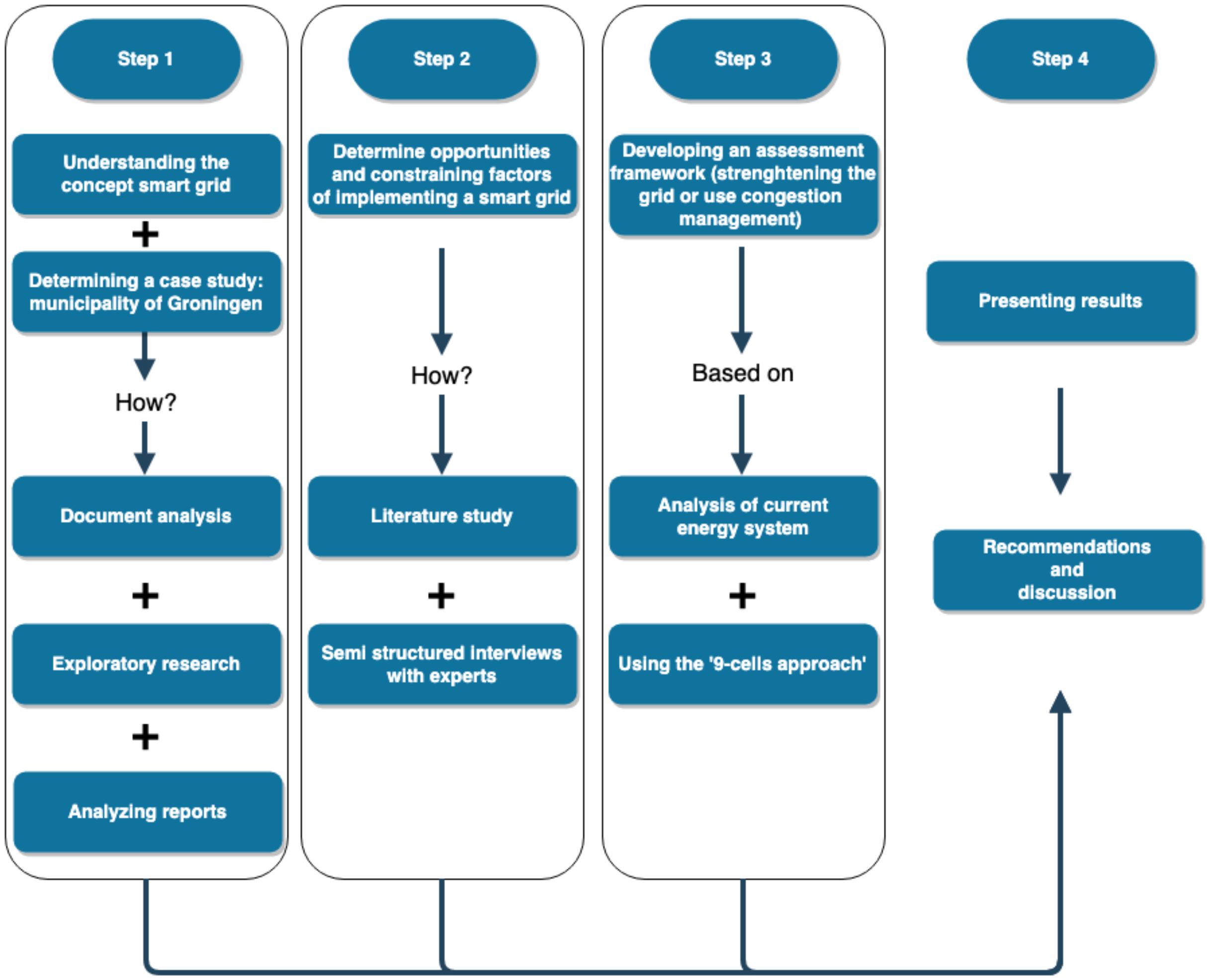

Figure 9: Research strategy of this study.

3.1.1 Step 1: Background research

The first step consists of a background research of smart grids, using document analyses, exploratory research and analyzing reports. Table 5 presents an overview with the conducted interviews and the used documents and reports are shown in table 4. A background research was chosen to gain basic knowledge about the subject smart grids and then to be able to interpret the playing field. With the help of background research, it is determined which frameworks, parties and their roles are important in smart grids. The background research was helpful by determining what data was needed for this study and how is this data collected. The background research was also helpful for determining the case study of this research: the municipality of Groningen.

Case study: the municipality of Groningen

The research will be focusing on a case. The municipality of Groningen (fig. 10) is central in this study. The province of Groningen, and therefore the municipality Groningen, is part of the so called 'energy valley' (EnergyValley, 2018). This energy valley is an area with a strong concentration of the Dutch energy production and knowledge. It is located in the north of the Netherlands and is the national energy supplier with large-scale and decentralized generation and small storage. It is also located in a convenient location with energy ports at the North Sea and in the heart of the North European gas and electricity grid. To finalize, the project 'Powermatching City I & II' in Hoogkerk, shows that the municipality focuses on the development of a smarter electricity grid.

Doing research by a case study provides insights in most aspects of one phenomenon within a functional whole (Crowe et al., 2011; Yin, 2014).

Figure 10: The municipality of Groningen. Source: 'Gemeente Groningen' (2018).

According to Timmermans (2009), a case study consists of three elements. The first part focuses mainly on understanding the case by applying theories of the theoretical framework. The second part gives the researcher freedom to apply knowledge from practice on the case and add a personal angle of approach. An example is to translate the ambitions and policies of the municipality of Groningen into a new spatial strategy. The third part is the fact that doing a case study can create a realistic and holistic view of the practice. To avoid a different or wrong interpretation, it is highly advisable to approach the data from different views (Yin, 2014).

According to Yin (2003) a case study design should be considered when: (a) the focus of the study is to answer "how" and "under which" questions; (b) one cannot manipulate the behavior of those involved in the study; (c) one wants to cover contextual conditions because one believes they are relevant to the phenomenon under study; or (d) the boundaries are not clear between the phenomenon and context. The focus of this study is to answer a "how" question (*How can a smart grid system contribute to solve the problems of the increasing demand for electricity?)* and therefore relevant.

3.1.2 Step 2: Literature study and interviews

The use of smart grids is a new development within the entire energy transition from a system based on fossil fuels towards sustainable recourses. To get a theoretical framework, as discussed in chapter 2, a literature study has been carried out. This literature study has been done by using both Dutch and English articles. The articles were found using various search engines, such as Smart cat and Google Scholar. A snowballing technique has been applied. Snowballing means that new literature has been searched based on the search terms with additional information or new concepts. Snowballing stops when there is saturation or when the literature expand too much to other domains. Some examples of search terms that were used during the process are: 'Smart grid', 'energy transition', 'smart meters', 'electricity grid'. In addition, a search was made based on the references in the literature articles.

Furthermore, semi structured interviews have been conducted to collect the information. A qualitative approach was chosen for the study. This was chosen because of the exploratory nature of this study. Complex issues (such as institutional design), visions and arguments are often nuanced. The nuance is difficult to capture with quantitative methods.
To get the best possible view, it has been decided to discuss with three experts with different insights on the implementation of smart grid. Table 5 provides an overview of the conducted interviews in the study. The first interviewee was Marlous van der Veen. She works in the department corporate strategy at Enexis group and has a strong passion for sustainability and smart grid implementation. The second interviewee was Han Slootweg. He is a professor of smart grid at Eindhoven University of Technology and he is also asset manager at Enexis group. His experience in the process of implementing smart grids was very valuable for this study. The third and last interviewee was Anne Venema. He works as an energy transition project manager in the municipality of Groningen and is therefore also very helpful for this study. He has other interests (more social based instead of the economic interests) than energy supplier or the network operator and knows a lot about the current situation of smart grid implementation in the municipality of Groningen. The combination of the three experts on smart grids with the literature study and the document analyses, provided sufficient information and knowledge about the opportunities and constraining factor of implementing smart grids.

3.1.3 Step 3: Developing an assessment framework

The third step is about developing an assessment framework 'Quick scan'. This assessment framework provides a checklist when to strengthen the grid and when to make use of the congestion management. As mentioned before, the assessment framework in this study can be seen as a checklist combined with a multi-criteria analysis (MCA). A MCA is a scientific evaluation method to make a rational choice between various discrete alternatives based on multiple distinction criterion (Janssen, 2001). Multiple criteria, set up in the first two steps of this research strategy, are included in the framework. The goal of this study is to develop an assessment framework and hopefully this framework will be used in the future. The development of the assessment framework 'Quick scan' is based on the analysis of the current energy system plus the use of the '9-cell approach'. The 9-cell approach (De Roo & De Voogd, 2019) is mainly used as an analytical tool and consists of three main concepts. First the material aspect, then the organizational aspect and the third and final concept is the institutional aspect. Implementing smart grids is a complex planning issue and the 9-cell model could help by splitting the issue into (three) different concepts. According to De Roo & De Voogd (2019), these concepts are multi-level and are mostly interconnected to each other. The criteria used in the assessment framework in this study stem from the analysis of the 9-cell model and the collected data.

3.1.4 Step 4: Presenting results and discussion

The fourth and final step of the research strategy actually is an outcome of the first three steps 'background research', 'literature study' and interviews and 'developing an assessment framework'. This 'step' concerns the presentation of the results, which eventually will lead to the discussion and recommendations of this study. The development of the implementation of smart grids is done in step 3 of the research strategy and the fourth step consists an evaluation of this assessment framework 'Quick scan'. The evaluation of the assessment framework of this study can be found in chapter 5. Immediately after the conclusion of this study, the reflection on this research is discussed. Also the shortcomings of this study are mentioned in the reflection of this study.

3.2 Research methods

3.2.1 Desk research and literature study

The first way to collect relevant information for this study is to make use of desk research. Desk research is a research methodology which uses existing data to gather more information about the subject (O'Leary, 2017). Literature study focuses on theoretical and scientific information and can also be part of doing desk research. Both approaches are useful for this study and complementary as well. Van Den Akker (2018) is one of the policy reports used in this thesis (table 4). This policy report is about the making of an assessment framework and therefore very relevant. Another policy report used in this study is 'the SER energy agreement for sustainable growth (Afman, 2019). Akkerboom et al. (2011) is the third report used in the study and provide insights about the law and legislation of implementing a smart grid. Furthermore, the reports of the municipality of Groningen (2015) and CE Delft (2012) were also used to gain background information of implementing smart grids (both generic and specific). An overview of the used documents and reports are shown in table 4.

Author report	Year	Title/ documents	Added value
Van den Akker	2018	Rapport netbeheer Nederland	This report provided relevant information about making an assessment framework within the energy sector. Furthermore, the use of flexibility was included in this report.
Afman	2019	'Openingsbod Groningen. Aanpak en bevindingen'	Discussed the preferred alternatives for natural gasses in several municipalities in the Netherlands, including Groningen
Akkerman et al.	2011	'Smart Grid Pilots. Handvatten voor toepassing van wet- en regelgeving'	Gave insights about the law and legislation (institutional design) of implementing smart grids
Municipality of Groningen	2015	'Groningen geeft energie'	Relevant information about the vision on smart grids of the municipality of Groningen (case study)
CE Delft	2012	'Maatschappelijke kosten en baten intelligente netwerken'	Oversight of the opportunities and constraining factors of implementing smart grids

Table 4: An overview of the used reports.

Together with the semi structured interviews, the desk research and literature study form the base for this study. Finally, this will lead towards a new assessment framework 'Quick Scan'. This assessment framework provides a checklist when to strengthen the grid and when to make use of the congestion management.

3.2.2 Semi structured interviews

In addition to studying policy documents, research reports and scientific articles, interviews were conducted with people involved in smart grid development and the energy transition. The interviews were conducted in the period February 1st up to February 26th, 2019. The interviews offered the opportunity to view the story behind the projects. According to (Clifford et al., 2010) three different types of interviews can be distinguished. These are: the non-structured interview, the semi-structured interview and the structured interview. A structured interview has a set number of questions, completely opposite to a non-structured interview. This flexibility is not present in structured interviews and overrepresented by non-structured interviews. The interviews conducted in this thesis are all semi-structured: some of the key-questions will be answered but since the thesis is of an exploratory origin, room for new insights is left open. The interviews in this study contain a semi structured character.

A semi-structured interview has the advantages that the answers of the respondent are not completely guided by the questions asked. There is room for the respondent to shed light on other relevant aspects that can be of relevance for the researcher but were yet unknown (Clifford et al., 2010). The interviewer creates depth in the interview. This may result in more relevant information being collected from the interviewee (Merriam, 1998). In addition, semi structured interviews are a useful method for qualitative research to gain information, knowledge and the attitude of the interviewee concerning the subject. Furthermore, semi structured interviews have the advantage that ambiguities can be specified by the interviewee. These qualities are important in a complex topic such as the implementation of a smart grid and are missing in, for example, a fully structured interview. Totally unstructured interviews are too wide and open and claim too much knowledge and experiences of the interviewer about interviews. Appendix 1 contains an overview of interview questions and their relation to the conceptual framework.

Table 5 presents an overview of the conducted interviews. Due to time constraints of an interviewee one of the interviews is conducted by telephone instead of the traditional face-to-face method.

	Interviewee	Organization/ company	Location and date
Interviewee 1	Marlous van der Veen	Corporate strategy, Enexis group	Enexis, Den Bosch 14-02-2019
Interviewee 2	Anne Venema	Municipality of Groningen, energy transition project manager	Municipality of Groningen, Zuiderdiep 20-2-2019
Interviewee 3	Han Slootweg	Assetmanager, Enexis group and professor of smart grid at Eindhoven University of Technology	Telephone, 26-02-2019

Table 5: overview of conducted interviews.

The interviews are recorded and then transcribed. Each respondent has been asked for permission to record the interview. In addition, the interviewees were informed that they could withdraw from the interview at any time without giving a reason. Some of the interviewees wanted to receive the transcribed pieces before publishing. More respondents were contacted, but some of them could not show up due to various reasons. Nevertheless, sufficient information for this study has been collected by talking to various experts in the field of smart grids.

3.2.3 Analysing data

Transcribing an interview is a representation of the research that has been carried out (Oliver et al., 2005 in Hennink, Hutter & Bailey, 2011). The focus must be on what is said during the interviews, instead of how it is said. Furthermore, transcribing provides more details that are essential for qualitative research (Hennink, Hutter & Bailey, 2011). After that, the most relevant information is highlighted and divided into different groups. The transcript obtained are then coded into different groups and led to a clear overview. The transcripts can be found in the appendices (Appendix II – Appendix IV).

3.3 Towards an assessment framework

After analysing the collected data from the conducted interviews and the literature, an assessment framework for two alternatives (strenghtening the electricity grid or congestion management) can be made. The assessment framework in this study can help by choosing the right option between the two alternatives.

As mentioned before, the assessment framework in this study can be seen as a checklist combined with a multi-criteria analysis (MCA). Bonte et al. (1998) claim that MCA a systematic, transparent approach provides that increases objectivity and generates results that can be reproduced. The MCA approach is relatively simple: a linear function is used to standardize the quantitative scores and the overall score is calculated as the weighted average of the standardized scores (Janssen, 2001 : 104).

This assessment framework can consist of a couple of technically oriented questions, which aim to identify bottlenecks that always lead to grid reinforcement and therefore prevent unnecessary market demand. For these bottlenecks, the assesment framework does not have to be completed fully. Furthermore, it is sufficient to justify briefly why the use of flexibility is not suitable for the bottleneck. All other bottlenecks do have a good chance that the use of flexibility is a more efficient solution than grid reinforcement. These bottlenecks go through the assessment framework. Table 6 provides an overview of the assessment criteria (based on own input and collected data) among the different solution alternatives. Every criterion gets a score from 0 (very bad) to 5 (very good). Chapter 4.5 elaborates on this assessment framework by elaborating the criteria mentioned in table 6. This should make it easier to choose the right solution between the different options.

