The influence of Smart Grids on the Dutch electricity distribution

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08-09-2015

Masterthesis

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1.Introduction

The Dutch society is currently facing some trends with regard to electricity which could lead to challenges in the demand and supply of electricity. Goals of the European Union (EU) envision a 90 percent reduction of the CO2 emission by 2050. An important way of reaching this goals is to use more renewable resources, according to the EU. It is the Netherlands' task to make sure that 14 percent of their energy consumption is generated from renewable resources by 2020, as set out in directive 2009/28/EG. This should be even 16 percent by 2023 (SER, 2013). Using an increasing amount of renewable resources such as sun and wind leads to challenges in the electricity supply. Generating electricity from renewable resources leads to a less stable supply of electricity (G. Verbong, Beemsterboer, & Sengers, 2013). This is called the intermittency of renewable resources which means that they are not always able to supply when we need it. Currently we are used to get electricity when we demand it, but sustainable resources are unable to fulfil that need. Renewable resources such as wind and sun supply when they are able to, this is not necessarily the moment we need the electricity. The introduction of new loads such as electrical vehicles and heat pumps and a further electrification of energy consumption are envisioned (G. Verbong et al., 2013). This increased electrification could also lead to challenges in the electricity demand.

The Smart Grids Innovation could be a solution for both the challenges in the demand and supply of electricity and enable the trends with regard to electricity. Smart Grids can be used to control the intermittency of renewable resources and to modify the discrepancy between supply of the renewable resources and the demand of the consumers (G. Verbong et al., 2013). This way the Smart Grid enables the trend and vision of the EU to use more renewable resources. Smart Grids could also be useful for future goals and trends at the demand side of electricity. Smart Grids can enable the use of new loads such as electrical vehicles and head pumps and the Smart Grids can facilitate this envisioned increased electrification of energy consumption (G. Verbong et al., 2013).

The concept of Smart Grids needs some clarification. Many different definitions exist and many aspects of the Smart Grids are still unclear. We will elaborate on this in the second chapter, but we decided to conceptualize the Smart Grid on our own way by not only taking into account the technical aspects, but also the organizational aspects and the goals of the innovation. When trying to explain the concept to people who never heard of it before, one could explain it as a technical system full of ICT tools and other technology that enables us to use the energy produced by the solar panels of our neighbour directly. This is a very simple definition that does not cover all the aspects of smart grid. We encounter Smart Grids as a vision to create an intelligent grid which can cope with current and future challenges and trends. It is an integrated set of technologies which changes the organization of the grids. Chapter two further explains how we conceptualized the concept of Smart Grids.

We are mainly interested in the organizational changes which the Smart Grids brings about and how this affects the netoperator. The term netoperator is a complicated. In the Netherlands a netoperator can be either the regional or the national netoperator. The national netoperator is responsible for the transmission of the electricity, while the regional operator is responsible for distributing the electricity to the consumers in their assigned region. Based on article 2.4 and 2.6 of the Electricity Directive 2009/72/EC the tasks are divided along the voltage lines: the high voltage grid is operated by the Transmission System Operators (TSO's) and the middle and low voltage grid is operated by the Distribution System Operators (DSO's). Applying this to the Dutch case, the national netoperator is the TSO. Nevertheless, the Dutch regional netoperators cannot be called DSO's (yet). In the Netherlands the regional netoperators are currently only responsible for the net, not for the system. That is why they have to be called Distribution Net Operators(DNO's). However, this is specific for the Netherlands. In international academic literature, they always refer to DSO's instead of regional netoperators. In order to ensure the international understanding, we therefore chose to also refer to DSO's.

In 2011 the government of the Netherlands already stated that the implementation of smart grids is necessary in order to benefit optimally from sustainable energy (energie akkoord, 2013). With an eye on the development of smart grids, the Dutch government has made available 22.5 million euro for pilot projects of smart grids (Energy Report, 2011). This seems like the government is convinced that the future includes inevitably a Smart Grid. The DSO's are also actively engaging in pilot projects with regard to Smart Grids.

Our focus will be on the DSO. The role of network operators is quite complex because of their legal position and the enormous investments required in grid innovation (Steenhuisen & De Bruijne, 2014). In 2011 the Dutch government introduced a new statutory procedure for investments in the infrastructure which are needed for smart grids. This procedure makes it obligatory for the DSO's to report their investments in the infrastructure to the Autoriteit Consument en Markt (ACM). The ACM has to determine whether the investment is needed and whether it is allowed to raise the tariffs as a result of the investments (Energy Report, 2011). Due to these formal requirements, the DSO's face several dilemma's. Smart grids can be regarded as part of energy transition. On the one hand they are supposed to facilitate the energy transition with huge investments, but actually cannot made adequate independent decisions. On the other hand their role in the energy transition is not clearly defined in the law (Steenhuisen & De Bruijne, 2014). In sum, the DSO is in an uncertain position due to dependencies and vaguely specified formal responsibilities. As mentioned above, they are dependent on the regulator and the government while ensuring the stability of the grid.

This complicated position makes us interested in the DSO. Currently the main task of the DSO is to distribute the electricity to the consumer, but will this still be the main task of the DSO when the conventional grid has been transformed into a Smart Grid? The Smart Grid changes the organization of the grid. Will distributing the electricity still be the main tasks of the DSO after the organization of the grid has been changed due to the Smart Grid? And what does it mean for the position of the DSO? Currently the position of the DSO is described and protected by the electricity law, but what will the position of the DSO be in case of the Smart Grid?

We are also interested in the changes in the interaction of the DSO with other actors. As mentioned in the previous paragraph, the DSO depends on the government and the regulator. Will the DSO still be dependent on them when the Smart Grid is implemented? Furthermore, the Smart Grid enables the consumer to produce electricity, instead of only consuming it. How will this influence the interaction between the two? Therefore, we chose the government, the regulator and the consumer as point of focus.

The government: We will both looking mainly at the Dutch national government, but also at the local government. The national government decides by writing policies and the electricity law what the DSO is supposed to do. Will this interaction remain the same after the Smart Grid has been introduced?
The regulator: The Dutch regulator is called Autoriteit Consument en Markt(ACM). The regulator is responsible for monitoring the activities of the DSO.
Consumer: Currently there is not much interaction between the consumer and the regulator. The DSO connects the consumer to the grid and distributes the electricity to the consumer. The Smart Grid enables the consumer to also produce electricity. How will this affect the interaction between the consumer and the DSO?

1.2 Problem statement

This introduction can be summarized into the following problem statement: The Smart Grid innovation changes the organization of the grid, but what does this mean for the tasks, position and interaction of the DSO?