Criteria	Explanation
Financial; investments, net present value, operational costs and incentives	What are the total costs of using the alternative? These are all the costs included: investments, net present value, operational costs, incentives etc.)
Cooperation	How does the cooperation between the different stakeholders look like? Are there many stakeholders (which mostly takes a lot of time) or are there only a few stakeholders?
Safety; mitigation safety risks, safety during construction, safety operational phase	Is this way of operating a safe choice?
Quality transport services; mitigation life assurance risks, robustness major incidents, transport capacities, voltage quality	What about the transport capacities? What will happen in case of a blackout?
Environment	What will be the effects on the environment?
Project duration	How long will the entire process of implementation take?
Existing resources	Are the resources already in the area?
Projects risk (time related, costs related)	What are the risks of implementing the alternative, both time related and cost related)?

Table 6: Criteria of the assessment framework.

4.Developing an assessment framework

As mentioned before in this study, this chapter is about the development of the assessment framework 'Quick scan'. The energy transition is increasingly characterized by a dynamic and therefore unpredictable character of the need for transport capacity. Because of those characteristics, there is an increasing need for an assessment framework. The function of an assessment framework is that it can help by choosing the right option. This study uses the '9-cells' model of De Roo & De Voogd (2019) for the development of an assessment framework. The 9-cell model will be elaborated in this chapter and can be seen as an analysis tool. Therefore, this 9-cell model could help develop an assessment framework by splitting the issue into (three) different concepts. In the end, the use of the 9-cells model combined with the analysis of the current electricity grid, will help choosing the criteria of the assessment framework 'Quick scan'. This assessment framework is a combination of an MCA and a checklist. The criteria mentioned in the assessment framework 'Quick scan' are the most important aspects of deciding between the 2 options: strengthening the grid or the use of flexibility.

The current Dutch energy system is based on an electricity grid which contains a facilitating role to the consumers and the market. A distinction can be made between three different market freedoms: freedom of connection capacity, freedom of transaction and freedom of dispatch (van den Akker, 2018). To guarantee these three freedoms, it is up to the network operator to invest in the electricity grid. The investments ensure that the transmission needs of grid users can be met and transport restrictions or congestion are prevented. The growth of wind and solar PV, the increasing number of heat pumps and the further growth of electric transport lead to new challenges for the network operator. These developments can cause peaks in the electricity transmission, which can lead to overloading of grid components. As mentioned before in chapter 2.5, two solutions that might help the overloads are strengthening the electricity grid and congestion management. These solutions can be divided into different concepts, to make the benefits and constraining factors clear. Based on De Roo & De Voogd (2019), three main concepts can be distinguished: material, organizational and institutional. The first section is about the material part, the second section explains the organizational part and the third section elaborates the institutional part. Afterwards, these three concepts will be linked to the different levels of scale they operate. Figure 11 shows a comprehensive view of the concepts and their levels of scale.

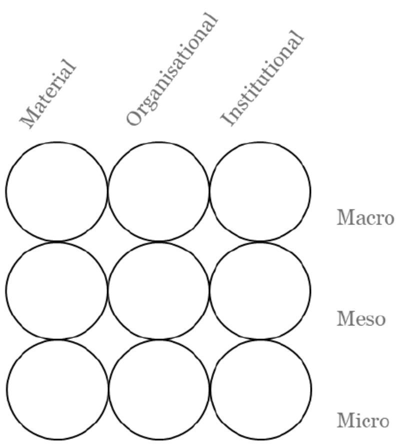

Figure 11: 'Nine cells' according to De Roo & De Voogd (2019).

4.1 Material

'Strengthen, unless...' Assessment framework

De Roo & De Voogd (2019) could help to make the function of the assessment framework 'Quick scan' clearer by making the distinction between the concepts 'material', 'organizational' and 'institutional'. This section of chapter four focuses on the 'material' part of the '9 –cells approach' (fig. 12).

The network operator works on a transparent and objective way to consider what the best solution is to prevent future shortages of transport capacity. The time between signaling and the occurrence of bottlenecks in the available transport capacity is usually longer for grid surfaces with higher voltages than with lower voltages. However, in all cases there has to be a certain realization time for the grid reinforcement.

The application of an assessment framework is expected to contribute in a positive way to a cost-effective transition to a sustainable energy system for three reasons (van den Akker, 2018). First, efficient solutions for the electricity grid can be used to lead to lower social costs. Secondly, the response to demand from the market can be quicker, and therefore less delay in projects because infrastructure is not ready in time. Finally, it adds value to the market for flexibility. This stimulates the process of unlocking new flexibility sources and is positive for the flexibility of the energy system (Van den Akker, 2018).

A smart grid system is one of the solutions to create that flexibility of the energy system (Middelweerd, 2018). In this thesis, material contains the technology to be able to construct a smart grid system. Some flexibility already exists in the current electricity grid, but mainly on the macro level (high voltage network). According to Edelenbos (2018), the Dutch high voltage network has been a smart grid for recent years, but it is completely different at the local level. He adds, the fact TenneT works properly, does not mean this is automatically the same in your street. A smart grid system is potentially a good solution, although it is more complex than most people imagine.

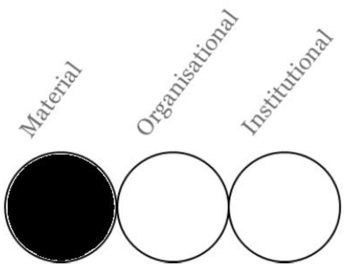

Figure 12: The material side within the 'nine cells'. Source: De Roo & De Voogd (2019), modified by author.

The value of the use of flexibility by the network operator as alternative to strengthening has been measured. In calculations of the costs for electricity networks, the use of flexibility will increase the potential cost reduction from only a few percentages up to more than 20% (Van den Akker, 2018). In some pilots, a positive business case seems to be created because large grid investments (over 1 million euros) can be postponed for several years.

The use of flexibility as a solution for a transmission capacity shortage can be studied from different perspectives or viewpoints. First, as a solution in a congestion management systematic. Secondly, as an alternative for strengthening the electricity grid. The assumptions of both frameworks differ, despite them being technically closely related:

- From the perspective of congestion management, the existing grid capacity is a given and is measured the way how overloading of the available grid capacity can be prevented using flexibility in the electricity grid.
- Congestion management starts from the existing grid capacity and generally has an operational perspective for the shorter term. On the other hand, network reinforcement starts from possible developments in the longer term that need to be facilitated with a future network.
- There may be obligations imposed within congestion management. For example, some restrictions in the dispatch freedoms of the market parties are located in the congestion area. The latter is not the case with the use of flexibility as alternative to grid reinforcement.

In short, the use of flexibility in a congestion management framework is related to an existing transport capacity shortage (grid reinforcement cannot be realized in time). An investigation to the expected bottlenecks in the available transport capacity in the medium or long term must performed, while using flexibility as alternative for grid reinforcement.

Nowadays, the human being is living in a period in which network reinforcement is possible and must be realized within the current legal framework of the network operators (van den Akker, 2018). In the Netherlands, congestion management is only applied within an electricity grid with a voltage of 110kV and higher (transport network). Because of the aforementioned developments, the possibility of applying congestion management in electricity grids lower than 110 kV (distribution networks) is considered desirable as well.

A two-step approach for congestion management can be realized by a request for information (RfI) followed by a request for proposal (RfP) (Van den Akker, 2018). The more details the network operator knows about the desired flexible capacity, the more specific a RfP-request can be. A material assumption is that every request from a network manager for flexible capacity must be set up in a technology-neutral way so market parties can offer all forms of flexibility. This means no conditions can be imposed on the source.

According to Han Slootweg (Appendix IV), some (large scale) pilots are going on in the field of smart grids in the Netherlands. He adds that the techniques of smart grids are 'pretty good' and network operators could already use them. Nowadays, practice shows that improving the electricity grid is mostly done by strengthening the grid instead of implementing a smart grid system.

To conclude, the material (technologies) for 'changing' the grid is already there. The delayed development of the current electricity grid is probably caused somewhere else. Following the 9-cell model, we will first look deeper into the organizational aspect of smart grids, to figure out if we can better explain the delayed development of smart grid.

4.2 Organizational

This part of the 9-cell model explains the organizational part within the smart grid development (figure 13). The organizational aspect is mainly characterized by the fact that a market for supply and demand has been created with an operator in between. The shares are still owned by the national government. Chapter 2.1 of this study (table 1) provides an overview of the different actors and their roles within the energy sector. How is the cooperation between these actors organized and how is the organizational aspect related to smart grids?

Besides network operators with a demand for flexibility, there must be other market parties active within flexibility so flexibility providers can offer their services to different actors. The market is created that is not dominated by the demand of one single actor. The deployed flexible capacity by a network operator can cause new bottlenecks at other times because the demand for transport capacity is shifted to an earlier or later time. How to prevent new bottlenecks in supplying flexible capacity? After all, electricity storage must be loaded again after a period of discharge.

Other examples are the heating- and cooling applications. These applications can consume extra energy just before a period of flexibility to maximize thermal reserve into the system for the flexibility period. After the period of flexibility, the average consumption is probably higher because the thermal buffers are brought back to nominal level. This is called 'the rebound effect' (D'Hulst et al., 2015).

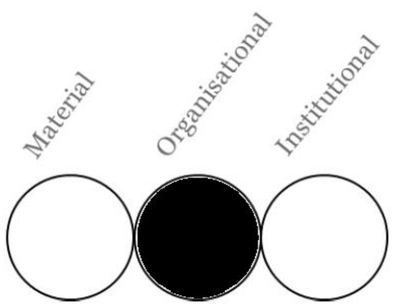

Figure 13: The organizational part within the 'nine cells'. Source: De Roo & De Voogd (2019), modified by author.

In order to make a proper assessment, the network operator must compare the costs and other aspects of a grid reinforcement with the costs of supplying flexible capacity from the market. Therefore, the interaction with potential providers is crucial. Depending on the situation, a first informative phase is useful to determine whether flexible capacity is available or can be initiated near the bottleneck. Then, a targeted tender or purchase might take place.

Two important conditions for reaching a successful request of the network manager are:

- **Clear formulation of the required flexible capacity;**
  The network manager must communicate clearly and transparently about the flexible capacity that is requested; which area is involved, which hours, etc. The network manager must also indicate whether the requested flexible capacity can be offered in several clipped parcels and what the possible minimum and maximum size of a parcel is. This will allow more providers to respond.
- **Program responsibility for all market parties;**
  This important principle must continue to apply to every market party that takes positions into the electricity market. Providers of flexible capacity must also have sufficient time to inform their program-responsible party about the deployment of the flexible capacity, so they can take this into account in the portfolio optimization. This optimization will be carried out by the market parties. The flexibility provider will include the costs for balancing in his quotation for offering flexible capacity.

To be able to make a good offer for flexible capacity, market parties need at least the information that is summed up in table 5. A part of this information has been set up by Van den Akker (2018) and this list has been supplemented on the basis of information mentioned before in this section.

Need for information	
Location data	The network operator indicates which locations are involved. This can be based on area, customers (EAN codes) or via another indication of locations. The network operator must take into account the requirements arising from privacy legislation.
How much capacity; required energy and the ratio between them	This provides insight into the capacity/ energy ratio of the requested flexible capacity.
The characteristic of the flanks of the requested flexible capacity	Is a steep peak expected (triangular) or a flat peak (rectangle)?
Expected frequency, duration and possible correlations of the call for flexible capacity	The network operator gives an indication of the frequency of the requested calls for flexibility (for example: once a year, once a week, etc.), possible correlations with seasons or weather conditions (sun and wind). Also, the expected duration per call and the minimum/maximum time between the calls. In this way, the market party can make the best possible estimate of the requested flexibility and the possibilities to offer the remaining flexibility to other customers.
Dispatch time flexible capacity	The network operator indicates in the request the minimum call time. How much time in advance will the contractor receive a signal that he is needed for the network operator?
Method of dispatch time flexible capacity	Multiple possibilities to activate the deployment of flexible capacity occur. The options for the network operator must be clear.
Desired availability of the flexible capacity	How many hours is the provider expected to be active? What are the rules for maintenance or breakdowns?
The time period over which the flexible capacity is contracted	The network operator indicates for which period he wants to contract the flexible capacity. This can be a predetermined period (for example, a temporary capacity problem) or based on a periodic evaluation. This evaluation is in line with the evaluation of the capacity bottleneck and enables the network operator to make adjustments in response to the scenario and market developments.
Method of reimbursement for flexible capacity	How is the reimbursement (fixed/ variable) for the provision of flexible capacity and the used flexibility determined? How is this measured and what are the penalties for non-delivery or unavailability of the flexible capacity?

Table 7: The need for information. Based on Van den Akker (2018), modified by the author.

If the market for flexibility in a certain area is sufficiently liquid, the network operator can also use ‘balance-neutral activation’ instead of bilateral agreements with one or more providers that have been concluded in advance. This could be done by means of so-called congestion spreads (Van den Akker, 2018). In the assessment framework it is then decided to use this flexibility solution if bottlenecks occur.

Based on information request by the network operator (table 7), the market parties provide the network operator insight into the assessment that can be made by the assessment framework (chapter 4.5). The market party indicates:

- The capacity that is available (technical implementation, location, time and duration);
- When this capacity is available;
- Characteristics of available capacity (response speed, time required between calling and making available, flexible capacity, minimum duration, maximum duration);
- How reliable it is for the network operator;
- Which term he or she wants to be able to commit himself/ herself.

In the Netherlands, the cooperation between the different energy actors is already quite well organized (M. van der Veen, 2019). One of the few struggles is that network operators are not allowed to coordinate with suppliers. A company such as Enexis cannot ask Essent to raise the price, because of the legislation.
As mentioned in 2.4, there is a lot of cooperation between the infrastructure managers (M. van der Veen, 2019). All network operators are member of ‘network management Netherlands’. For example, Enexis Group is involved in a project called ‘Green grids’. They work together towards a sustainable grid (circular cables etc.). Subsequently, the ideal situation is to ban the suppliers and introduce a block chain technology into the current electricity grid (M. van der Veen, 2019). Unfortunate, the development of block chain technology is not that far yet and therefore not ready to implement. To conclude, it can be established that the organization between the different actors is well arranged. The ‘institutional’ aspect is the third and final aspect of the ‘9-cell model’ and we will look deeper into this aspect to figure out if we can explain the delayed development.

4.3 Institutional

Besides the material and the organizational there is an institutional world (fig. 14) (De Roo & De Voogd, 2019 : 20). As discussed in section 4.1 and 4.2, the material aspect and the organization between different parties are not the major constraining factors of the development of smart grid. The techniques for a good working smart grid are already there (almost no 'black-outs' occur). To get a better understand of the delayed development of smart grids, it is useful to discuss the current institutional framework for applying flexibility.

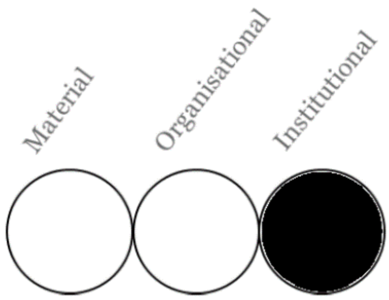

Figure 14: The institutional part within the 'nine cells'. Source: De Roo & De Voogd (2019), modified by author.

Current institutional framework for applying flexibility

It is difficult to assess whether the current legal framework implicitly provides a sufficient basis for applying an assessment framework for using flexibility from the market as alternative to grid reinforcement. As mentioned before in chapter 2.6 of this study, the focus will be mainly on the formal rules (law and legislation). It is more effective to properly safeguard the assessment framework (done by the network operator) and associated rules of the game into one of the planned changes to the electricity act. The Dutch ministry of Economic affairs and Climate is advised to make the possibility of using flexibility instead of strengthening the grid clear in the upcoming legislative change. This advisement is based on the assessment framework of van den Akker (2018).

Do the current regulations provide the right incentives for the network operator? Network reinforcements by the network operator are accompanied by investments. This includes capital expenditures (CAPEX). The purchase of flexibility from market parties is in fact a form of supporting services to the network operator that is associated with operational costs (COPEX).

Both strengthening the grid or purchasing flexible capacity can be used to ensure that the demand for transport capacity can be met. They also have an impact on both the CAPEX and the COPEX. The network operator has to decide which instruments will be used to meet the transport capacity. In a frame of reference by the regional network operators (RNOs), the transport services provided by the network operator are returned as composite output. These are related to the total costs made by the network operator to make the services possible. Then, the relative performance of an individual network operator is compared to its competitors; the other regional network operators. This comparison shows the efficient costs. Because both COPEX and CAPEX are included in the study, network operators will experience an incentive to make a cost-efficient choice within the 'strengthen, unless...' assessment framework. A network operator who structurally opts for the strengthening of the transport capacities instead of purchasing flexible capacities will therefore be worse than a network operator who chooses for purchasing flexible capacities. In case of the Dutch national network operator TenneT, costs are involved in an international TSO benchmark. Purchasing costs for energy and power are not included in the benchmark. The precise implications for the regulatory system will be further discussed between TenneT and the regulator to ensure an equal incentive between CAPEX and COPEX based solutions. To conclude, the current institutional framework for applying flexibility has some constraining factors. According to the Dutch law bank (2019), it is difficult to change the law. Table 8 shows a roadmap of how many steps must be taken during a law amendment, using the energy sector as example.

	Steps	Explanation
1	Ministry	The Minister wants to do something about the issues in the energy sector and asks officials or a committee to come up with a proposal. This proposal takes the form of a draft bill.
2	Council of Ministers	The ministers submit the bill to the Council of Ministers. They will then discuss the bill.
3	Council of State	After that, the bill goes to the advisory department of the Council of State. This advisory body examines whether the bill is feasible. They also check whether the bill does not violate the Constitution. The Board then gives its final judgment.
4	Submission to the House of Representatives	The bill and the explanatory memorandum are then submitted by the government (king and ministers) to the house of Representatives. From now on, the bill is public.
5	Written preparation	In each committee, one or two members of each group are always involved in a bill.
6	Plenary treatment	During the plenary session (the debate), several members of parliament will discuss the bill. The minister answers the questions.
7	Dutch senate	A bill adopted by the house of Representatives then goes to the Dutch senate. The senate is following a process of written treatment by committees: a report from the committee, a response from the minister and a formal final report from the committee.
8	Ratification and publication	The Dutch King and the minister sing the law, which will take effect.

Table 8: An example of changing the Dutch law. Source: PDC, 2018

As it is shown in table 8, a law amendment takes a lot of steps, and therefore time and effort, before it is realized. To accelerate the process of implementing smart grids, a change towards another institutional framework is desirable to reduce the time and cost aspects.

A change towards another institutional framework

The assessment framework ‘Quick scan’ provides a checklist for network operators to implement alternative market-based flexibility solutions for capacity bottlenecks. The assessment framework must have a natural link with solving the future bottlenecks in available transmission capacity. The assessment framework works with the time horizon of network investments and does not focus on the current bottlenecks in the transmission capacity that may occur in the daily operation of the electricity networks. Some functioning mechanisms for the resolution of these bottlenecks are already in the day-to-day operations, like:

- The possibilities to switch grid topology differently in business operations in order to distribute electricity flows through the network;
- Resolving transport restrictions, where ex ante bids from market parties are used to distribute production differently over the physical production locations and thereby prevent overloading in the network;
- In case of network investments are planned but these cannot be realized in time, there is an opportunity of applying congestion management.

Slootweg (2019) claims congestion management ‘does not really work at all’. TenneT uses this way of managing, but it is difficult to apply this way of management in the distribution. M. van der Veen (2019) adds; “Enexis Group has the task to provide every Dutch citizen with energy, but we (Enexis Group) then should purchase flexibility through batteries or smart solutions”. Nowadays, this is not allowed by law. An energy supplier such as Enexis Group cannot simply put a battery somewhere, because the market has to do that. It is mainly the regulation that is the constraining factor in implement smart grid and flexibility. The market does not buy flexibility, because no financial incentives occur and the market mode still makes it difficult to make it profitable (M. van der Veen, 2019). That is the main reason of the lack of batteries and why the electricity suppliers cannot use them. Therefore, there is a need for a new institutional design, based on a clear, more flexible legislation. A change of the authorizations of the actors in the energy sector is needed, i.e. that energy suppliers are allowed to use batteries. Providing the energy suppliers more authorizations would make the implementation of a smart grid easier, because they are allowed to use necessary instruments (batteries/ storages etc.). The process of implementing To make the implementation of smart grids even more difficult. The process of implementing smart grids becomes even more difficult because many aspects within the process are multi-level, i.e. the institutional design (shown in figures 11 and 15).

4.4 Multi-level

Yet, this is not everything. The three concepts 'material', 'organizational' and 'institutional' are often not isolated at one particular level of observation (De Roo & De Voogd, 2019). This section discusses and shows the relationship between implementing smart grids and the multi-level perspective and how these levels are connected to each other (figure 15).

Regional (meso-level) and local (micro-level) differences in the energy sector will occur because the size between supply and demand differ per area. More flexibility on the national level (third level) arises as a result of demand response and as a result of decentralized flexible supply (for example combined heat and power). At all levels (figure 15), this will lead to a new interaction between users, providers and networks. The combination of ICT and networks will make the grids at medium (meso) and low (micro) levels more self-directing and self-repairing, with increased security of supply (Ministry of Economic Affairs, 2010). However, the chance of cyber-attacks does exist. The multi-level perspective split a planning issue, i.e. in the energy sector, into three different levels: macro-, meso- and micro-level perspective. This section shows that almost all (planning) issues are interconnected at every level.

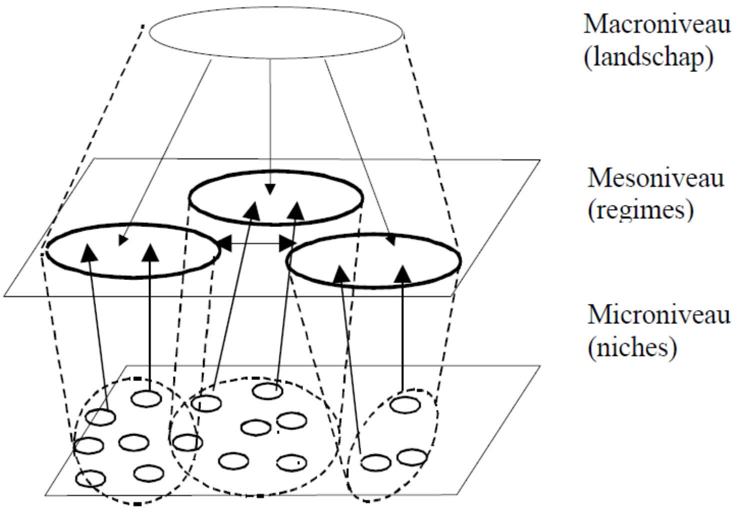

Figure 15: Different levels (Geels & Kemp, 2000).

- **Macro level (The Energy Union)**

This level is about the influence of global trends and autonomous development in the energy sector. In April 2019, a report was made public and it shows the commission has fully delivered its vision of an Energy union guaranteeing accessibility and secure-, affordable- and sustainable energy for all Europeans (European Commission, 2019). Europe is already a global leader in fighting climate change (Ibid). The European Union imposes rules and regulation on countries within the EU, whereby these countries are restricted in their actions and developments. Also the development of the Smart Grid systems in these countries is therefore difficult is some ways. According to Venema (2019), new European legislation is on the way and it gives local collectives (i.e. municipality of Groningen) more

power. Local initiatives, like a solar panel park in Groningen, are connected to the (inter)national electricity grid and this is an example of the multi-level perspective in the energy sector. Yet, this is not fast enough to implement changes in the grid. The introduction of the Energy Union creates a lot of optimism. Vice president of the European union Maros Sefcovic explains: “The Energy Union is Europe at its best: we are tackling together the major challenges of energy security and transitions that we cannot solve within the national borders. We have transformed the huge challenge of the energy transition into an economic opportunity for all Europeans. The changes in the electricity grid are no small adjustments in the margin but are a change in the entire system. No single European Union member state could have done that on its own. The Juncker Commissions have introduced a brand-new legislative framework for the Energy Union (European Commission, 2019). This gives the EU the opportunity to maintain its leading position in the field of climate change by setting even more ambitious targets for renewable energy, energy efficiency and reducing the emission from vans, trucks and cars. In addition to the new legislative framework, the Commission has adopted a number of accompanying measures to ensure a smooth transition for European industries, regions and cities (European Commission, 2019). A number of targeted initiatives have been taken to ensure all regions and Europeans benefit equally from the energy transition. An example of such an initiative is the European alliance for batteries/ energy storage.
In 2009, the European Commission asked different ‘groups’ to give advice about implementing a smart grid system in the European Union. One group advised to introduce flexibility on the demand side (Expert group 3, 2015). They claimed: ‘A consumer can benefit from demand side flexibility wherever he/she can get access to market data and adapt energy consumption (behavior) or injection accordingly’. Therefore, this advisement was never adopted due to the European legislation.

- **Meso level (The Netherlands)**

The second level is about the smart grids on national level and is located where macro- and micro level meet each other. The meso level is also the level where the local authorities (municipalities, provinces) must collaborate with supranational organizations, such as the European Union. The past shows that this is more difficult than it seems. The most important threshold is differences in legislation. It is the meso level, where different grid operators such as Liander, Stedin and Enexis must work together. Obviously, the electricity grid does not stop at the border of a province and therefore a smooth cooperation between those companies is indispensable. Installing the smart meters everywhere is the best-known example of implementing smart grids, but there is more. All grid operators are members of a group, called the Dutch network management. Within the Dutch network management, there is a coalition called ‘Green grids’, where all the grid operators try to make their grid as sustainable as possible (M. van der Veen, 2019). Within the same grid area this is arranged well, but it is not allowed to negotiate with energy suppliers.

According to Slootweg (2019), smart grids can be divided into different meanings. ‘Smart grids can be fundamentally distinguished into intelligence in which the customer is involved. This includes dynamic pricing, control of charging behavior of an electric car, etc. The other way of smart grid is the one that’s set up for network operator, i.e. smart meters. A company such as Enexis group is rolling out that form of smart grid at the moment’ (Slootweg, 2019). This has been underway for years and this is successful. Another project or plan of implementing smart grids is, besides implementing smart meters, installing smart grid in every street in the Netherlands. This is the smart grid variant where it is primarily the network operator and has been running for a while. Then, there is the variant whereby the customer is involved and is in the starting phase of its process. An example of this variant is 'Toon', where the customer gets information from a smart thermostat and tells the customer how to save energy and thereby money. That is a project rolled out all over the country.

- **Micro level (Provinces & municipalities)**

Demand and supply will fluctuate enormously at the micro level. For example, if a neighborhood starts to generate solar energy all together at the same time, there will be an overload on the electricity grid. The same thing happens when everyone is charging his or her car at the same time. It is no longer self-evident that the net can handle all those situations. These situations are currently dealt by with controllable gas and coal-fired power stations, but they will eventually have to close down. These developments, on both the demand and supply side, therefore require innovation and transformation, so the energy system also functions optimally in the future. An obvious solution is to expand and increase the electricity grid, but there is a major disadvantage: it costs billions. In addition, it takes decades to get the job done, while in some cases the problem is already urgent. As mentioned before in this study, a better solution is to make the link between demand and supply smarter and more efficient. This needs a lot of ICT. Venema (2019) claims the municipality of Groningen does not need a smart grid that much yet, because the current electricity grid can handle the challenges.

Nevertheless, various projects within the municipality of Groningen are realized. One of those projects is 'Sharing energy with your neighbors', which take place in the district Reitdiep. Reitdiep is a new residential area in the north of Groningen with mostly larger houses. These citizens generally have more to spend than the average citizen of Groningen and therefore solar panels are installed on most roofs. Then, the municipality of Groningen was thinking about sharing energy with each other, without an energy supplier. Block chain technology might be the solution for this, but is still in the pilot phase (Venema, 2019).

Another project within the municipality of Groningen takes place in Selwerd, which is located in the north of the city. The goal of the project is to deliver the surplus of renewable energy to the lower income households. This project is also in the first phase and the municipality of Groningen is currently working on developing that concept further. One of the constraining factors within this project is probably that not everyone will agree to give their energy to the lower incomes. The people from the upper class have to make investments in solar panels. The main problem here is that people with lower incomes often live in social housing and therefore do not have their own roof on which they could possibly install their solar panels.

Then, there is the cooperation between the local authorities and the network operators. Both parties have their responsibilities and more importantly, their preferences. According to Venema (2019), Enexis is not afraid for the peak moments, because 'it is not that far yet'. They prefer to strengthen the grid to handle these peak moments. Venema (2019) adds: "we, the municipality of Groningen, also have calculated it ourselves and strengthening the grid is necessary in every neighborhood of Groningen. This is not because the increasing number of cars powered by electricity, but because there will be more solar panels on the roofs. This raises again the following question: "should the grid be strengthened or will be there another solution?

An assessment framework could help answering this question. When including the material, organizational and institutional parts of smart grid, and link them to the multi-level perspective, criteria for the assessment framework become clearer. As mentioned before, developing the assessment framework is the main goal of this study and the 9 cell-model (De Roo & De Voogd, 2019) can be used as an analysis tool. Implementing smart grids is a complex planning issue and the 9-cell model could help by splitting the issue into different concepts.

All the parts are related to the energy sector and therefore they provide a better understanding of the current situation. For example, if the solution alternative 'strengthen the grid' is better organized compared to congestion management, it will be cheaper and smarter than 'just strengthening the electricity grid'. As mentioned before in this section, the cooperation takes place on multiple levels: macro, meso and micro. A distinction between different levels is made because most planning issues, such as within the energy sector, are interconnected at every level.

Another aspect of the 9-cell model is the material part. Is it possible to adjust the current infrastructure or is it (probably more) about installing a completely new network? Installing a completely new network will take a lot of time and financial investments/ operational costs etc. The incentives for the consumers must also be considered, because these incentives might cost a lot of money.

The final concept, besides the material and the organizational part, is the institutional part. Due to the different laws and regulations, the implementation of one option might take much longer than the other option. The shorter a project takes, the better for the assessment because of the time duration and the additional costs. Most of these concepts are the basis for a new assessment framework called 'Quick scan'.

4.5 Assessment framework 'Quick scan'

As mentioned before in this chapter, developing the assessment framework is the main goal of this study and the 9 cell-model can be used as an analysis tool. The concepts material, organizational and institutional (combined with the multi-level perspective) are the basic elements for drawing up the assessment framework. In the current practice, the network operator makes a risk analysis and therefore determines whether there is a problem that needs to be solved. It is possible that the network operator has also identified the opportunities that are involved in resolving the bottleneck.

The assessment can consist of a couple of technically oriented questions, which aim to identify bottlenecks that always lead to grid reinforcement and therefore prevent unnecessary market demand. For these bottlenecks, the assesment framework does not have to be completed fully. Furthermore, it is sufficient to justify briefly why the use of flexibility is not suitable for the bottleneck. All other bottlenecks do have a good chance that the use of flexibility is a more efficient solution than grid reinforcement. These bottlenecks go through the assessment framework. Table 10 provides an overview of the assessment criteria among the different solution alternatives. The selected criteria are relevant for the process of the both solution alternatives and therefore these criteria are included in the assessment framework 'Quick scan'. The criteria can be graded on a scale from 1 to 5 (1 = very bad, 5 = very good).

Assumptions assessment framework

Like any instrument or policy, the assessment framework 'Quick scan' (table 10) has been developed from a number of assumptions (based on Van den Akker, 2018). These principles and assumptions are made explicit in the table below (table 9). The principles and assumptions are primarily the result of policy choices.