1.3 Research objective

Our research objective is to contribute to the knowledge about how the Smart Grid innovation affect the position, tasks and interactions of the DSO. When this is known, the DSO and policymaker can anticipate on this.

1.4 Research questions

Central research question:

Does the Smart Grid innovation change the position and tasks of the DSO in the management of the electricity grid and the relationship with the regulator, consumer and government and if yes in what way?

Subquestions:

Which rules do currently structure the interaction between the DSO and the regulator, consumer and government within the conventional electricity grid and which currently determine the position and tasks of the DSO?

Which rules will structure the interaction between the DSO and the regulator, consumer and government within the Smart Grid context and which rules determine the position and tasks of the DSO within the Smart Grids context?

1.5 Theoretical framework

This research focusses on the management of conventional and smart electricity grids as an action situation as conceptualized by Elinor Ostrom's Institutional and Development Framework (IAD Framework). The theory is used as a lens on the changing setting of grid management due to smart grid innovation. The IAD Framework is suitable for the purposes of this research because it conceives an action situation as an institutional setting. With the help of the IAD framework we can define the conventional and the smart grid as an institutional setting, which allows us to analyse changes in the setting and how this will affect the position, tasks, and interactions of the DSO in the management of the grid. Ostrom conceptualizes the action situation as " a social space where individuals interact, exchange goods and services, solve problems, dominate one another, or fight" (Ostrom, 2011, p 11). For our research the action situation is of particular interest. The institutional rules suggested by Ostrom will be used for this research..

1.6 Methodology

Our methodology consists of both literature research and interviews to describe the rule based setting of the grid management under the conventional and the Smart Grid in order to answer our main research question. Our research design can be described as an embedded case study. Each case study consist of a DSO and its management in the electricity grid. The literature study will be used on the one hand to describe the external variables of the action situation as described by Ostrom. On the other hand, the literature study will be used to prepare the interviews by studying company's websites and literature on the DSO and Smart Grids.

The interviews will be used to fill out the action situation as part of the IAD framework. We will interview six of the eight DSO's in the Netherlands. All of them are involved in the ongoing pilots on smart grids. The people who will be interviewed are the ones who are responsible for innovation within the DSO. They will be either the asset manager or the manager Innovation. We will choose them because innovation is their field of expertise. The questions will address the position and task of the DSO as well as their interactions under condition of the conventional and the smart grid. The interviews, combined with company documents, will be used to fine tune our analysis of the institutional settings. Finally we will complete our analysis and will conclude on the implications of smart grid innovation on the position, tasks, interactions of the DSO.

1.7 Structure of the thesis

The second chapter will set out how we conceptualized the Smart Grid. In the third chapter, the IAD framework is explained. We elaborate on how we are going to use the framework and how we positioned it. The fourth chapter sets out our methodology. The fifth chapter provides the analysis based on the collected data.

2.The concept of Smart Grids

2.1 Introduction

The development of Smart Grids is ongoing. Many governments are willing to implement it in their country, but what does a smart grid actually contain? Many different definitions of the smart grids exist. Governmental institutions, the energy sector and academia have shed their light on smart grids. An example from the energy sector is the smart grids roadmap developed by Netbeheer Nederland, an organ representing the largest DSO's in the Netherlands (Netbeheer Nederland, 2012). The Dutch ministry of economic affairs has described Smart Grids as a necessity to benefit optimally from sustainable resources (Energieakkoord, 2013). Everyone defines it in their own way. Most of the definitions have a technical focus (for example: (Blumsack & Fernandez, 2012); (R. E. Brown, 2008); (Roncero, 2008)), while some definitions also take the organisational and economical aspects into account (for example: (Wolsink, 2012); (Mah, van der Vleuten, Hills, & Tao, 2012)). As Hledik describes " Smart Grid means many things to many people"(Hledik, 2009, p.30). When trying to explain the concept to people who never heard of it before, one could explain it as a technical system full of ICT tools and other technology that enables us to use the energy produced by the solar panels of our neighbour directly. This is a very simple definition that does not cover all the aspects of smart grid. To make it a bit more confusing: different terms exist for smart grids such as smart power grid, Future Grid and Intelligent grid (Hassan & Radman, 2010).

It is a difficult task to make a complete conceptualization of Smart Grids, because many aspects surrounding the grid are unsure. In the first place, it is unsure how the smart grid technology will develop. A lot of research is done on the smart grid technologies and it is still developing. This technology determines the feasibility and the impact of smart grids. Since this is still unknown, it is also hard to determine the boundaries of the smart grid. Secondly, it is still to some extent unsure what the impact of the smart grid technology on the organization of the grid is. This is an issue for our research because we focus on the role of the DSO in the organization of the grid. Moreover, some of the technologies have been discovered related to smart grid are not commercially available yet (Hledik, 2009). Lastly, it is unsure how the Smart Grid will be implemented. Different scenarios are possible. A smart grid can be built from scratch, but another option is to modify the existing grid into a smart grid (Hassan & Radman, 2010). A smart grid can be locally, regionally, nationally of globally implemented.

We have to tackle those uncertainties in order to make a complete conceptualization of Smart Grids that is workable for our research. Since our research focusses on the governance part of Smart Grids, we think that a conceptualization of Smart Grids based on the technology only is insufficient. This chapter will be structured in the following way. First, we will discuss different kinds of conceptualizations of Smart Grids and we will explain which aspects are missing according to us.

Furthermore, we will give an overview of the main characteristics. Lastly, we apply the concept to our research by making decisions on it scope and degree of implementation.

2.2 Technological aspects

As already mentioned many conceptualizations of Smart Grids have a technological focus (for example: (Blumsack & Fernandez, 2012; R. E. Brown, 2008; Roncero, 2008). This makes sense because smart technology is essential for the Smart Grid. It is not based on one kind of technology, but rather an integration of different sets of technologies. Roncero distinguished the following: 1) Integrated communications across the grid, 2) advanced control methods, 3) sensing, metering and measurement, 4) advanced grid components, 5) decision support and human interfaces (Roncero, 2008, p. 2). This technology is responsible for making the 'dumb' grid a smart grid, or the so called smartening of the grid. An example of a very simple definition with a technological focus is "Smart Grid is simply the application of modern communications infrastructure to various segments of the electricity grid"(Blumsack, 2011, p. 62). One of the reasons why this definition is incomplete, is because it does not explain what the purpose of those technologies is.