Assumptions development of the assessment framework	
1	The price for supplying flexibility is based on demand and supply. Flexibility is offered on voluntary basis.
2	There is a regulatory framework whose system is designed in such a way the network manager can be reimbursed for both the costs of efficient network reinforcement and any alternative use of market-based flexibility.
3	The current system principle is the starting point for estimating the desired transmission capacity. The network manager analyzes and publishes the expected developments of the desired transmission capacity. Offering flexibility is not mandatory and takes place on a voluntary basis.
4	The future laws and regulations are designed in such a way that "gaming" is prevented by market parties. Misuse of the assessment framework can be avoided and there can be fair pricing.
5	The assessment framework has two different options for using flexibility as alternative for network reinforcement: - As a temporary measure, to prevent congestion management is a proposed grid reinforcement cannot be realized in time. This ends when the network reinforcement is realized; - As an alternative to network reinforcement.
6	Generic measures that can influence the desired transport capacity cannot be used as solution to the assessment framework, but are a factor in the estimation of the desired transport capacities and the use of the assessment framework.
7	Sustainable is not given priority over non-sustainable. It is assumed that the current emissions trading system and the policy for stimulating sustainable energy will be continued. These stimulating measures are expressed in the price for which production and flexibility are offered on the market.
8	The social efficiency of the use of the flexibility can be assessed in two ways: 1) A consideration in which only the costs and benefits are compared by the network operator; 2) A consideration in which comparison under 1) is extended to a total social costs and benefits analysis of the entire energy system. This is called a SCBA (Social Cost-Benefit Analysis). Eventually, the assessment is a policy choice that must be taken.
9	For the use of flexibility as alternative to network reinforcement, the socialized costs of the deployed flexibility must be lower than the socialized costs for the network reinforcement.

Table 9: Assumptions assessment framework.

Assessment criteria	Solution alternative 1: Strenghtening electricity grid	Solution alternative 2: Congestion management
Financial		
- Investments	1-5	1-5
- Net present value	1-5	1-5
- Operational costs	1-5	1-5
- Incentives	1-5	1-5
(Total / 4) =		
Cooperation	1-5	1-5
Safety		
- Mitigation safety risks	1-5	1-5
- Safety during construction	1-5	1-5
- Safety operational phase	1-5	1-5
(Total / 3) =		
Quality transport services		
- Mitigation life assurance risks	1-5	1-5
- Robustness major incidents	1-5	1-5
- Transport capacity	1-5	1-5
- Voltage quality	1-5	1-5
(Total / 4) =		
Environment	1-5	1-5
Project duration	1-5	1-5
Existing resources	1-5	1-5
Project risks		
- Time related	1-5	1-5
- Costs related	1-5	1-5
(Total / 2) =		
Preferred solution	Total score	Total score

Table 10: Assessment criteria different solution alternatives.

The solution alternative with the highest number at the bottom of the tabel is the preffered solution. The criteria ‘financial’, ‘safety’, ‘quality transport services’ and ‘project risks’ have been subdivided into sub-topics. This means these four criteria receive an average score. The implementation of a smart grid differs per region (context-dependent) because of the different circumstances and stakeholders. For example, to strenghten the grid in a quiet residential area will cause less disruption than blocking a busy road in the middle of the city center.

'Quick scan'

An example of a 'quick scan" to determine whether the application of flexibility could provide an effective alternative for grid reinforcement:

a) Is the bottleneck suitable for applying flexibility within the approval period?
- A peak in the required transport capacity that occurs approximately [5] times a week or less, gives reason for reasearch into the use of flexibility as a solution.
- A capacity bottleneck that occurs approximately <[1500] hours per year (comparable to a daily peak of 4 hours) can be interesting for flexibility providers.
- Peaks that occur at times when weatherdependent production (Wind and solar) is approaching the total load, may be interesting for flexibility providers because of the possible low market price due to the large energy supply.
- It is not necessary to go through the assessment framework for bottlenecks with a permanent cause and occur for approximately [4000] hours or more a year because grid reinforcement alternatives come out of the assessment framework as most efficient.

b) Are technical instruments conceivable for solving the bottleneck?
- Is there sufficient flexible demand behind the bottlenecks or can it be expected if a market request is made?
- Is there sufficient flexible generator behind the bottleneck or can it be expected if a market request is made?
- Are there new technical flexilibity options from the market possible by adapting the primary process to this (for example energy storage, P2G, hybrid systems etc.)?

c) Are investments already planned in the short or medium term (for example replacement of outdated assets)? In the case, the use of flexibility can be an interesting alternative compared with brining forward the planned investments.

If bottlenecks are related to multiple network operators, coordination will be sought between these network operators in determining the solution that entails the lowest integrated costs. The importance of coordination is growing. Bottlenecks that are detected by the network manager can be canceled or, in some cases, increased if another network manager uses flexible capacity. This flexible capacity has, in some cases, less value than the network reinforcement of the relevant network operator. Coordination and regular updates of the desired transmission capacity are crucial to ensure that network operators include all the effects of the deployment of flexibility.

The assessment framework 'Quick scan' can be seen as a result of this study. This assessment framework can help by choosing the right option. The following chapter contains an evaluation of the assessment framework 'Quick scan'.

5.Evaluation of the assessment framework ‘Quick scan’

As mentioned in chapter 4, the material for ‘changing’ the grid is already available and the delayed development of implementing a smart grid system is caused somewhere else. This chapter is about the evaluation of the assessment framework presented in chapter 4 of this study. The goal of this chapter is to determine what the opportunities of the assessment framework are. The final part of this chapter contains an evaluation of the assessment framework ‘Quick scan’ and its contribution to the municipality of Groningen.

To change the micro- and meso level, different innovative applications will arise. Most of them will play an essential role in the energy transition. Solar panels also provide energy when you do not need the energy. This raises the question: how can we still use it? Do we supply it to our neighbor’s heat pump, or can we temporarily store it in an electric car or energy storage? According to Venema (2019), already some European projects, for example the Modular Energy Storage Architecture Project in the United Kingdom, are at the moment focusing on the development of energy storage. Slootweg (2019) agrees, but is also realistic and even a bit skeptical.

“Within energy storage, we have to deal with the legislation. The network operator is not allowed to do that because it is influencing the market. Besides that, there will be the abolition of the offsetting arrangement soon. Then you can buy power walls at Ikea within a few months, just like it happened in Germany. There, the offsetting arrangement went down because of its own success. Therefore, we (Enexis group, red) think that the power walls will be used much more here. In addition, sensible incentives (financial and technical) of the power wall will be used to utilize the grid and to limit the investments in it”, Slootweg (2019).

A comprehensive business case for smart grid applications is also essential for scaling up (Middelweerd, 2018). It simply has to be interesting for companies to get started on a larger scale. New solutions that bring flexibility to the grid, such as energy storage in batteries, still have to compete with the large, adjustable alternatives, such as gas- and coal power stations. That is an unfair playing field. ‘We’ need to come up with something that allows new solutions in the field of flexibility to compete right now. How to make those business cases relevant? The answer is obvious, take flexibility into account while setting out new tenders (Middelweerd, 2018). Do not stick to getting new wind farms only, but also arrange flexibility.

To make interaction between the remaining energy possible, all devices must be connected to each other, literally. Then you talk about an important first step towards a smart(er) grid. The data flows in combination with good measuring and control technology, then performing proper measurements and finally exchanging data. Then supply and demand can be linked to each other in an optimal way. Well-known examples of a smart grid application are Vehicle-2-grid and Smart Charging. A normal electric car can only charge at a predetermined speed. However, a smart variant can temporarily stop charging, charge more slowly or even return electricity to the grid. The flexibility that an electric car offers, can be sold to a grid operator in the future. Then, the grid operator can use cars to balance the grid, by temporarily stopping the car from charging, supplying energy or even charging faster.

The key is to introduce the flexibility into the grid, if necessary. The problem of implementing flexibility is caused by the Dutch law. The market does not buy flexibility, because no incentives occur and the market mode still makes it difficult to make it profitable (M. van der Veen, 2019). As mentioned before in this study, the goal of this thesis is to develop an assessment framework. The evaluation of this assessment framework 'Quick scan' is that almost all projects eventually are based on strengthening the grid, even when the outcome of the assessment framework is to apply flexibility. This is due to the current institutional design. Until the Dutch regulations are adjusted (another institutional design), the best solution is to keep the 'strengthen, unless…' (chapter 4) principle.

5.1 Benefits and disadvantages of smart grids

Benefits of implementing smart grid

Benefits
Sources of renewable energy supply their overcapacity to the grid, so less (fossil) energy is needed for power stations.
By converting heat into electricity, losses of energy can be avoided.
When a large number of sources supply the network, the chance of major power outages is small.
Smart grids have the potential to reduce electricity consumption by 30%, therefore environmental benefits as well.
Reducing peak moments by following and using the consumer' data. Therefore, the grid operator is able to anticipate where they have to focus.
Smart appliances for global energy distribution could reduce the greenhouse gas emissions of the energy sector.
Because there is more detailed information on the demand side, more benefits occur for the network operation.
Raising Reliability: building a complete electrical system monitored and controlled in real time, with a capacity of self-establishing (self-healing) (Sivaranjith, 2018).
According to the participating partners of the project PowerMatching City II(2015), the use of smart energy systems can bring the Netherlands between 1 billion and 3.5 billion euros.

Table 11: Overview of benefits Smart grid.

One of the biggest benefits of a smart grid is that it offers more insight in the energy consumption (M. van der Veen, 2019). The benefit is that individuals can monitor and manage their energy consumption by checking their smart appliances. Smart meters interact with the electricity grid by sending production data and consumption back and forth, allowing consumers a real-time view of their energy consumption (Artemia, 2016). Artemia (2016) also claims smart meters allow energy suppliers to offer real-time pricing which provides consumers with an incentive to more effectively manage their energy consumption and therefore save lots of money. The network operator is also able to reduce the electricity grid losses, because the network operator is able to detect the energy losses. The moment the market starts to develop, and therefore the flexibility market starts to develop as well, some opportunities arise for the network operator to provide people with energy that is a more cost-effective way at most times. Within the current transport capacity, there is a lack of structural periodic analysis by local developments. Data from smart appliances should improve this.

Disadvantages of implementing a smart grid

Disadvantages
The system is complex and therefore error prone (slow, phased input).
Multiple problems have shown up within the data security and privacy (cybercrime). 1) The legacy of energy technologies that are based on closed systems. 2) The interweaving with legal and regulatory aspects that introduce additional constraints. 3) The complex structure of the energy sector, with a variety of interconnected stakeholders, thus requiring more standardized solutions (Asghar, 2017).
It is expensive to install smart meters in almost every house compared to the traditional electricity meter. For example; in the United States, the estimated cost of rebuilding the existing electricity grid is between 13 and 50 billion dollars.
The privatized large electricity network managers must be prepared to admit the 'small' companies as well.
Who determines the price of the energy supplied to the grid?
An emergency power supply may be required for each customer.
The implementation of a smart grid system is not within only one level, but it spreads out in multiple levels (macro, meso, micro). This makes it more complex because there are a lot of stakeholders.

Table 12: Overview of disadvantages smart grid.

The disadvantages are mainly caused by the extra data generated by smart appliances. An extra layer (for the smart appliances) is built in the network, so the CO2 emissions will be even bigger. This increased data is directly linked to another issue; the privacy of the consumers might be affected. Some serious challenges will occur. The network operator, utility companies, the national government and energy suppliers must consider before changing the whole electricity grid.

Another disadvantage is the high expenditure for installing smart meters through the whole country. Installing one smart meter for electricity costs approximately €66, - (Author unknown, 2016). Of course, it is the intention that this amount will be earned back in several years. Therefore, this can be seen as an investment instead of an expenditure.

5.2 Case study: municipality of Groningen

The evaluation of the assessment framework 'Quick scan' also applies to the case study of this research. What effect could an assessment framework have in the future in the municipality of Groningen?

In the municipality of Groningen, still no large projects of smart grid implementation occur. This is because of a couple of reasons. According to Venema (2019), the major reason is because the municipality of Groningen does not have much renewable energy. The municipality of Groningen has a clear goal: CO2 neutral in 2035 (Gemeente Groningen, 2018). To achieve this goal, the municipality is dependent of several stakeholders. For the cooperation between these stakeholders, the municipality must convince stakeholders to participate, such as by supporting them financially (incentives). In some situations, it is necessary to enforce cooperation, which often does work well. For the latter, regulations become more important. Nowadays, the municipality is looking for solutions in the local regulation and financing, because this is lacking on the national level.
Between 2013 and 2017, the percentage of renewable energy within the municipality of Groningen went from 3.8% up to 5.4%. To be CO2 neutral in 2035, emissions must decrease faster. In the next few years, CO2 emissions must fall by 30 percent (Gemeente Groningen, 2018).
According to several energy companies, such as Enexis group, energy storage projects is not necessary at this time. Venema (2019) adds:

'A part of a quarter of Groningen is warmed by heat pumps, in other words: electric. That is a tremendous investment, which can go up to 30,000 euros per home. It is also an investment for the new parts of the municipality to make it affordable. A second solution is a heat network. We are working on a project in the northeast of the city with such a heat network. Citizens of this part gets their hot water delivered by large pipes underground. The first idea was through geothermal energy, so geothermal heat. Unfortunately, that project has been put on hold. There now is a sort of combined heat and power plant that has been built and still partly powered by natural gas. Geothermal heat was not an option anymore, because one party decided to stop their support. They are afraid of the consequences of the possible earthquakes in the area. Consequently, this could possibly lead to a legal battle with the NAM, which is not desirable. It might be a solution, in the far future'.

According to Afman (2019), regardless of the chosen heat technology, grid reinforcement for electricity seems necessary in all neighborhoods of Groningen, mainly caused by the increasing number of solar panels. At the moment, storing energy in small batteries does not seem like a solution. The calculation follows that 300 GWh storage volume would be required for the municipality of Groningen (Afman, 2019).

Groningen does not produce all the required electricity in its own area (Gemeente Groningen, 2018). Production within the municipality is supplemented with production from outside the municipality. It is plausible that this production is also volatile, so supply and demand do not always connect well. Especially in the summer are many surpluses. One possibility is to convert it to hydrogen and re-use it as electricity when needed. Then, the municipality of Groningen needs about 300 GWh storage of hydrogen (Afman, 2019). Another possibility is to invest less in solar PV and to focus more on techniques that have a better match with the electricity demand such as wind during the winter. To finalize, solar thermal is also an option, only if linked to a network and in combination with seasonal storage (Afman, 2019).

To conclude, an important condition for the further development of smart systems (smart grids) is that demand and supply of energy can be matched by using wind and solar energy. First, the municipality has to invest in ways of generating sustainable energy. Then, the large-scale rollout of smart grids can be realized. At this moment, the need for a large-scale smart grid in the municipality is apparently not sufficient. In addition, a shift towards another institutional (re)design is required. If these aspects change in the energy sector, the implementation of a smart grid in the municipality of Groningen is just a matter of time (could take several years). Until that time, it is advisable to adhere the “Strengthen, unless…” principle.

6.Conclusion

This chapter presents the conclusion and discussion of this research. In contrast to other resources, electricity has to be used the moment when it is generated, because still no large storages are realized (Rodriquez et al., 2018). The main reason for this is the current Dutch and European energy regulation. Due to this regulation, the network operator (i.e. Enexis) is not allowed to install an energy storage somewhere. In addition, energy storage is more expensive than overproduction.
A change in the electricity grid is needed, since the network operator increasingly has to deal with the increasing demand for electricity and the bigger peak moments in current networks. The use of smart grids is one of the best solutions to reduce those peak moments and ensure that almost no blackouts will take place. In this study, the municipality of Groningen is used as a case study and the main question of this research is: *"How can a smart grid system contribute to solve the problems of the increasing demand for electricity?"*.

The use of market-oriented resources to prevent network congestion is limited in the current legal framework to a temporary and supplementary role. The grids must always be strengthened in the long term. The future developments show that in specific cases of network congestion, the social costs of strengthening the grid can increase strongly. In some cases, where network congestion occurs in a limited number of moments, the social costs of strengthening the grid can be demonstrably higher than the alternatives, such as the use of flexibility options. This is the case with most of the low-voltage networks. In the built environment, solar panels are installed on the roofs of buildings. Usually, the amount is tailored to the required energy used in the relevant building. The peak for solar PV will also only take place a few times a year, so the utilization rate of the electricity grid will become very low in such neighborhoods. In those cases, incidental congestion management can be more beneficial than grid reinforcement, even on the longer term.