We see the Smart Grid as an enabler of current trends and future goals in the consumption, generation and distribution of electricity. It can also be an enabler of governmental policy on energy and environment (Scott, Vaessen, & Verheij, 2008). Firstly, the Smart Grid enables current trends and goals related to electricity. It is a response to ongoing trends in the electricity sector. The European Union(EU) set the goals to reduce the CO2 emission by 90 percent by 2050. According to the EU, using more renewable resources is an important step in order to reach this 90 percent reduction. The Netherlands has the task to make sure that 14 percent of their energy consumption comes from renewable resources by 2020, according to directive 2009/28/EG. This should be even 16 percent by 2023 (SER, 2013). This goal to use an increasing amount of renewable resources leads to some challenges in the electricity supply. The use of renewable resources such as sun and wind lead to a less stable supply of electricity (G. Verbong et al., 2013). This is called the intermittency of natural resources which means that they are not always available. Currently we are used to get electricity when we demand it, but sustainable resources are unable to fulfil that need. Renewable resources such as wind and sun supply when they are able to, this is not necessarily the moment we need the electricity. Smart Grids are used to control this intermittency and to modify the discrepancy between supply of the renewable resources and the demand of the consumers (G. Verbong et al., 2013). Smart Grids could also be useful for future goals and trends at the demand side of electricity. Due to the introduction of new load such as electrical vehicles and heat pumps and a further electrification of energy consumption are envisioned (G. Verbong et al., 2013). Smart grids can be used to enable the use of those new loads and the further electrification of the energy demand.

In general, the goals that the smart grid have to meet is to generate and to distribute electricity more effectively, economically, securely, and sustainably. The grid has to become a "smart" grid, in order to facilitate or handle this (Molderink, 2011). So the purpose of the Smart Grid is to meet those future and current trends and goals.

The following description of Smart Grids is one that both takes into account the smart grid technology and the purpose of the technology. " A Smart Grid generates and distributes electricity more effectively, economically, securely, and sustainably. It integrates innovative tools and technologies, products and services, from generation, transmission and distribution all the way to customer appliances and equipment using advanced sensing, communication, and control technologies. It enables a two-way exchange with customers, providing greater information and choice, power export capability, demand participation and enhanced energy efficiency" (Scott et al., 2008, p.8).

The previous definition needs some clarification. The beginning of the definition refers to the purposes of the smart grid which already have been discussed in the previous paragraph. To generate and distribute electricity more effectively means that costs will be controlled, the distribution and transmission costs will be kept minimal and the electricity is produced efficiently (National Energy Technology Laboratory, 2009) To generate and distribute electricity more economically means that the grid leads to fair prices and sufficient supplies (National Energy Technology Laboratory, 2009). To generate and distribute electricity securely means that no one is harmed, that it can resist physical and cyber-attacks, and recovers from disturbances(National Energy Technology Laboratory, 2009). To generate and distribute electricity more sustainably means that the grid enables a larger inclusion of renewables sources than before (National Energy Technology Laboratory, 2009).

The last part of the definition refers to the tools and functionalities regarding communication, sensing, monitoring and control. The smart meter and Demand Side Management are important aspects of the Smart Grid. Demand Side Management means that the load during peaks is transferred to periods during which the demand is low (G. Verbong et al., 2013). This is where the smart meter comes in. The meters are important nodes in the grid which function as hubs for data flows. They monitor the supply, demand, distribution and storage. The data that the smart meter sends between the users and the network is used to balance it (G. Verbong et al., 2013). The data which is provided by the meter is used to make sure that the demand follows supply, while also taking into account the storage capacity. At the same time, this is matched with the usual load pattern of the equipment which demands electricity (Wolsink, 2012). The introduction of electrical vehicles to the grid could serve as local storage option. The vehicles would be charged with electricity from renewable resources. This can be done when the energy of the sun of the wind is available. Moreover, the vehicles could be used as local storage of electricity which would improve the ability to incorporate renewable resources

(Wolsink, 2012). Those tools and functionalities enable the use of renewable resources and makes the distribution of electricity more efficient.

In sum, the smart grid enables the integration of different technologies to meet the current trends of more distributed generation of sources with an intermittent character and the goals of generating and distributing electricity more effectively, economically, securely and sustainably.

2.3 Organizational aspects

Although the previous section covers how and for what purpose the smart grid technology is used, there are still some aspects missing. Since our research focuses on the role of the DSO, the organizational aspects need to be part of the conceptualization.

Firstly, the inclusion of sustainable resources leads to a different way of organizing the grid. The current grid is based on more centrally organized generation of electricity, combined with a number of diverse and decentral sources. When electricity is based on renewable resources for the generation of electricity, the organization of the grid changes. The amount and diversity of decentral sources will increase further. The electricity will be generated from different sources such as solar panels and windmills which lead to an even more distributed generation, instead of the current centralised generation with a limited number of decentral resources (Scott et al., 2008).

Secondly, Smart grids creates a change from an one directional to two directional system(Delft, 2012). The ICT technologies enables the bidirectional flows between the consumers and producers of electricity. Those flows concern electricity, but also the flow of information. Through smart meters which function as hubs of data, information is exchanged between the consumers and producers which helps to make sure that the demand and supply of electricity are matched.

Thirdly, the tools and functionalities such as the smart meter and Demand Side Management change the whole system of generation, transmission and distribution from a mainly demand driven system into a mainly supply driven system. The system as we know it now, is mainly focussed on supplying electricity when we demand it. Smart grids is mainly focussing on making sure that the demand follows the supply in order to match the two (G. Verbong et al., 2013).

Fourthly, the ability to transfer the electricity generated by sustainable resources to the grid or to another consumer, changes the position of the consumer. The consumer is in the context of the conventional grid a passive actor who depends on other actors to get electricity. This changes when the grid becomes a smart grid, because it enables the consumer to produce electricity and give this electricity back to the grid. The consumer has the ability to become a producer (or a so called prosumer) (Molderink, 2011).

Fifthly, new business opportunities can become available because the smart grid enables the inclusion of local, distributed, renewable electricity resources. Those business opportunities are related to the generation of electricity. This generation could for example take place at the household level, when someone has solar panels and transfer this back to the grid. It could also take place at a larger scale, when someone for example has a larger collection of solar panels and produces more electricity than one household. The business models can also consist of a aggregation of smart technologies. A household can have an electrical vehicle, apply active demand response and solar panels (Ruester, 2014).

Lastly, changes in policies of the government are needed for the introduction, but also for the maintenance of the smart grid. In order to make the introduction of Smart Grids possible, the policies of the national government have to be changed in such a way that they incentivize the actors of the electricity grid to change their behaviour towards a working smart grid. An example of a barrier for the development of a smart grids are the high investment costs(Brown & Zhou, 2013). The national government could help to lower this barrier by determining policies in which investment cost are for example subsidized or make sure that the costs are covered by higher charges. There are many more barriers for the deployment of smart grids and many more sorts of policies that can be used to overcome this, but this will be elaborated in the following chapter. On the other hand, policies have to be changed in order maintain a well-functioning smart electricity grid. An example of this are the regulatory policies on the cooperation and differentiation between the DSO and the TSO (Brown & Zhou, 2013). This is likely to change when the smart grids are introduced and therefore this needs to be reflected in national policy. More of such changes are needed, but this will be explained in a following chapter.

Shortly, the organization of the grid changes due to an increase in the number and diversity of decentral sources of electricity. The system shifts from one directional to two directional, from mainly demand driven to mainly supply driven. The position of the consumer changes from passive to active. New business models will become possible and policies need to be changed. How this influences the other actors that are part of the organization of the grid is still not completely known. In our research we will focus on how this changing way of organizing the grid influences the role of the DSO.

2.4 The vision

Besides this uncertainty on how the changing way of organizing the grid affects the other actors, we also discussed the uncertainties on the development, the implementation and the impact of the smart grid technology. Therefore, we prefer to conceptualize smart grid as a vision defined by goals for the future. “The Smart Grid vision generally describes a power system that is more intelligent, more decentralized and resilient, more controllable, and better protected than today’s grid” (National Energy Technology Laboratory, 2009, p.12) as described by National Energy Technology Laboratory for the US government. This definition shows that a smart grid is a vision to create a smarter and advanced grid that can cope with current and future problems and needs. By conceptualizing smart grid as a vision, we do not see it as a simple thing consisting of different technologies. This way we can avoid the discussed uncertainties. We see it as a vision to cope with the current trends and the future goals (that we mentioned above), independent of which technology is available today.

2.5 Conclusion

Overview of the main characteristics of the concept of smart grids

- Integration of different sets of technology as key part of the smart grid
- Enabler of current trends and goals. Trends: more distributed generation of resources with an intermittent character. Goals: generate and distribute electricity more effectively, economically, securely, and sustainably
- A mainly decentral organization of the grid, more distributed generation
- From one directional to two direction, from mainly demand driven to mainly supply driven
- Consumer becomes prosumer
- Smart grids as a vision for the future defined by goals.

2.6 Application of the concept to our research

We will use the concept as defined by the characteristics above, but we will limit down a few aspects. Firstly, our research is limited to the smart electricity grid. Although most of the research is also focussed on the electricity, there are also plans to develop a smart gas grid or a combination of both. Secondly, we limit our research to the workingfield of the Dutch DSO's. Smart grids can be implemented locally, regionally, nationally and even globally. We chose to focus on a nationally operating grid because our research focusses on the Dutch DSO's and they only have the responsibility for the grid within the Netherlands. Thirdly, due to our focus on the DSO's, we will focus more on the distribution part of the electricity grid than on the transmission and generation part (although those parts are interrelated).

3.Theoretical framework: The Institutional Analysis and Development framework

3.1 Introduction

In order to analyse how the position of the DSO changes due to the Smart Grids, we need a theoretical framework that we can use as a guide for our research. The framework should guide us in what questions we should ask and which aspects we should take into account. It should help defining the position of the DSO in the conventional electricity grid and the position of the DSO in the smart grid context. It should be a lens through which we can see the changing electricity grid and provide a certain focus for us.

We chose the Institutional Analysis and Development framework (IAD-framework) as developed by Elinor Ostrom as a foundation for our analysis. This is a broad framework which can be used to analyse complex social situations taking into account both physical, cultural and social aspects, by breaking it down into different pieces (Polski & Ostrom, 1999). It is a framework that is meant to make sure that the researcher asks the right questions for her analysis, rather than explaining or prescribing something(Ostrom, Gardner, & Walker, 1994). The first part of this chapter will explain the framework further by introducing the concepts of IAD and its composition. The focus will be on how Ostrom described and meant the framework.

One of the advantages of using the IAD framework for analysis is that it pays attention to cultural aspects that influence a social situation. In the second part of this chapter, we discuss more advantages of using the framework for our research. The framework has been developed by an interdisciplinary collective of social scientists who participated the past twenty-five years in a workshop called Workshop in Political Theory and Policy Analysis (Polski and Ostrom, 1999) and is based on political economy, public choice theory, transaction theory and noncooperative game theory(Ostrom et al., 1994). Over the past years Ostrom and other scholars have reflected upon the framework and based on those reflections, Ostrom decided to make some changes. In the second and last part of this chapter, we will elaborate on how we are going to use the framework and how it applies to our research. We will elaborate on the parts we use for our research and we will explain how we interpreted the framework.

So this chapter continues as follows. In the first part we describe the IAD framework as developed by Ostrom by introducing its concepts and its composition. In the second part we elaborate on why we chose for the framework. And lastly, we explain how we are going to use the framework and how we will apply it to our research. We will provide a more detailed explanation of the part of the framework that we will be using and explain how we interpreted the framework.

3.2 The concepts of the IAD framework and its composition

The IAD framework is a broad framework which is meant to analyse complex social problems by breaking it into pieces. It is a mulitier conceptual map because it takes into account both the cultural and physical aspects of a situation, but also the rules that the determine the interaction between actors (Ostrom, 2011). Those variables are mapped in the framework. The figure beneath shows the different components of the framework. It shows how the different components influence the main component, namely the action situation, and the other components. We will discuss each, starting with the action situation.

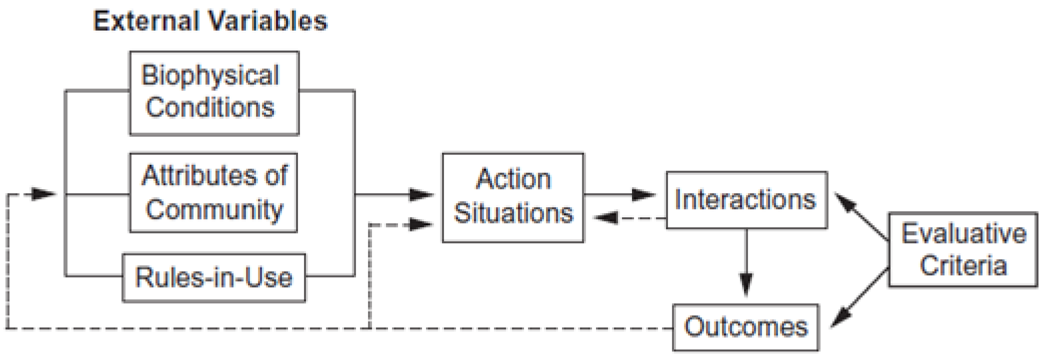

Table 1: A framework for Institutional Analysis
Source: (Ostrom, 2011, p. 10)

Action situation

The action situation is the main concept of the framework. The action situation is the social space in which the interaction between the different actors takes place. An actor in the action situation can be both an individual or a group acting as a corporate actor. The interaction that takes place between the actors can for example involve the exchange of goods and services, dominating the other, fighting or solving problems (Ostrom, 2011). The action situation is the core of the framework. On the one hand it is influenced by the external variables, but on the other hand it also influences itself the outcomes of the processes. In previous versions of the IAD framework, the action situation together with an actor was part of an action arena (for example: Ostrom, 1994). Ostrom has changed this into only the action situation and she added the second figure, which specifies the components of the action situation (Ostrom, 2011).