The goal of this study was to develop an assessment framework for strengthening the grid or applying flexibility. This assessment framework is a clear table and include the following aspects: finance, safety, quality transport services, environment, project duration, existing resources and project risks (time- and costs related). The 9 cell-model of De Roo & De Voogd (2019) can be seen as an analysis tool in this study. The assessment framework presented in this study consists of several, relevant criteria and can be seen as a combination of a checklist and a multi-criteria analysis (MCA). This assessment framework can help by choosing the right option between strengthening the grid or applying flexibility. Introducing an assessment framework is consistent with the findings of Van den Akker (2018) and it could be helpful for the development of a smart grid. But, the current institutional design plays a major role in the implementation of smart grids and causes a delay in the development.

The prevention of disruptions or blackouts is also a benefit of the implementation of a smart grid. Both the grid operator and the individuals can monitor and manage their energy consumption by checking their smart appliances. Therefore, it will be clear where and when the grid might face overload and so where to intervene. The introduction of flexibility will help this process, by maintaining the balance between demand and supply, all within the limits of distribution and transmission systems with controllable, flexibly deployable resources in the short term. Unfortunately, due to current laws and regulations, the use of flexibility by the grid operators is not allowed. Therefore, strengthening the grid is, despite a different outcome of the assessment framework ‘Quick scan’, the only realistic option. The development of the assessment framework ‘Quick scan’ is the result of this study and hopefully this framework will be used in the future, when the institutional design is changed.

This brings us to another conclusion of this study. The institutional design of the energy sector must be adjusted to give the grid operator and energy suppliers more power to operate. Hereby, it is important to keep in mind that most influential laws and regulations are imposed by the EU. At this moment, the EU partially meets the Dutch energy sector by drafting new energy legislation that will give the local collectives (i.e. the municipality of Groningen) more power.

To finalize, a (small) need for smart grids does indeed exist, but it is not as urgent as is generally thought. In addition, some constraining factors are in the organizational part and the institutional design of the current Dutch energy sector. Yet, (small) pilots are already going on in Groningen, i.e. the application of smart meters. Also in the near future, several projects concerning smart grid are planned to be realized. These projects are on a lower scale and it is still unknown when these projects will take place. In the planned projects, the introduction of flexibility in the electricity grid can be helpful in the development of smart grids in the municipality of Groningen. At this moment, the principle “Strengthen, unless…” is what must be followed, until the changes discussed in this study are realized.

7. Reflection

In this chapter, a short reflection from the authors point of view and the recommendations of this research are discussed. The first section is about the reflection; what went well during the process and what did not? In addition, the contribution for planning theory and practice is explained. The third and final section of this chapter contains a couple of recommendations for further research.

7.1 Reflection

The initial phase of the process was quite difficult for me. Smart grid systems are a relatively new field of research. My knowledge about smart grids was also limited at the start of this research, so I knew a little about smart grids. Therefore, formulating a research question was not very easy. Through a lot of consultation with different actors and feedback from the faculty, it finally will succeed. Data collection by scientific research papers and policy documents went very well, because a lot has been written about smart grid recently. Finding respondents for the (semi-structured) interviews was harder than I thought. Luckily, a few respondents were willing to discuss about smart grids and therefore I have been able to collect sufficient information for my thesis. The next time, I will conduct more interviews from different organizations, i.e. the national government and other employees within the municipality of Groningen. Including these organizations could help me to gain more useful information, i.e. the question how the national government could contribute to the development of smart grid.

Furthermore, this research is based on only one case: the municipality of Groningen. In some cases, this does not provide sufficient information to be able to state that the conclusion and the recommendations applies to multiple projects in the Netherlands. However, this choice was made consciously by the author. The choice was made to be able to look closer within the projects. Flyvbjerg (2006) correspondents to this choice made by the author. He claims that one can often generalize on the basis of a single case (the municipality of Groningen in this study), and the case study may be central to scientific development via generalization as supplement or alternative to other methods. Yet, I think it depends on the criteria of the case selection whether this study can be used in other Dutch cities. Is the relevant municipality comparable or different from the municipality of Groningen?

The process of the research took longer than expected as well, which means that the data is partly less accurate towards the end of the thesis. The data collection related to the case has also been a couple of months ago, which means that the factors that played a role at that time may have changed because in the Netherlands, the energy transition is shifting rapidly.

The outcomes of this research might be obvious at first sight, but that does not make them less important or convincing. There is a lot of potential in the implementation of smart grid and it will be one of the best solutions for the electricity grid. This contains too many constraining factors (i.e. the regulation and the share of sustainable energy in the municipality) at the moment. The recommendations mentioned in the conclusion of the study, can therefore be used to accelerate the development of the implementation of a smart grid.

7.2 Relevance for planning theory and planning practice

This master thesis contributes to planning theory by putting the implementation of a smart grid in the current planning debate. Furthermore, this thesis contributes to planning theory by using the 9-cells approach, what results in the criteria for the assessment framework 'Quick scan'. With the help of the 9-cells approach, the issues among the implementation of smart grids can be made clearer. Implementing smart grids is a complex planning issue (according to this study) and the 9-cell model could help by splitting the issue into different (three) concepts. Micro level organizations are hampered in their functioning because rules are imposed from higher levels (macro level: the European Union). The contribution to the planning practice of this thesis is the role of the assessment framework 'Quick scan'. The presented recommendations can be seen as idealistic, but not unrealistic. A lot of literature about the energy transition and governance does already exist, but the link towards planning practice was missing. The multi-level perspective of De Roo & De Voogd (2019) in combination with the assessment framework shows the interaction between the planning theory and the planning practice. Of course, recommendations for further research became clear as well.

7.3 Recommendations for further research

Smart grid is one of the most 'hot topics' within the energy transition and therefore a lot of research has been done. Yet, after writing this thesis, a couple of recommendations for further research arise. A first recommendation is to involve energy storage and the opportunities of energy storage for the energy sector. According to the collected data, energy storage has a lot of potential, provided that the regulations will allow it. Doing research to find the opportunities and possibilities for energy storage will be useful for the development of this sector.

Another next step is to bring new insights into the heat transition vision and energy plans at the neighborhood level. After that it is necessary to indicate which of the Groningen neighborhoods will get rid of the gas before the year 2030. This is part of energy transition, since the use of electrical devices will probably increase in these neighborhoods. In the follow-up steps, the solutions need to be further explored for each neighborhood, together with the residents and stakeholders. If such a smart grid can be established, then the municipality, residents, corporations, energy suppliers, network operators, installers and other stakeholders have the desired clarity to develop the electricity grid further.

Furthermore, when focusing on the municipality of Groningen, it might be interesting to collect data by doing a survey in the neighborhood Hoogkerk. This is the neighborhood where the projects PowerMatching City I & II took place a couple of years ago. It will be interesting to hear the opinion of the citizens in the neighborhoods about using smart appliances and what aspects can be improved. The combination of collecting data by doing surveys, the study of several documents and conducting interviews will lead to a lot of useful data, and it will make the outcomes stronger.

The final recommendation is to pay more attention to the national government during the process. Their contribution in the whole process of the implementation of a smart grid is quite big and it would therefore helpful to conduct a (semi-structured) interview. They have a different point of view and it will be helpful to get more insight in their considerations and decisions.

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9. Appendices

Appendix I: Interview guide

An overview of interview questions and their relation to the conceptual framework

Introduction	Dutch question	Translation	Relation to conceptual framework
Introduction	*Wat is uw visie op de huidige energietransitie?*	What is your vision about the current energy transition?	Energy transition
	Wat voor rol speelt uw bedrijf/ instelling in de energietransitie?	What is the role of you company/ organization in the energy transition?	Energy transition
	Wat is uw mening over de doelstelling om in 2050 nauwelijks nog broeikasgassen uit te stoten? Is het haalbaar?	What is your opinion about the objective of hardly emitting greenhouse gasses in 2050? Is it feasible?	Sketching the development within the energy transition

Smart grid system	Dutch question	Translation	Relation to conceptual framework
Smart grid system	Hoe staat het met de huidige situatie rondom de implementatie van het smart grid systeem?	What is the current situation about the implementation of smart grid?	Energy transition
	Wat zijn de grootste doordelen van Smart Grid volgens u?	What are the biggest advantages in your opinion?	Opportunities and containing factors
	Wat zijn de grootste nadelen van Smart Grid volgens u?	What are the biggest disadvantages in your opinion?	Opportunities and containing factors
	Hoe is de huidige wet- en regelgeving geregeld omtrent Smart Grid implementatie?	Based on the smart grid implementation, how does the current laws and regulations look like?	The regulation of smart grid systems
	Welke rol zouden financiële prikkels kunnen spelen in het bevorderen van het smart grid system?	What role can financial incentives play in developing smart grid system?	Financial motivation to make smart grid successful
	Hoe is de samenwerking binnen het elektriciteitsnetwerk geregeld in Nederland?	How is the cooperation within the Dutch electricity network regulated?	The cooperation between the different stakeholders

	Hoe zou deze samenwerking volgens u verbeterd kunnen worden?	How could this cooperation be improved in your opinion?	The cooperation between the different stakeholders

Case based	Dutch question	Translation	Relation to conceptual framework
Case based	*Wat kan de energie branche leren van congestie- en watermanagement?*	What can the energy section learn from congestion- and water management?	Lessons learned from congestion- and water management
	Wat is de toegevoegde waarde van het huidige congestiemanagement van TenneT?	What is the added value of the already existing congestion management of TenneT?	Lessons learned from congestion- and water management
	Is het verstandig om een soort Energie schap op te richten, naar het voorbeeld van het Waterschap?	Is it advisable to establish a sort of 'Energy board', like there is already a 'Waterschap'?	Lessons learned from congestion- and water management
Powermatching City	*Wat is/ was uw rol in de het powermatching city project?*	What is/ was your role in the Powermatching City project?	Case study; municipality of Groningen
	Met wat voor gevoel kijkt u aan tegen dit project?	What feelings do you have about this project?	Case study; municipality of Groningen
	Wat voor lessen kunnen er geleerd worden uit het project?	What lessons can be learned from this project?	Case study; municipality of Groningen
	Wat is de reden waarom dit project binnen Groningen nog niet is uitgebreid binnen de gehele gemeente?	**What the reason why there are no projects like this on a bigger scale within the municipality of Groningen?**	**Case study; municipality of Groningen**

Conclusion	Dutch question	Translation	Relation to conceptual framework
Final remarks	Zijn er nog aspecten die u nog wilt benoemen m.b.t. de energie transitie of smart grid?	Are there some final aspects you want to mention regarding to the energy transition or smart grid?	-
	Kent u nog personen waarmee ik in gesprek zou kunnen gaan?	Do you know persons I must talk to?	-
	Wilt u de eindversie van deze master thesis ontvangen?	Would you receive the final version of this master thesis?	-

Appendix II: Interview Marlous van der Veen – Enexis group

Interview Marlous van der Veen - Enexis

Samenvatting

Marlous van der Veen werkt nu ongeveer 4 jaar bij Enexis, waarvan de eerste twee jaren zij actief was als trainee. Hierbij heeft zij verschillende projecten uitgevoerd en is momenteel actief binnen de afdeling 'strategie'. Marlous heeft aan de Rijkuniversiteit Groningen Sociale Planologie en Vastgoedkunde gestudeerd en is inmiddels al een paar jaar actief in de praktijk.

Onderzoeker: De focus van mijn scriptie ligt op de gemeente Groningen, mede doordat er in 2009 een project is geweest op het gebied van smart grid. Dit project heette Powermatching city en de resultaten bleken vrij positief en optimistisch. Na powermatching city I is er ook een tweede project gestart in Hoogkerk en ook die resultaten waren goed. Wat ik mij als eerste afvroeg is hoe een bedrijf als Enexis inspeelt op dit soort projecten?

Marlous: Wat versta jij precies onder smart grid?

Onderzoeker: Je hebt nu een elektriciteitsnetwerk waarbij je als het ware éénrichtingsverkeer hebt, van de generator naar de woning. Bij smart grid heb je ook informatie en data die van de woningen naar een derde partij wordt geleverd, door middel van smart meters. Je kan dus door middel van slimme apparaten bij houden wanneer je het beste energie kan gebruiken.

Marlous: Het is allereerst belangrijk om helder te hebben wat wij bedoelen met smart grid. Er is namelijk niet één vaste definitie. Het reguliere netwerk gaat in principe top-down, van de opwekker naar de klant. Daarmee doel je denk ik op de communicatie? Het feitelijke energienet is helemaal ingericht op dat tweerichtingsverkeer, het is dus echt een data vraag. Binnen Enexis zijn er twee dingen die wij daarin doen en die niet meer in de pilot fase zitten maar die echt geïmplementeerd gaan worden. Ten eerste de uitrol van de slimme meters in de woning. Ik geloof dat wij ongeveer 5 slimme meters per minuut installeren in heel Nederland, dat gaat dus in een hoog tempo. Dat betekent dus ook dat je al die data beschikbaar hebt. Maar om aan een betrouwbare 'boundary' te komen, heb je best een hoog percentage meters nodig. Stel: je hebt een straat en daarvan nemen 5 huishoudens wegens privacy redenen geen slimme meter, dan kan je eigenlijk niet heel veel met de data die daar uit voortkomt. Als er bij die 5 huishoudens bijvoorbeeld een paar twee verdieners zitten en een elektrische auto van de zaak, geeft dat direct een ander beeld.

Onderzoeker: Zo iets werkt dus alleen wanneer de gehele straat meewerkt dus?

Marlous: De betrouwbaarheid gaat omhoog naarmate je van meer mensen de live data hebt. Wij werken met zogenaamde energieprofielen. Dat is data van verbruik van mensen gedurende de dag waar dus ook de pieken ontstaan. Die energieprofielen leggen we allemaal over elkaar heen voor bepaalde type wijken en dan komt er een overall profiel uit. Over dat overall profiel hebben een bandbreedte en daar leggen we ons net op uit. Precieze percentages kan ik je niet vertellen, maar die bandbreedte maakt dus eigenlijk, omdat ie er is, dat de urgentie van smart grid omlaag gaat. Doordat die bandbreedte er is, is het niet noodzakelijk om een smart grid aan te leggen in dat bepaalde gebied.

Die kabels gaan voor 30 a 50 jaar de grond in en als het toch past, waarom zou je dan gaan voorspellen? Het loopt pas mis wanneer mensen massaal zonnepanelen nemen en dat vervolgens niet aanmelden. Ook het opsporen van wietplantages is het interessant. Deze worden namelijk vaak om de meter heen gelegd en valt op wanneer er een hoger energieverbruik is dan de omringende huizen. Dit wordt nog niet veel gebruikt, omdat de datakwaliteit op dit moment nog vrij beperkt is. Je zou pas harde acties kunnen ondernemen wanneer die data waterdicht is.

Onderzoeker: In hoeverre staat de wetgeving smart metering/ smart grid in de weg?

Marlous: Simplistisch gezegd: het is met de huidige wetten niet verboden op een smart grid aan te leggen. Technisch gezien mag het. Waar je vervolgens tegenaan loopt is dat je allemaal data hebt waar je dingen wel en niet mee kunt. Hoe betrouwbaar is die data eigenlijk als je drie adressen mist. Kun je bijvoorbeeld iemand oppakken aan de hand van data van Enexis wegens energiediefstal? Hetzelfde geldt voor het congestieverhaal; je zou namelijk kunnen zeggen dat Enexis de taak heeft om iedereen altijd van energie te voorzien, maar die flexibiliteit zouden we dan moeten inkopen door bijvoorbeeld batterijen of andere slimme oplossingen. Dit mag wettelijk gezien niet. Enexis mag niet zomaar een batterij ergens neerzetten, dat moet de markt doen.

Onderzoeker: Is dat het grootste probleem bij de ontwikkeling van batterijen en energieopslag?