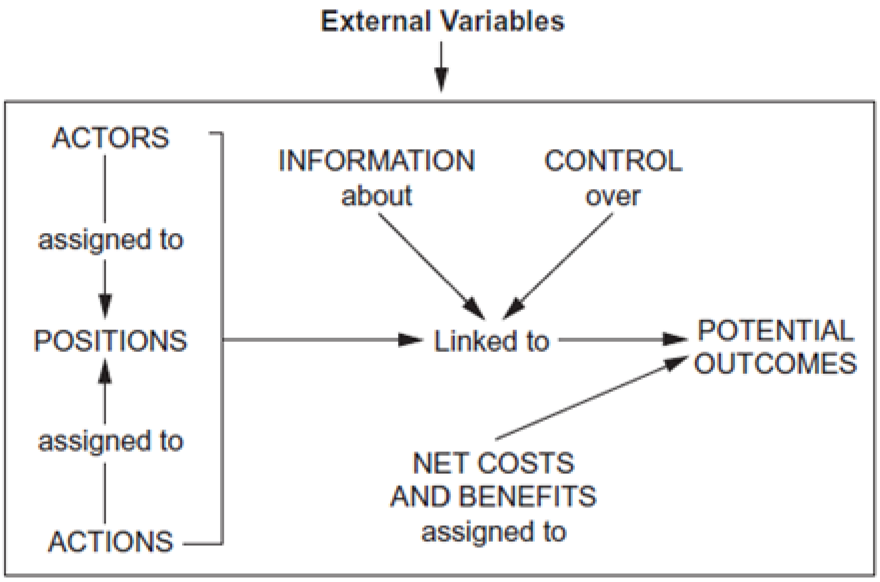

Figure 2: The internal structure of an action situation
Source: (Ostrom, 2011, p. 10)

The figure above displays the internal structure of the action arena. It shows how actions and actors are assigned to certain position. And how this position is linked to potential outcomes, influenced by control and information variables and the costs and benefits that are assigned to it. The different concepts are defined in the following way:

Positions

A position is a place in the process that a participant holds. This place is associated to the participants with an authorized set of actions. "Positions are simply place holders to associate participants with an authorized set of actions (linked to outcomes) in a process"(Ostrom, 1994, p.30). The other elements within an action situation determine the position of the participant and what capabilities and limitations this position contains (Ostrom, 1994). Within the IAD framework, the focus is on what actions a participant in a certain position would take rather than on what an individual participant would do (Ostrom et al., 1994). Thus, it is the structure consisting of different variables that determines what position a participant has and what this positions means. So in order to describe the position of an actor completely, all other components need to be taken into account.

Action

This element refers to the kind of actions participants can take within the action situation at a certain moment in the process (Ostrom, 1994). Those are the actions that are allowed and how they are linked to the outcomes (Ostrom, 2011). Usually an analysis only takes into account the actions that have significant influence on the outcome.

Potential outcomes

The potential outcomes are "the outcomes a participants can affect through their actions" (Ostrom, 1994, p.31) To put it differently, the outcomes are the results of different actors interacting with each other in a certain institutional setting. The potential outcomes are the possible results of the interaction between the actors.

Information

This is the amount of information available to an actor in a certain position at a certain moment in the process. It is for example possible that an actor has incomplete information due to a certain rules (Ostrom, 1994).

Level of Control

This refers to the degree of control participants have over the other components of the action situation (Ostrom, 1994).

Costs and Benefits

This refers to the costs and benefits assigned to actions and outcomes. It assigns positive or negative weight to actions and outcomes (Ostrom, 1994).

3.3 Remaining components of the IAD-framework

Patterns of interaction

Patterns of interaction are the structure of the action situation that determine the behaviour of the actors. Based on the behaviour of the actors and the conduct within the action situation, the patterns of interaction can be found (Polski and Ostrom, 1999). Those structures become clear after doing an IAD analysis looking at all the elements discussed above.

Outcomes

The outcomes of an action situation are determined by all the different elements discussed above.

Evaluative Criteria

Ostrom distinguished the following evaluative criteria which can be both used for evaluating outcomes and the process of achieving outcomes: Economic Efficiency, fiscal equivalence, redistributional equity, accountability, conformance to values of local actors and sustainability (Ostrom,2011, p. 16). She focussed on those criteria, but it is also possible for a researcher to use her own criteria (Ostrom, 2011).

3.4 External variables

Returning back to the first figure, we will discuss the context of the action arena. As can be seen on the left side of the figure, the action situation is influenced by three different external variables, respectively biophysical conditions, attributes of the community and the rules-in-use. Those external variables can be regarded as the context in which the action situation takes place. They all influence the types of action an actor can take, what the costs and benefits of those actions will be, and what the outcome of those actions will be (Ostrom, 2007).

Biophysical conditions

Ostrom described the biophysical conditions also as physical and material conditions which she defined "the physical and human resources and capabilities related to providing and producing goods and services. These conditions include production inputs like capital, labor, and technology, as well as sources of finance, storage, and distribution channels" (Polski and Ostrom, 1999, p. 9). The physical world is an important variable influencing the action situation. The physical and material characteristics and their changes can be seen as variables that condition what is possible in the action situation. Furthermore, the physical world determines the possibility of all the different aspects of the IAD-framework (Ostrom, 2007).

Attributes of the community

This set of external variables is socially and culturally oriented. They are related to the culture and community in which the action situation is located (Ostrom, 1994). Facts such as how a community demographically is organised, what norms with regard to politics exist in a community, what degree of common understanding participants have about political activities are attributes of a community which influence an action situation (Polski & Ostrom, 1999).

Rules-in-use

The rules-in-use in an action situation are the rules that determine the behaviour and interactions of the actors. "Rules are shared understandings among those involved that refer to enforced prescriptions about what actions (or states of the world) are required, prohibited, or permitted" (Ostrom, 2011, p. 17). The IAD framework will be used in the first place to analyse the working norms and rules that the actors use to make decisions. Working norms and rules are the rules actors will refer to when they try to justify and explain their actions and decision to other actors (Ostrom, 2011). Those rules create a certain order and predictability in an action arena.

3.4 How the framework will be used and why

After giving a description of the fundamental part of the IAD- framework, this part of the chapter will explain why this framework has been chosen and how it will be used.

The main reason for choosing this framework and the main purpose of this framework is that it provides a guide for doing analysis. In order to analyse how the position of the DSO changes due to the Smart Grids, we use the IAD-framework as a guide for our research. The framework guides us in what questions we should ask and which aspects we should take into account. It helps defining the position of the DSO in the conventional electricity grid and the position of the DSO in the smart grid context. It is a lens through which we can see the changing electricity grid and provides a certain focus for us. The IAD-framework is a foundation for our analysis. It is a broad framework which can be used to analyse complex social situations taking into account both physical, cultural and social aspects, by breaking it down into different pieces (Polski and Ostom, 1999). It is a framework that is meant to make sure that the researcher asks the right questions for her analysis, rather than explaining or prescribing something

For this kind of research, there are more theoretical frameworks to choose from, for example the Multi-level perspective as used and described by Verbong and Geel (for example: (Geels, 2005);(G. P. Verbong & Geels, 2010)). The multilevel perspective helps to understand how transitions take place as an interplay between technology and society. It takes into account multiple levels of society and different dynamics(Geels, 2005). Since it takes into account both society and technology, it could be suitable for our research because Smart Grids are a combination of technology and societal aspects. Nevertheless, Multi-level Perspective does not focus on the rules that shape the actions in the institutional setting, which the IAD framework does. Other reasons for choosing for the IAD framework and the advantages of it will be discussed in the remainder of the chapter.

The fact that the IAD framework is an institutional framework is also an important reason for using it. It is an institutional framework in the sense that it identifies the main structural variables that are present in all institutional arrangements, but the degree to which those are present in an arrangement differs (Ostrom, 2011). This is useful for our research because we can apply it to the situation before and after the introduction of the Smart Grid. We will be looking at how the position, tasks and interactions of the DSO in the management of the conventional electricity and the smart grid changes. We will analyse to what extent the structural variables distinguished by Ostrom are present and in what way. Focussing on the same variables enables a comparison between the situation before and after the introduction of the Smart Grid. It enables a comparison between the two institutional settings.

Those institutional settings are analysed by looking at the action situation as defined by Ostrom as a the social space in which the interaction between the different actors takes place (Ostrom, 2011). The action situation is used as a conceptual unit to analyse the institutional setting. It enables us to isolate the structure that influences the position of the DSO and its interaction with the other actors. In this research, the institutional setting is the management of the electricity grid. Within the management of the electricity grid, we focus on the position of the DSO and its interaction with the consumer, regulator and government. We will use the set of variables that Ostrom has distinguished to describe the structure of the action situation. We discuss how we interpreted the variables and how we are going to use them. It includes a *set of actors*: those are the main participants in the process, who are the actors who are involved in the management of the electricity grid? *The positions* that those actors fulfil: what kind of positions exist and how do they relate to the participants, who has what kind of position in the management of the grid and what kind of position does the actor has towards the other participants. *A set of allowable actions*: the actions the participants are allowed to take and how this is linked to the outcomes of the process. We will look at which actions the actors are allowed to take with regard to the management of the grid and how this influence how the grid is managed in the end. *The potential outcomes* and how this is linked to the actions taken: how do the actions that have been taken influence which outcomes are possible. *The degree of control each actor over choice*: to what extent are actors able to choose which actions they take and to what extent are they able to change this. *The information available*: what do and are the actors able to know about the structure of the action situation. *The costs and benefits*: the positive and negative weights which can be assigned to the potential outcomes, those can also be seen as incentives or deterrents of the outcomes. The description of these variables forms the structure of the action situation, which we use as an institutional setting. This analysis will be done in the case of the conventional electricity grid, but also for the electricity grid in the smart grid context.

The variables discussed are the endogenous variables of the action situation, but there are also external variables. Those variables represent the context in which the action situation takes place. The fact that the IAD framework takes those external factors into account makes it suitable for our research. We expect the context in which the electricity grid is managed to have influence on how it is managed. The IAD framework enables us to take into account the cultural, social and physical dimensions by looking at those external variables. As described in the previous part of this chapter, Ostrom distinguishes three kinds of external variables, namely the biophysical conditions, attributes of the community and the rules-in-use (Ostrom, 2011). We understood the *biophysical conditions* as the physical and material characteristics of electricity. We will look at the characteristics of electricity as a good, but also at the infrastructure and the physical possibilities. It is important for our research that the IAD framework takes this into account, because there is a high degree of path dependency with regard to the infrastructure of electricity. This means that decisions that have been made about the infrastructure of electricity determine which actions and decision are possible now (Wolsink, 2011). We understood the *attributes of the community* as the aspects of the community that influence what can be done in an institutional setting. Those aspects can be for example public support or the norms with regard to the use of electricity. We will be looking at the consumers of electricity, but also at what the general thoughts are among the public with regard to using energy and being more sustainable. How supportive is the community of Smart Grids? The last external variable are the *rules-in-use*. We understood the rules-in-use as the rules which determine why an actor behaved in a certain way or made a certain decision. This does not only include the formal written rules, but also the informal unwritten rules. An advantage and therefore an important reason for us to choose for the IAD-framework is that it pays a lot of attention to the influence of culture and tradition on how an institutional setting functions. By both describing the attributes of the community and the rules in use, the IAD framework allows us to analyse the influence of culture and traditions for the management of the electricity grid and the interactions between its actors. Taking all three variables together shows us the context in which the DSO operates and interacts with the other actors.

An important point of our research are the working rules that Ostrom defines as the rules to which actors refer when they explain or justify their actions and decisions(Ostrom, 2007). Those working rules can be identified by examining how those rules influence the variables in the action arena. Together with the biophysical conditions and the attributes of the community, those working rules explain the actions of the actors in the action situation. Therefore, we will after examining the biophysical conditions and the attributes of the community, analyse the working rules that affect the management of the grid. Ostrom distinguished seven types of working rules which influence the structure of the action situations, as shown in figure 3 below.