Marlous: Ik weet niet of dat het grootste probleem is voor opslag in het algemeen, maar wel het grootste probleem in de opslag voor ons. Stel je voor dat je een situatie hebt waarbij je een woonwijk hebt die tegen die bandbreedte aan begint te drukken, waardoor de pieken net erboven uit komen. Dit veroorzaakt hogere slijtage van de kabels en meer uitval etc. Je zou dan flexibiliteit in kunnen kopen zodat die piek opgevangen kan worden, maar dit mogen wij als Enexis zijnde nog niet doen. Die batterijen moeten eerst door de markt daar neer gezet worden. De markt doet dit echter niet, omdat er geen prikkels zijn en het marktmodel het nog moeilijk toestaat om daar winst op te maken. Daardoor zijn die batterijen er nog niet en kunnen wij er geen gebruik van maken. Dan ontstaat er een moeilijke situatie want voor ons kan het wél uit om daar een batterij neer te zetten. Dan heb je de vraag: bij wie ligt de verantwoordelijkheid? Enexis heeft er baat bij dat er een besluit genomen wordt, zodat daar op kan worden ingespeeld. Die piek afvangen kunnen wij heel goed in het huidige systeem door de straat open te gooien. Dan leg je er een dikkere kabel neer bijvoorbeeld. De duur van zo'n kabel is ongeveer 20/30 jaren.

Onderzoeker: Dus dat is in principe, zoals het nu staat, dé oplossing?

Marlous: Ja, de oplossing in principe 'verzwaren, tenzij..' en 'tenzij' staat dus eigenlijk voor tenzij er een slimmere, goedkopere oplossing gevonden wordt. Maar op het moment dat je daar over gaat praten, ga je ook direct praten over dingen die wellicht in een grijs gebied vallen. Dat maakt het erg moeilijk, want van verzwaring weten we exact wat het kost, hoeveel mensen we nodig hebben, kunnen we inplannen en materiaal bestellen. Dat is in principe erg makkelijk, ondanks dat het tijd en geld kost natuurlijk. Van al die andere oplossingen weten we niet hoe het werkt, maar daar draai je dus die pilots voor. We hebben onlangs twee pilots gehad, één daarvan heet 'Jouw energie moment' en dat was een project in een wijk in Tilburg. Wij hebben hen slimme apparatuur gegeven, zoals powerwalls, 'slimme' wasmachines die aan gingen op het moment dat de prijs laag is. Daar heb je weer flexibele tarieven nodig, want dan zou je tarieven moeten hebben die reageren op de aanbod en vraag in de markt maar dat mag nu niet. We hebben op het moment maar twee tarieven, dat is het piek- en daltarief. Zolang er geen prijsincentive is, gaat niemand zijn een duurdere wasmachine kopen die op een bepaald moment aan gaat omdat de stroomprijs laag is.

Onderzoeker: Dat is inderdaad een onderdeel van mijn onderzoek. In hoeverre denk je dat die financiele prikkels echt een rol gaan spelen binnen smart grid?

Marlous: Ik denk dat die flexibele tarieven al erg zouden helpen. Dat is het interessant in de smart grid discussie, want als deze flexibele prikkels er zouden zijn dan zou er bij ons al heel veel oplossingen en verzwaringen niet meer nodig zijn. Dan balanceert de vraag zich weer uit en wordt ie in zijn totaliteit constanter. Bij enexis verzwaren wij op de piekmomenten

Onderzoeker: Kan je dan niet als Enexis zijnde daar meer op in spelen om die flexibele tarieven te krijgen?

Marlous: Dat is inderdaad wel een lobby onderwerp van ons in Den Haag en wij hebben ook een voorstel liggen.

Onderzoeker: Wat is dan de reden van Den Haag om die flexibele tarieven niet te doen?

Marlous: Omdat we die nu ook niet hebben. Het is alleen beter voor ons, maar het is niet beter voor de leverancier. De leverancier gaat minder winst maken op de energie die ze verkopen. Nu kunnen ze gedurende de hele dag, ook wanneer de kosten en energieverbruik laag is, het piek tarief vragen. Op het moment dat je die tarieven aanpasbaar maakt, wordt het misschien goedkoper voor de burger, maar niet per se beter voor die bedrijven. En je moet niet onderschatten hoe groot hun invloed is in Den Haag.

Onderzoeker: Dat snap ik. Hoe is die samenwerking tussen die verschillende energie instanties op het moment?

Marlous: tussen de infrabeheerders zelf is er wel veel samenwerking. Alle netbeheerders zitten bijvoorbeeld samen in netbeheer Nederland. Ik zit namens Enexis in een coalitie dat heet 'Groene netten' waarbij we gezamenlijk bezig zijn met het verduurzamen in ons eigen net. Hierbij kan je denken aan circulaire kabels en dat soort oplossingen. Binnen hetzelfde stukje van het energie netwerk is dat allemaal best goed geregeld, maar wij mogen bijvoorbeeld met de leveranciers niet zoveel afstemmen. Ik kan bijvoorbeeld niet bellen met iemand van Essent en vragen of zij zomaar de prijzen verhogen, dat mag niet.

Onderzoeker: Hoe ziet die ideale situatie qua samenwerking er volgens jou uit dan?

Marlous: Dit is geen corporate standpunt van Enexis, maar mijn mening is dat je het beste de energieleveranciers er tussenuit kunt halen en een blockchain introduceert op het net. In principe zijn die leveranciers gewoon overbodig namelijk.

Onderzoeker: Is dat dan een kwestie van tijd dat de blockchain technologie geïmplementeerd gaat worden?

Marlous: Dat weet ik niet. Er werken veel mensen aan die kant van de sector (leveranciers) en die willen zichzelf er natuurlijk niet uitwerken.

Onderzoeker: Even samenvattend; wat zijn volgens jou de grootste voor- en nadelen van smart grid?

Marlous: Een voordeel is dat je meer inzicht hebt. Er zullen ongetwijfeld dingen zijn als we daar inzicht van hebben, dat we dan anders gaan handelen. We kunnen ook onze netverliezen terugbrengen, omdat we beter in staat zijn om energieverliezen op te sporen. Op het moment dat de markt zich gaat ontwikkelen, en dus ook de flexibiliteitsmarkt zich gaat ontwikkelen, dan is het voor ons een kans om op een voordeligere manier mensen altijd en overal van energie te voorzien. Helaas is dit nog niet het geval. De nadelen zitten vooral in de enorme datastroom die daardoor vrijkomt. Die data heeft namelijk ook een hele grote CO2 impact. We bouwen nog een laag over ons net heen waardoor de CO2 uitstoot nóg groter wordt.

Onderzoeker: In hoeverre is het dan veel groener om smart grid te implementeren?

Marlous: Dat kan je je inderdaad afvragen. Ik denk niet dat een smart grid per se een duurzame optie is. Het is eerder een slimme oplossing. Je zou het wel in kunnen zetten voor verduurzaming en dat zie je nu met de slimme meters. Een voorbeeld hiervan is 'mijnenergieinzicht.nl' en helpt mensen thuis beter inzicht te krijgen waar hun energie verbruik naartoe gaat. Inzicht ergens in krijgen betekent ook dat het makkelijker wordt om ergens op te acteren. Ik heb het nu de hele tijd over slimme meters, maar we hebben ook DA (distributie automatisering). DA houdt in dat het hele energienetwerk is verdeeld in allemaal ringen, die allemaal in elkaar haken. Als ring A een storing heeft, kan ring B dat voor een deel opvangen. Om dat te kunnen doen heb je distributie stations in de wijk. Vroeger moest er een monteur naar een kast komen om een deel van de straat weer te voorzien van stroom. Wij worden tenslotte afgerekend op onze storingsminuten. We hebben geen concurrentie, maar er wordt gekeken naar totaal aantal storingsminuten. We moeten dus zowel de kosten als de storingsminuten zo laag mogelijk houden.

Onderzoeker: En dat kan onder andere door de implementatie van smart grid?

Marlous: Onze distributiestations zijn constant in contact met onze bedrijfsvoeringcentra, waar het net wordt bediend. Doordat er geen monteur meer naar die kasten hoeven te gaan, kunnen de storingsminuten gereduceerd worden.

Onderzoeker: In hoeverre zou het afschaffen van de salderingsregeling in 2023 invloed hebben op het elektriciteit netwerk?

Marlous: Het interessante is dat de salderingsregeling voor het net niet heel positief is. Door salderen aan te moedigen, moedig je aan dat mensen niet nadenken over hun verbruik versus hun opwek. Als jij eigen zonnepalen hebt die rond het middaguur de meeste energie opwekken, dan zou het logisch zijn dat je op dat moment de wasmachine aanzet. Nu hoeft daar niemand bij stil te staan en er wordt gewoon geleverd aan het net en de mensen thuis krijgen hun geld. Op het moment dat je de keuze maakt om niet meer te salderen, dan gaan mensen nadenken over hun verbruik. Dan gaan mensen meer nadenken en op zoek naar oplossingen, wellicht door het nemen van een Tesla powerwall of door je apparaten op een ander moment aan te zetten. Door het salderen af te schaffen, creëer je een financiële prikkel om zelf na te denken over jouw totale verbruik.

Onderzoeker: Dus eigenlijk is het positief dat de saldering regeling afgeschaft gaat worden?

Marlous: Het is positief voor het net, maar het is niet per se positief voor duurzame energie in Nederland. Ik vind het niet positief als daardoor bijvoorbeeld niemand meer zonnepanelen op het dak aanlegt.

Onderzoeker: Binnen het watermanagement heb je verschillende waterschappen met al hun verschillende verantwoordelijkheden en functies. Hoe kan het dat het watermanagement beter functioneert dan de energiesector?

Marlous: Dat komt door het aantal partijen waar je mee te maken hebt. Wij hebben ongeveer 4,7 miljoen aansluitingen in Nederland en dat betekent dus ook dat je 4,7 miljoen spelers hebt. Dat is verschillend ten op zicht van de watersector. Ik weet niet of het niet haalbaar is, maar ik vraag mij af welke elementen van de waterschappen maken dat zij succesvol zijn. Staat de hoeveelheid water bijvoorbeeld vast, dan gaat dat model niet voor ons werken. Blijkt het dat zij op een slimme manier een samenwerkingsvorm hebben gevonden waardoor er sneller een besluit gevormd kan worden, dan is het wel interessant voor ons. Het hebben van een bepaald orgaan daarin maakt niet zo veel verschil. Nóg een orgaan in de energiesector maakt het enkel complexer.

Onderzoeker: Je noemde net al een aantal projecten waar jullie mee bezig zijn. Zijn er nog wat projecten die op grote schaal uitgevoerd worden momenteel?

Marlous: De slimme meter is vrij grootschalig, want die is door heel Nederland. In 2020 willen wij dat iedereen een slimme meter heeft. Iedereen krijgt een brief thuis met de vraag of zij een slimme meter willen en de bijbehorende folder. Dat is dus een megaproject om er voor te zorgen dat dat in 2020 gereed is. Iedereen heeft het volste recht om dit te weigeren en wij mogen niet verplichten om een slimme meter aan te leggen. Wij worden teruggefloten door het ACM wanneer wij een soort marketingstrategie er van maken. In die zin zijn wij een vrij onafhankelijke partner. Het merendeel van de mensen neemt wel een slimme meter. Er zijn ook mensen die de slimme meter niet vertrouwen. En net als bij de analoge meters worden er ook wel eens fouten gemaakt bij de slimme meters.

Onderzoeker: Is de privacy de grootste reden om geen slimme meter aan te leggen? Er worden namelijk wel persoonlijke gegevens naar jullie teruggespeeld en je weet niet wat er onderweg met die data gebeurd.

Marlous: Dat is wel goed beveiligd natuurlijk. En je houdt altijd mensen die achterdochtig zijn, maar zoals ik net als zei is dat natuurlijk hun volste recht.

Onderzoeker: zijn er verder nog belangrijke aspecten binnen de energie transitie of Smart Grid?

Marlous: het gaat allereerst om de definitie van smart grid. Ik zie het als een middel om een bepaald doel te bereiken. Dat doel kan zijn meer inzicht of minder congestie in een bepaald gebied. De vraagstelling lijkt alsof het is: Waarom ligt er nu nog geen smart grid in Nederland? Zoals ik er tegenaan kijk is dat heel logisch omdat dat nog niet echt nodig is. Als je dan al die investeringen doet in het aanleggen ervan terwijl je nog niet weet waar we het voor gaan gebruiken.

Onderzoeker: Oftewel: zo urgent is het dus niet om een smart grid aan te leggen?

Marlous: In sommige gevallen wel. De slimme meter vinden wij wel een urgent project, want dat rollen we uit voor 2020. Dat klinkt misschien ver weg maar het is wel een miljardeninvestering. Het is goed om te realiseren dat wij dit niet in ons eentje bepalen. Naast het feit dat men het wel of niet wil om een slimme meter in huis te hebben, moeten ze er ook een ochtend voor thuisblijven om te laten installeren. Maar door deze investering te doen, kunnen wij in de toekomst hopelijk sneller inspelen op het reduceren van de storingsminuten. Daarnaast levert het hebben van die data an sich helemaal niks op. Er moet wel iets mee gebeuren, alleen de vraag is wat er mee moet gebeuren. Waarom wil je zo snel een smart grid? Afgezonderd van die storingsminuten. Er is maar één manier om hier achter te komen en dat is door het gewoon te doen.

Onderzoeker: Hoeveel mensen maken op dit moment gebruik van de slimme meter?

Marlous: Dat weet ik niet exact uit mijn hoofd, maar dat staat wel in het jaarverslag.

Onderzoeker: Hoe is jullie samenwerking met bijvoorbeeld TenneT?

Marlous: TenneT is momenteel ook bezig met het slimmer maken van hun net, maar dan op een heel ander niveau. Indien nodig dan is de samenwerking gewoon goed. Zij hebben een soort van hoofd leidingnet. In dat net zit een gebied waar wij dan energie afnemen en daar zit een bepaalde capaciteit. Die kunnen wij dan vervolgens gebruiken voor een dorp dat daar op aangesloten zit. Pas op het moment dat zo'n dorp in zijn geheel zó veel gaat gebruiken dat die aansluiting bij TenneT te klein wordt, dan hebben wij actief met hen te maken. Maar zolang het binnen die bandbreedte blijft is het ons probleem en bemoeit TenneT zich er niet mee. Dat is uiteindelijk beter want dan zijn er minder partijen bij betrokken.

Appendix III: Interview Anne Venema – Gemeente Groningen

Interview Anne Venema – Gemeente Groningen

Samenvatting
Anne is momenteel een paar jaar aan het werk binnen het energieprogramma van de gemeente Groningen. Hij houdt zich vooral bezig met de wijkaanpak; opgericht om volledig van het aardgas af te gaan. Anne bekijkt via modellen per wijk wat het beste alternatief is voor aardgas. Voordat Anne aan het werk ging bij de gemeente Groningen, deed hij vrijwilligerswerk voor Grunneger Power.

Onderzoeker: Wat houdt het project 'Energie delen met je buren' in?

Anne: In een wijk waar alleen maar wooncorporatiebezit is, daar kan je makkelijker een warmte oplossing implementeren dan in een wijk waarbij allerlei verschillende huiseigenaren zitten. Wij kijken per wijk wat het beste alternatief voor aardgas is. Met verschillende wijken zijn wij al in gesprek om een plan te maken dat gedragen wordt door iedereen om uiteindelijk van het aardgas af te gaan. Eén van die wijken is Reitdiep en dat is meer een nieuwbouwwijk met grotere woningen. Deze bewoners hebben over het algemeen wat meer te besteden dan de gemiddelde Groninger en op de meeste daken vind je dan ook zonnepanelen terug. Daar kregen wij de vraag: 'ik heb een heel groot dak op het zuiden, maar als ik deze vol leg met zonnepanelen hou ik stroom over. Waarom kan ik niet aan mijn buren leveren?' Helaas mag dat niet zomaar, omdat er allerlei regels aan zijn verbonden. Wij zaten te denken; is het niet mogelijk om aan je buren te leveren, zonder dat er een energieleverancier tussen zit? Een blokchaintechnologie zou hier een oplossing voor kunnen zijn.

Onderzoeker: Wat zijn de huidige ontwikkelingen wat betreft blokchaintechnologie en smart grid?

Anne: Blokchaintechnologie is één van de oplossingen, maar in principe heb je geen blokchaintechnologie nodig. Het voordeel is dat je de partij die overal tussen zit, die heb je dan niet meer nodig.

Onderzoeker: Maar ik kan me voorstellen dat een energie leverancier zoals Eneco of Nuon hier niet echt om staat te springen?