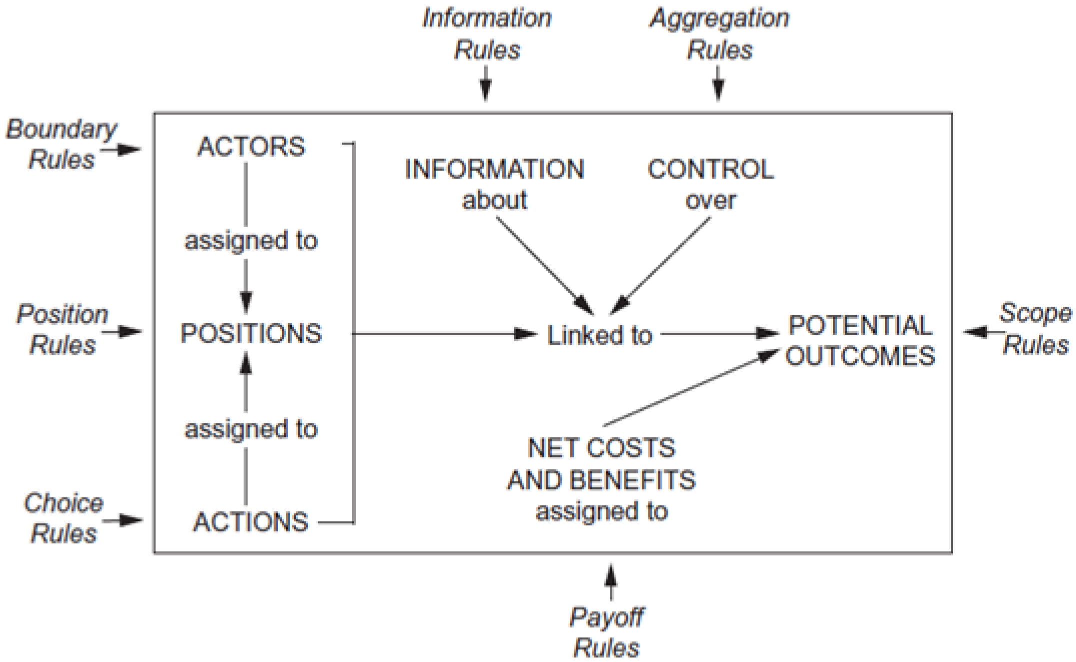

Figure 3: Rules affecting the elements within an action situation
Source: (Ostrom, 2011, p. 20)

We will discuss each rules, explain how we understood it and how we are going to apply it to our topic. *Boundary rules*: Those rules determine the number of actors in the action situation and their resources and attributes. They influence whether actors can enter the action situation freely and on which conditions they can or have to leave (Ostrom, 2011). So basically those rules determine whether someone is and can be an actor in the action situation or not. This is also shown in figure 3, since the boundary rules are linked to the actors. For our research, the boundary rules prescribe that we have to look at how actors become part of the institutional setting of the management of the grid. What rules make them part of the action situation and what makes them leave?

Position rules: Those rules are related to the boundary rules. They determine what kind of position an actor has and what kind of positions exist in an action situation. Those rules also determine how an actor leaves or enters such a position. Ostrom shares this in her book under boundary rules (Ostrom, 1994), but in her most recent article under position rules (Ostrom,2011), therefore we also decided to share it under position rules. In our research those rules mean that we have to look at what kind of positions there are with regard to the electricity grid. What kind of position does the DSO have? What positions do the other actors have. What rules determine those positions? And how can the actors change from position? In figure 3, the position rules are related to the positions.

Choice rules: Choice rules are related to the position rules. Those rules determine what kind of action an actor in a certain position at a particular point may or must (not) take (Ostrom, 2011). So which kind of actions are considered appropriate for which position? What is considered forbidden, mandatory or authorized? In figure 3 the choice rules are linked to the actions. Applying this to our research, we have to figure out which actions relate to which positions regarding the management of the grid. Which actions are considered appropriate for the DSO and the other actors? In what position should an actor be to determine how the grid is managed?

Scope rules: Those rules are related to the potential outcomes in the action situation as shown in figure 3. They determine which potential outcomes may and can be affected (Ostrom, 2011). In our research we have to investigate what the scope is of the actors and which rules delimit that. Are there rules that determine what domain of the management of the grid belongs to what actor? Does the scope of the actors change after the Smart Grid?

Aggregation rules: Those rules are linked to the control an actor has over its actions. Aggregation rules influence the degree of control actors in a certain position have in the selection of its actions on a certain moment in the process (Ostrom, 2011). Applying this to our research means that we have to look at what the weight of the vote of each actor is in deciding how the grid is managed. We have to think of the following questions among others. Do the tasks that the DSO fulfils for the grid depend on rules? Does the DSO need permission to take action? Does the choice for Smart Grids depend on permission from others?

Information rules : This refers to the rules that affect the knowledge that is available to the actors at each position, at each decision moment (Ostrom, 1994). For our research we must figure out which rules determine what information actors have before they take a decision. Are there rule which force actors to make information public? Do the actors have full information about all aspects of the electricity grid?

Payoff rules: Those are the rules that affect which benefits or costs will be assigned to the combinations of actions and outcomes. The payoff rules form the deterrents and incentives for action. They specify "how benefits and costs are required, permitted, or forbidden in relations to players, based on the full set of actions taken and outcomes reached" (Ostrom, 1994, p. 42). Applying this to our research means we have to ask the following questions among others: who monitors the tasks of the DSO? Are there sanctions imposed when the DSO performs its task insufficiently? Does the DSO receive rewards for sufficient performance? Who imposes those sanctions and rewards? Does this change in case of the smart grid?

Those rules are related to each other and the effect of one type of rules also depends on the effect of the other types of rules. Therefore, it is the effect of those seven types of rules that affect the seven elements of the action situation (Ostrom, 1994). The effect of a change in one of the rules depends also on the other rules-in-use (Ostrom, 2011). By describing those rules, we are able to explain which rules currently structure the interaction between the DSO and the regulator, consumer and government within the conventional and smart electricity grid and which rules currently determine the position and tasks of the DSO.

In sum, we chose the IAD framework to be the guide for our research. A lens through which we can see the management of the electricity grid. A framework that helps us to analyse the structural variables in the institutional setting. It helps us to describe the institutional setting by using the action situations and its components. It enables us to take into account the cultural and physical aspects of the context in which the DSO operates. It distinguishes seven types of rules that help us make clear which rules currently structure the interaction between the DSO and the regulator, consumer and government within the conventional and smart electricity grid and which rules currently determine the position and tasks of the DSO. By looking at the same variables, we can make a comparison between the management of the conventional grid and the smart grid.