Anne: Als innovatie zouden wij het interessant vinden om een pilot te doen. Op dit moment, in onze eigen pilot, doen we het samen met één leverancier van ons. Zij willen wel meewerken, alleen het ideaalbeeld van ons dat er geen leverancier meer nodig was, dat is wettelijk niet toegestaan. Er is wel een experimenteer regeling, maar er zijn dus verschillende stappen nog die genomen moeten worden.

Onderzoeker: Wat zou op het gebied van wetgeving dan bijvoorbeeld veranderd moeten worden?

Anne: Er komt sowieso een nieuwe Europese wetgeving aan en die geeft de lokale collectieven meer bevoegdheden. Maar dit gaat volgens ons nog steeds niet snel genoeg. Eigenlijk wil je energie via het openbare net transporteren en dan moet je een vergunning hebben. En alleen de energie bedrijven hebben die, aangezien je een energie bedrijf moet zijn. Dit zou dus moeten veranderen als je zonder energie leverancier energie uit wil gaan wisselen op buurtniveau. Dat gaat niet zomaar veranderen en dit is ook logisch. Je hebt bijvoorbeeld te maken met levering zekerheid en alle vraagstukken van de netbeheerders. Die hebben er ook belang bij dat vraag en aanbod goed op elkaar wordt afgestemd. Wij willen nu een pilot starten waarbij we virtueel transacties gaan doen. Mensen blijven aangesloten bij hun eigen leverancier en daarboven op zit een soort laag. De mensen die meedoen krijgen een kastje op hun slimme meter en die houdt niet alleen bij hoeveel ze opwekken en verbruiken, maar ook hoeveel ze aan hun buurtgenoten leveren. Dat kastje is dus een soort blokchain die alle transacties bijhoudt.

Onderzoeker: Hoe staat het nu met die pilot? Is die inmiddels al begonnen of moet het nog beginnen?

Anne: Het was de bedoeling om in maart echt live te gaan. We hebben afgelopen maand een paar werksessies gehad om te kijken of het wel gaat werken. We gaan natuurlijk virtueel, dus werkt de techniek bijvoorbeeld. Uiteindelijk willen we ook iets in het echt gaan doen, daar hebben we als gemeente wat aan.

Onderzoeker: Ja duidelijk. En je had het over de minima huishoudens. Hoe kunnen zij het beste profiteren van duurzame energie?

Anne: Daar willen we ook een koppeling mee maken. In de volgende fase willen we in Selwerd een portiekflat aansluiten. We willen dan het overschot van duurzame energie aan die minima huishoudens leveren. Dat concept zijn we op het moment nog verder aan het uitwerken. Niet iedereen zal het hier mee eens zijn om zomaar energie aan de lagere inkomens te geven. Zij moeten natuurlijk investeren in zonnepanelen en dan snap ik wel dat ze niet gratis energie aan anderen geven. Als gemeente kunnen wij hier wel op inspelen. In Groningen hebben sommige huishouden een zogenaamde 'Stadjerspas' waarbij zij theater of naar het zwembad kunnen gaan. Wij zaten te denken om dit misschien te gaan koppelen aan duurzame energie. Dus dat deze huishoudens die pas kunnen gebruiken om lokale, duurzame energie te krijgen. Het grote probleem hierbij is dat mensen met lagere inkomens vaak in corporatie woningen wonen en hebben dus geen eigen dak waar ze eventueel zonnepanelen op zouden kunnen aanleggen. Bovendien hebben ze hier ook geen geld voor. Wellicht zouden wij als gemeente zijnde een zonnepanelenpark voor kunnen financieren en dat een deel van de opbrengsten dan weer terugvloeien naar de gemeente en een gedeelte naar die minima huishoudens. Dan heb je niet zozeer te maken met de smart grid, want je stemt niet echt vraag en aanbod op elkaar af. Het is meer waarde creëren voor de lagere inkomens, meer op sociaal gebied dus. Daar neigen wij nu toch meer naar. Wij werken samen met Enexis en Empuls. Zij hebben momenteel al meerder projecten lopen in andere delen van het land en ze hebben aangegeven dat ze wel input willen leveren, maar geen actieve rol gaan spelen.

Onderzoeker: Wat is volgens jou dé reden waarom smart grid tot dusver nog niet echt op grote schaal is geïmplementeerd?

Anne: Het is heel simpel eigenlijk omdat wij nog niet veel duurzame stroom hebben in Groningen. Ook projecten met het opslaan van energie is volgens energie bedrijven zoals Enexis nog helemaal niet nodig op dit moment. En als we kijken naar de wijken waar ik het net al over had. Een deel van die wijken wordt met warmtepompen verwarmd, dus elektrisch. Dat is wel een forse investering, wat op kan lopen tot 30.000 euro per woning. Het zijn ook alleen de nieuwere wijken waar wij die oplossing voor zien. Een tweede oplossing is warmtenet, waarbij een project in het noordwesten van de stad nu aan de gang is. Daar krijgen mensen warm water geleverd die in grote buizen onder de grond zitten. Het eerste idee was door geothermie, dus aardwarmte. Maar dat project is voorlopig 'on hold' gezet. Dat ging helaas niet door, dus nu is er een soort warmtekracht koppeling centrale gebouwd die deels nog op aardgas draait. Geothermie kon niet doorgaan doordat een partij al jarenlang aan tafel zat bij dat project en vlak voor het einde er toch gaven zij toch rood licht. Ze waren er bang voor dat ze last zouden hebben van het gasveld en daardoor kunnen aardbevingen ontstaan. Daar kan dan eventueel weer een juridisch gevecht met de NAM uit ontstaan en dat is niet wenselijk. In de toekomst kan het wel een oplossing zijn. Een andere oplossing waar we naar kijken is de restwarmte uit de Eemshaven bij Delfzijl. Daar is veel restwarmte tot wel 100.000 woningen en dat wordt nu gewoon geloosd. We zijn nu aan het testen of het haalbaar is om dat richting de stad te verplaatsen, hoewel daar ook haken en ogen aan zitten. Komend voorjaar weten we meer of dat door kan gaan. Een laatste oplossing is nog met hybride warmte pompen. Dat is eigenlijk een klein elektrisch warmtepompje naast je cv-ketel. Hierdoor gaat je gas verbruik naar beneden. Het gas wat je nog hebt zou je dan eventueel kunnen 'vergroenen'. Ook dit helaas maar beperkt. Dus je hebt allerlei opties maar ze hebben allemaal hun nadelen. Voor de nieuwbouwwijken is die all electric methode wel een goede optie. Het nadeel daar is weer dat die mensen rond hetzelfde tijdstip thuiskomen en dan tegelijkertijd die warmtepompen aangaan. De vraag hoe je die piekmomenten kan voorkomen stellen wij ook aan enexis, maar zij zeggen 'zo ver is het nog lang niet'. Zij willen het net verzwaren om alle pieken aan te kunnen. Wij hebben het zelf ook doorgerekend en voor iedere wijk in Groningen moet het net wel verzwaard worden. Dat komt niet zozeer door de toename van het aantal elektrische auto's, maar meer door het feit dat er zonnepanelen op de daken komen. De vraag is dan: Ga je het net verzwaren of ga je het tijdelijk opslaan?

Onderzoeker: Weet je meer over de ontwikkeling van de opslagpunten?

Anne: Daar weet ik niet zoveel van. Het nadeel van accu's is dat het seizoensgebonden is. 's Winters heb je die energie echt nodig en met name in de zomer wordt er veel opgewekt. In de stad worden zonnepanelen het belangrijkste, omdat er gewoonweg weinig ruimte is voor windenergie. Dan heb je in de zomer een overschot en in de winter een tekort. Technisch gezien is opslag wel mogelijk, maar financiel gezien is het niet aantrekkelijk. Je hoort tegenwoordig steeds vaker dat bepaalde sportverenigingen en boerderijen geen zonnepanelen meer op de daken mogen leggen. Dat is ook vrij logisch ook, want er ligt niet een heel zwaar net.

Onderzoeker: Dus je breekt eerder de straat open in plaats van het aanbrengen van een smart grid?

Anne: Dit is wel wat je steeds vaker hoort inderdaad. Het is waarschijnlijk financieel aantrekkelijker om het net 'gewoon' te verzwaren. Voor de gewone huishoudens heeft het ook bijna geen nut om energie op te gaan slaan. Op dit moment heb je nog de salderingsregeling. Dat betekent dat je maximaal zoveel gaat opwekken als dat je verbruikt. Het is nog niet precies wanneer het wordt afgeschaft omdat er nog geen goed alternatief is.

Onderzoeker: Wat zal er gaan gebeuren wanneer dit wordt afgeschaft?

Anne: Wat je hoopt is dat er een nieuwe regeling komt, een soort terug lever vergoeding. Nu kan je dus niet meer opwekken dan dat je verbruikt, maar eigenlijk wil je dat huishoudens gewoon per kilowattuur betaald krijgen en het dus niet uitmaakt hoeveel men opwekt. Hoe meer je opwekt, des te meer subsidie je ontvangt. Het moet financieel aantrekkelijker worden voor de huishoudens. Je hoopt dan wel dat mensen hun hele dak vol gaan leggen in plaats van net genoeg voor hun eigen verbruik. Dan zit je nog steeds dat je in de zomer veel opwekt en in de winter veel verbruikt. Je zou eigenlijk variabele tarieven moeten krijgen, niet alleen dag- en nachttarief.

Onderzoeker: Dat is iets wat de leveranciers tegenhouden denk ik? En waarom zijn die flexibele tarieven er nog niet?

Anne: Ja goede vraag, dat weet ik zo niet. Ik denk dat het nog niet echt dringend nodig is. Het maakt het ook een stuk ingewikkelder.

Onderzoeker: Hoe zie je het voor je wanneer Groningen aardgasloos wordt? Levert dat niet veel problemen op?

Anne: Ja in principe wel, in iedere wijk in de stad zal het net verzwaard moeten worden. Tenzij er in die tussentijd iets met smart grids en/ of opslag komt. Het is aan de netbeheerder wat ze vervolgens er mee doen. Zij kijken naar ons met de vraag: wat voor plannen heeft de gemeente met zonne-energie bijvoorbeeld. Ook op het gebied van gasloze wijken kijken ze naar ons en op basis daarvan maken zij plannen. Zoals het nu lijkt gaan zij dat gewoon verzwaren. Wij hopen wel dat ze ook naar slimme netten gaan kijken. Het kost de netbeheerder veel geld om in het verzwaren van netten te investeren, in principe kan je dat geld ook in smart grids investeren. Je neemt hiermee wel een groot risico uiteraard. Er zijn wel wat initatieven momenteel. Wij zijn nu met blokchain bezig en dat heeft niet zozeer met smart grid te maken. Maakt wellicht kan dat in de toekomst wel aan elkaar gekoppeld worden. Verder hebben we ook nog een Europees project lopen. Twee delen in de stad waar we energie positieve gebieden gaan oprichten. Daar komt dan de opslag en bijvoorbeeld de ICT bij kijken.

Onderzoeker: Een grootschalig project is er dus nog niet?

Anne: Niet dat ik weet.

Onderzoeker: Is het nog steeds het doel dat in 2020 7.3% van de energie duurzaam is?

Anne: Voorheen hadden we een masterplan, maar dat was een beetje vaag. Er was niet duidelijk en concreet wat er nog moest gebeuren. Vorig jaar is besloten om het niet energieneutraal te noemen, maar CO2-neutraal. Vanuit het rijk en Europa wordt er meer gefocust op CO2 reductie. En we weten ook dat als gemeente Groningen niet genoeg energie kunnen opwekken om aan de vraag te voldoen. Alle energie die straks verbruikt wordt, zal CO2 neutraal moeten zijn. Ongeveer $1/3^e$ deel zal van buitenaf moeten komen. Dat is allemaal per 2035. Dat is 15 jaar eerder dan het rijk het bijvoorbeeld wil. Dus qua regelgeving en subsidies zal dat wel lastig worden om dat te realiseren. Wij zijn momenteel al heel druk bezig in de wijken, maar we hebben helemaal nog geen middelen om iets te doen qua regelgeving.

Onderzoeker: Wat is dan de reden waarom jullie nu al begonnen zijn in de wijken?

Anne: Met name de grote gemeenten zijn er al jaren mee bezig en die willen ook sneller dan het rijk. Groningen is één van die gemeenten en al die grote gemeenten hebben geen zin om op het rijk te wachten. Het schiet niet op om achter over te gaan leunen.

Onderzoeker: Maar hoe groot acht je de kans dan dat het doel in 2035 gehaald gaat worden?

Anne: ik denk dat dat vrijwel onmogelijk is. Zoals ik net al zei moet 1/3e van de stroom van buitenaf komen en die stroom is nog niet CO2 neutraal. Dat gebeurt pas in 2050. Aan de andere kant, je kan nu ook niet terugkrabbelen en zeggen dat je 15 jaren later pas CO2 neutraal wil worden. Het is al aangepast, want het was eerst 2025. Maar ik vind het wel goed dat er een ambitieus plan op tafel ligt. Dan kan je als gemeente al aan de slag met innovaties. Daarnaast heb je hier belangrijke werkgevers zitten, zoals Gasunie en GasTerra. Die zijn veel bezig met projecten op waterstof etc.

Onderzoeker: Hoe is die samenwerking met andere partijen? Zoals Gasterra, TenneT, Enexis et cetera?

Anne: TenneT wat minder contact mee want die gaat over het hoogspanningsnet. Met Enexis hebben we wel behoorlijk veel contact. Sinds 2 a 3 jaar doen we veel projecten samen. Daarvoor liep het soms nogal wat moeizaam. Zij richtten zich meer op het netbeheer en dat was hun taak en keken niet zo ver vooruit. Nu denken ze wel meer met ons mee. Met name ook omdat er dus problemen bij Stadskanaal waren met het aanleggen van zonnepanelen. Wanneer een partij zegt dat er ergens een zonnepark aangelegd moet worden, dan móet Enexis dat ook doen. Die kosten zijn soms erg hoog en eigenlijk is het niet slim dat je voor miljoenen euro's een zonnepark aanlegt in een afgelegen gebied. Dat kost hun heel veel geld, dus je ziet dat ze nu vooraf meer mee willen denken. Enexis kijkt welke transformatoren en welke netten er nog genoeg ruimte is. Dat is de plek waar zij het liefst een zonnepark installeren. Gemeenten en provincies kijken meer landschappelijk, wat zijn de juiste gebieden. Daar zorgt soms voor wat tegenstrijdigheid. Je zag jarenlang dat de gemeenten en provincies daarin de leiding hadden. Nu levert het wat meer problemen op en wordt het belangrijker om met Enexis in gesprek te gaan. Dat is een samenwerking die wel wat verandert.

Onderzoeker: Hoe staat het momenteel met de slimme meters in de gemeente Groningen? In hoeverre staat het wantrouwen van mensen deze innovatie in de weg?

Anne: Dat durf ik zo niet te zeggen, maar ik denk dat het merendeel wel een slimme meter heeft. Behalve de mensen die geweigerd hebben natuurlijk. Het levert nu al soms problemen op want die ouderwetse 'terugdraaimeters' zijn niet altijd goed geijkt. Met name wanneer mensen met zonnepanelen energie opwekken, dan is er niet altijd bekend of ze te hard terugdraaien, of juist te traag. Op den duur denk ik dat die oude meters niet meer mogen en dat de slimme meters verplicht worden.

Onderzoeker: kan je mensen echt verplichten dan om een slimme meter te nemen?

Anne: Op dit moment nog niet. Ik verwacht wel dat dat wel gaat komen. Als die flexibele tarieven er gaan komen, dan denk ik wel dat die slimme meters verplicht worden. Wanneer we meer duurzame energie gaan krijgen dan zie je dat de prijzen gaan fluctueren. Daar kan je de vraag ook op aanpassen, juist door die flexibele tarieven te hanteren. Nu heb je alleen dag- en nachttarief. Als de zonnepanelen overdag hun energie opwekken, wil je dat mensen dan hun wasmachine aanzetten of hun auto gaan opladen. Dan kom je toch weer bij de smart grid uit. Je hebt daar minder verliezen en kan je het systeem goedkoper houden. In theorie zou dat kunnen, maar het hele energie net is nu anders ingericht en is het wel een lange weg daar naartoe. Uiteindelijk heb je die slimme meters wel nodig.

Appendix IV: Interview Han Slootweg – Enexis group

Han Slootweg – Enexis

Samenvatting

Han Slootweg is inmiddels ruim 15 jaar actief binnen Enexis. In de beginjaren was hij actief als manager innovatie, waarbij hij samen met kennisinstituten en toeleveranciers aan de ontwikkeling van productontwikkeling heeft gewerkt. Sinds 2 jaar is hij directeur asset management en is hij eindverantwoordelijk voor verschillende vormen van asset management. Daarnaast is hij deeltijd hoogleraar aan de TU in Eindhoven. Hier geeft hij één dag per week college over de onderwerpen smart grid en hoogspanningsnetten en begeleidt hij daarnaast meerdere promovendi.

Onderzoeker: Wat is de reden waarom er op dit moment nog geen smart grid project is op nationale schaal?

Han: Die is er in toenemende mate wel. Smart grids kan je fundamenteel onderscheiden in intelligentie waar de klant bij betrokken is. Hierbij kan je denken aan dynamisch beprijzen, de aansturing van oplaadgedrag van de elektrische auto etc. De andere kant op is de smart grid die je voor de netbeheerder inricht. Die vorm van smart grid is Enexis ontzettend hard aan het uitrollen op dit moment. Hier zijn wij al jaren mee bezig en hier boeken wij ook daadwerkelijk successen resultaten mee.

Onderzoeker: Jullie zijn momenteel bezig met het installeren van slimme meters in heel Nederland toch?

Han: Dat is inderdaad nog een tweede waar we mee bezig zijn binnen smart grids. De smart grid variant waarbij het voornamelijk de netbeheerder zelf is, die loopt al volop. De variant waar de klant ook bij betrokken is, loopt wat minder hard. Je hebt bijvoorbeeld wel de Toon van Eneco, dat gaat een beetje die richting op. Je ziet tegenwoordig ook steeds vaker dat bewoners van huizen met een slimme meter en een beperkte capaciteit, een oplaadpunt op de oprit staat. Daarbij wordt er via de slimme meter bewaakt dat de elektrische auto niet heel veel gaat trekken, terwijl ze ook andere apparaten aan hebben staan op dat moment. Dan zou de hoofdschakelaar eruit vliegen.

Onderzoeker: Ik las in een artikel op het internet dat de wetgeving de ontwikkeling van smart grid in de weg staat. Hoe gaat dat in z'n werk?

Han: Als je vanuit de netbeheerder bekijkt en zij willen een ander tarief gaan heffen, dat mag nu niet volgens de wet. Elke klant betaalt hetzelfde en dat maakt dus niet uit of ze in een Tesla rijden of een warmtepomp hebben. Als dat de wet is, dan heb je verder weinig intelligentie nodig. Een tweede punt is dat je een dynamisch tarief zou willen. Eneco werkt daar al mee met experimentele pilots. Die dynamische tarieven van de levering zie je wel langzaam op gang komen.

Onderzoeker: De leveranciers houden in principe die flexibele prijzen tegen toch?

Han: Ja het is een beetje hetzelfde als de hypotheekrente. Sommige mensen nemen 30 jaar vaste rente en zijn van elke onzekerheid en risico af. De bank hangt daar natuurlijk wel een prijskaartje aan. Daarom is de rente bij 30 jaar hoger dan bij een variabele rente. Omgekeerd heb je ook mensen die de gok durven te nemen en maakt de bank minder winst op hen. Binnen de energie sector is dat eigenlijk net zo. Sommige partijen vinden toegevoegde waarde in het stabiliseren van die prijs op lange termijn en daar verdien ik een hoop geld mee. Andere partijen kopen een computer, zij kopen in en verkopen door en heffen daarop 7.15 euro administratiekosten en verder niks.

Onderzoeker: Als je die flexibele prijzen introduceert, wat nu dus al op kleine schaal plaatsvindt, dan heb je al een aanzienlijk deel van de piekmomenten gereduceerd toch?

Han: Dat helpt natuurlijk wel. De netbeheerder heeft een ander doel dan de commerciële leverancier bijvoorbeeld. Stel: het waait hard op de Noordzee 's nachts, dan wil de leverancier alle Tesla's volladen met energie. Maar als die Tesla's toevallig in één straat staan, dan komt de het net in die straat rokend uit de grond omdat ie daar niet op berekend is. Dat maakt de situatie in Nederland nogal anders dan bijvoorbeeld in Frankrijk of Duitsland.

Onderzoeker: Wat is de reden waarom jullie als Enexis zijnde vele wegen nog openbreken en het net verzwaren.

Han: Op het moment dat wij die smart grids meer invoeren, kunnen we dat natuurlijk beperken. Als je nog oude netten hebt die vervolgens veel gebruikt worden, dan red je dat niet alleen met slimmigheid. Met slimmigheid kan je ongeveer 20/25% meer uit je net persen, maar als je bijvoorbeeld 50% nodig hebt dan red je het dus niet met alleen smart grid. Je kunt bestaande netten en eventueel de uitbreiding ervan, effectiever gebruiken. Dat bespaart tijd, geld, overlast voor de burger en heeft dus allerlei voordelen. Maar het is natuurlijk niet zo dat door het aansluiten van slimme apparaten Nederland gelijk duurzaam is en wij niks meer hoeven te doen.

Onderzoeker: Hoe lijkt het met de techniek van de smart grids op dit moment?

Han: Dat gaat ook goed. Wij hebben zelf twee soorten smart grid; de 'plus variant' en de 'light variant'. Die zijn tegenwoordig relatief goedkoop. Ongeveer 15 jaar geleden zei iedereen dat die distributieautomatisering of slimmigheid in de midden- en laagspanningsnetten gaat er nooit komen. Dat is veel te duur en gaat om enorme aantallen. In de hoogspanningsnetten kon het al jarenlang uit. Inmiddels is die techniek zo goedkoop geworden dat de toegevoegde waarde ruimschoots opweegt tegen de extra kosten. Eerst zijn we begonnen met het uitrollen van de plus variant en dat komt in ongeveer 10% van het middenspannings net te hangen. Dat komt neer op 7000 a 8000 stuks. Een aantal jaren daar achteraan hebben we ook de light variant ontwikkelt samen met de toeleverancier en uiteindelijk hangen wij die in alle middenspannings ruimtes op. In combinatie met de slimme meter, die ook maar een paar honderd euro per stuk kost, hebben wij enorm zicht op wat er in ons net gebeurt. In potentie kunnen wij dan flexibel tariferen gewoon doen, omdat het fundament is gelegd.

Onderzoeker: Hoe staat het met de energie opslag op dit moment?

Han: Dat gaat ook steeds beter. Daar heb je ook weer te maken met de wet. De netbeheerder mag dat namelijk niet doen omdat het beïnvloeding van de markt is. Dat zal eerder bij klanten komen die dat ook kunnen gebruiken richting de netbeheerder. Het tweede is de afschaffing van de salderingsregeling, want dan kan je binnen een paar maanden de powerwalls bij de Ikea kopen bij wijze van spreken. In Duitsland is dat al gebeurd en hier zal dat ook gaan gebeuren. Daar is de salderingsregeling aan zijn eigen succes ten onder gegaan. Dus wij denken dat de powerwalls hier dan ook veel meer gebruikt zal gaan worden. Daarbij worden verstandige prikkels (financieel/ technisch) van de powerwall ingezet om het net te benutten en de investeringen daarin te beperken.

Onderzoeker: worden die financiële prikkels nu al gebruikt?

Han: Nee, nu nog niet. Alleen bij grote klanten gebruiken wij financiële prikkels. De kleine gebruikers kunnen gewoon doen waar ze zin in hebben en dat is natuurlijk niet een model waar veel intelligentie bij komt kijken.

Onderzoeker: En dat zal veranderen wanneer de saldering regeling wordt afgeschaft?

Han: Niet per se voor de netbeheerder. Als de salderingsregeling wordt afgeschaft kunnen ook de opslagsystemen voor de netbeheerder nuttig gemaakt kunnen worden. Dat zal dan wel moeten worden geregeld en gaat niet vanzelf. Als iedereen een powerwall koopt en ons tarief blijft hetzelfde, dan zal de klant wel wat doen met de powerwall ten behoeve van de netbeheerder want anders schieten zij er niks mee op. Dat wil niet zeggen dat niet kan. Dat zal wel tot de nodige politiekmaatschappelijke discussies leiden. Wanneer de straten opgebroken moeten worden en de tarieven gaan omhoog, dan komt die discussie voor het inzetten van de powerwalls vanzelf op gang.

Onderzoeker: Wat denkt u dat de rol van blockchaintechnologie binnen smart grid gaat spelen?

Han: Daar heb ik eerlijk gezegd niet heel veel kijk op. Ik ben meer betrokken binnen de hardware. Als je al deze geavanceerde handelingen in de praktijk wilt laten werken, dan is het belangrijk dat de juiste signalen naar de juiste plekken gaan, gevolgd door de juiste berekeningen. Men zegt dat blockchain daar een belangrijke rol in kan gaan spelen en dat geloof ik eerlijk gezegd wel. Ik houd mij meer bezig met de vraag welke informatie er dan heen en weer moet en hoe die prikkels er dan uit zouden moeten zien. Of je dat dan implementeert met blockchain of e-mail, dat maakt dan niet zoveel uit.

Onderzoeker: Wat voor informatie zou er dan volgens uitgewisseld moeten worden.

Han: Stel: ik zet mijn Tesla neer ’s avonds thuis, dan stel ik de vraag of ik nog weg moet diezelfde avond. Als dat het geval is dan zal ik gewoon mijn auto op moeten laden en dan krijg ik daar de rekening voor. Als je pas de volgende ochtend je auto pas weer gebruikt, dan heb je een heel ander soort flexibiliteit bij het opladen van die Tesla. Datzelfde geldt ook voor het gebruiken van een wasmachine. Al dat soort informatie, plus de rekeningen die daar dan bij horen naar aanleiding van de dynamische prijzen, moet ingespeeld op worden. Dat gebeurt nu nog niet.

Onderzoeker: Er zijn nu nog mensen die weigeren om een slimme meter te nemen. Denkt u dat dit op termijn een soort van verplicht wordt?

Han: Meestal werkt dat pushen niet zo. Mensen die nu nog een ‘domme’ meter hebben en daardoor niet op een geavanceerde manier kunnen worden behandeld. Dan moet je er wel voor zorgen dat zij de rekening daar te zien van krijgen. Als ik niet scherp afgerekend kan worden op mijn feitelijke gedrag omdat ik een slimme meter weiger, dan moet je daar uiteraard de vrijheid voor hebben. Je wordt echter wel in de worst-case ingeschat. De aanname is dan namelijk niet dat jij je heel systeemvriendelijk gedraagt. Dan krijg je daarom de worst-case rekening gepresenteerd.

Onderzoeker: Dan spelen de financiële prikkels eigenlijk al een rol toch?

Han: bij het huidige systeem heeft het niet direct heel veel zin om een slimme meter te nemen. Voor de netbeheerder heeft het sowieso nog niet zoveel zin. En als jij niet geïnteresseerd bent in de variabele prijzen van Easy Energy, dan heeft het vanuit dat perspectief ook niet zoveel zin. Het heeft ook geen zin als je zelf geen behoefte hebt aan de overzichten en trendlijnen die de commerciële leveranciers naar je toesturen.

Onderzoeker: Het is voor Enexis zijnde toch wel fijn als zo veel mogelijk bewoners een slimme meter hebben in een straat?

Han: Het is voor ons handig dat we dan geen meter opnemers meer op hoeven sturen, want dat kost ons geld. De klanten betalen dat met zijn allen. Dus als jouw buurman geen slimme meter heeft en wij moeten daar een werknemer naar toe sturen om de meter op te nemen, dan betaal jij daar zelf aan mee ondanks dat je een slimme meter hebt. Ook als wij een dekkingsgraad van 70/80% hebben, komen wij ook al een heel eind. Wij hoeven niet ieder huis individueel te bemeten om er goed zicht op te hebben op wat er binnen ons netwerk gebeurt. Afgezien van de kosten van de meteropnemer, zit ik er als netbeheerder niet heel erg mee als 5/10% die slimme meter weigert. Dat belemmert mij niet in het benutten van die slimme meter.

Onderzoeker: Kunt u misschien vertellen op welke wijze congestie management momenteel een rol speelt?

Han: Dat werkt niet echt. Tennet werkt daarmee, maar je kan het in de distributie heel moeilijk toepassen. Liander doet er wat mee in Nijmegen. Alleen het probleem is dat je een soort van balans tussen vraag en aanbod hebt. In Drenthe hebben wij momenteel aanvragen voor zonnepanelen en windparken die meer dan 5 keer hoger zijn dan de maximale piek in die regio. Daar heeft congestie management natuurlijk helemaal geen zin. Dus er zit een begin aan congestie management, maar ook zeker een eind. Een tweede probleem, als je kijkt binnen de distributie netten gaat kijken, dan heb je vaak maar weinig partijen die uiteindelijk leverage hebben op een congestie in het net. Bij Tennet zijn dat hele grote regio's. Dus het gaat om het aantal klanten. Een straat is niet te vergelijken met een hele provincie. Ik heb er beetje mijn twijfels bij, maar we moeten het zeker proberen. Het is alleen niet zo simpel, als je congestie management invoert dan is alles opgelost. Zo werkt het ten slotte niet.

Onderzoeker: Kan de overheid niet meer invloed uitoefenen op het installeren van energie opslag punten? Of gebeurt dat nu al?

Han: Nee, niet echt. Het systeem zit nu best krom in elkaar. Degene die nu voor het minste geld zonnepanelen of windmolens kan kopen en plaatsen, diegene krijgt de subsidie. Het probleem wat je dan krijgt is dat je juist in de gebieden waar veel plaats en grond is, daar wil iedereen gaan zitten. Dat is ons probleem nu ook in Groningen en Drenthe omdat daar veel grond en ruimte is. Vervolgens plaats je dan zo'n park en zit het net vol, dat werkt dus niet. Het bizarre is dat je nog steeds subsidies aan kan vragen, ook al zit het net al vol. Terwijl het van te voren al helder is dat je de komende 3 a 5 jaar het net niet opkomt. Dat zou je eventueel kunnen oplossen door te zeggen dat ze er een opslagsysteem bijplaatsen. Zo'n opslagsysteem is momenteel niet rendabel dus dan heb je een hogere subsidie nodig. Als jij je dan inschrijft voor een hoger subsidie bedrag, dan zegt de overheid dat de subsidie te hoog is en dat iemand anders met een lagere aanvraag de subsidie krijgt.

Onderzoeker: Dus het probleem zit dus in de subsidie regeling?

Han: Ja, dat zit in die toekenningsgronden. Die houden geen rekening met de situatie van de netbeheerder. Daar heb ik al redelijk vaak met economische zaken over gesproken, maar zij hebben geen zin om de wet te wijzigen en het duurt te lang.

Onderzoeker: Als u realistisch bekijkt, hoe zal de ontwikkeling de komende 10 a 15 jaren eruit zien?

Han: Dat zal gewoon doorgaan zoals het nu gaat denk ik. We krijgen andere tarieven voor levering met de bijbehorende management systemen achteraan. We krijgen een ander tarief voor het netbeheer en dat schuiven we ook het home net systeem in. Al die dingen gaan er gewoon komen en dat ontwikkelt zich vanzelf door. Dat zal niet op korte termijn gaan. Ten eerste gaan alle technieken lang mee en ten tweede is alles ontzettend duur. Ten derde zit er een heel wettelijk bouwwerk omheen dat ook traag is.

Onderzoeker: Dus het verzwaren van de kabels is het meeste kosteneffectief op dit moment?

Han: Die afweging kan je op dit moment niet echt maken. Op dit moment is het aanbrengen van een dikke kabel de enige oplossing. Zolang wij niet anders kunnen, leggen we gewoon dikkere kabels aan.