4.Methodology

4.1 Introduction

Our methodology consists of both qualitative research methods and literature study in order to answer our research question. As already mentioned in the previous chapter, the IAD framework of Ostrom will be the foundation of our research. We focus on the external variables and the composition of the action situation as an institutional setting. In order to get the required data, we will do a literature study and interviews. The interviews will be semistandardized and consist of open ended question. The literature is related to the social, cultural, physical and rule-oriented aspects of the context and institutional setting in which the DSO operates. This chapter is structured in the following way. The first part will elaborate on the research design. The second part focusses on the data collection. It sets out how the data is collected and why we chose for these methods. The last part explains how the collected data will be analysed.

4.2 Research design

The research design for our research can be described as an embedded case study. "A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 1994, p. 13). Each case study consists of a DSO and its management of the electricity grid. The DSO's have been selected based on the following criteria; geographical workingfield of the DSO and the commodity for which the DSO is responsible. The geographical workingfield of the DSO is taken into account due to time and financial constraints. We only looked at Dutch DSO's. The commodity is a selection criteria because we only focus on the smart grid for electricity.

It is an embedded case study because we focus on multiple units within the case study. We are looking at how a DSO manages the grid, but also on how the DSO perceives its role and tasks. We will conclude our research by comparing the management of the current electricity grid with the management of the Smart Grid.

4.2.1 Data collection

Which data will be collected is based on the IAD framework of Ostrom. We will be using two parts of her framework. The focal point of our use of the framework will be the action situation. We will focus on the structural variables that form the action situation. Ostrom distinguished seven types of working rules that influence the variables of the action situation. We will investigate what those rules are in the conventional and the smart grid context. Based on those rules we try to find out what the position and tasks DSO are in the conventional and the smart grid context. Moreover, we will look at what rules structure the interaction between the DSO and the regulator, consumer and government in both situations. All this happens in a context. To understand this context, Ostrom has described external variables. We will look at those external variables in order to find out in which context the DSO operates and how this will change due to smart grids. This context together with the rules help us to determine how the position and tasks of the DSO in the management of the electricity grid and the interaction with the regulator, consumer and government change due to Smart Grids.

4.2.2 Literature study

The literature study will be used in two ways in this research. Firstly, it will be used to describe the external variables that have been distinguished by Ostrom. In her IAD framework, Ostrom refers to the biophysical conditions, attributes of the community and rules-in-use as the external variables which influence the behaviour of the actors in the action situation. We will try to describe the biophysical conditions under the conventional grid and how this changes due to smart grids by using literature, focussing on material, physical and the rule-oriented aspects of managing an electricity grid. We will set out the attributes of communities in the conventional electricity grid and how this changes due to the smart grid by using literature, focussing on the role of consumer and the public opinion on sustainable energy. We will explain the rules in use only partly based on literature, because it is not possible to describe the informal working rules based on literature. The formal rules will be explained by referring to government policies and company documents. We will be looking only at the government policies and regulation which are available until August 2015. We are aware of the fact that changes are upcoming[1], but those are not part of our research. Based on a literature study we try to make clear what the context is in which the DSO operates. Keeping the biophysical conditions, the attributes of the community and the rules in use in mind, we describe what the literature says about those aspects. We will do this for both the conventional situation and the smart grid situation. It basically explains the changing world in which the DSO functions.

The second way in which we will use literature study is a more exploratory way. We will use it for our research is to prepare our interviews. We will study company documents of the DSO to see what their developments are on Smart Grids. We will look at what steps they already have taken towards Smart Grids. We want to know what their perspective is on Smart Grids. Besides studying the company's documents and website, we will also study the literature that is available on the DSO and Smart Grids and the related aspects. This data contains background information on which problems

[1] Currently the Dutch government is working on the development of STROOM which might change the rules of the institutional setting of the DSO. STROOM is a legislative agenda which aims to streamline, optimize and modernize (**STR**oomlijnen, **O**ptrimaliseren, **M**oderniseren) the current laws and policies regarding electricity and gas in order to facilitate energy transition and market developments (Zaken, 2014)

the DSO's are facing and make prediction on the position of the DSO in Smart Grids. Just as already studying the company's websites and documents will makes us better prepared for the interviews, so will studying literature. During the interviews we can reflect on what we have studied before. We can test what has been described in literature.

4.2.3 Interviews

The interviews will be a tool to fill out the action situation as part of the IAD framework. The action situation consists of different components. Each of them will be discussed. Our focus will be on the rules that are related to those components. Ostrom distinguished seven types, each of them is related to one of the components. By interviewing Dutch DSO's, we will try to get to know the rules that exist in the management of the conventional grid. We will do the same for the management of the smart grid.

We will interview six of the eight Dutch DSO's. In the Netherlands each DSO has its own region in which it operates. The DSO's are all in some way involved in Smart Grids. They have pilotprojects, either on their own or in cooperation with other DSO's. The people we will be interviewing will be either the or the manager innovation or the asset managers of the DSO. We chose them because they are responsible for the strategy and development of the DSO. They are in charge to decide which direction the DSO will go and what the DSO will do with regard to Smart Grids.

Table 1: Overview of the interviewees

DSO	**Region**	**Function interviewee**
Alliander	Friesland, Gelderland, Noord-Holland, Flevoland	Innovatie en Strategie Consultant
Delta Netwerkbedrijf	Zeeland	Adviseur Asset management, kwaliteit en processen Project manager Duurzaamheid en lange termijn planning
Endinet	Eindhoven	Specialist asset management, department of innovation
Enexis	Groningen, Drenthe, Overijssel, Noord-Brabant, Limburg	Innovator at the department of innovation
Cogas	Oldenzaal, Almelo, Goor	Adviseur Asset Management
Stedin	Utrecht, Zuid-Holland	Asset Management – Netstrategie

We chose interviews as a research method because we believe it is the best way to understand how the DSO perceives and encounters the management of the grid and the Smart Grid. Interviews are a tool to get to know the subjective understanding of actors. By interviewing actors, a researcher can get to know the context of the actor's behaviour. The researcher gets to know what kind of meaning an actor gives to its behaviour and experience (Seidman, 2006). This is what we need for our research. We want to get to know the working rules that determine the position of the DSO and that structure the interaction of the DSO with the other actors. Those working rules are the rules that an actor refers to when she wants to explain or justify her actions and decisions (Ostrom, 2011). Those rules are informal and unwritten. Only by asking the relevant actors which informal rules exist, we can get to know those rules. Posing questions, should help us understand what meaning actors give to certain actions and rules.

We chose face to face, semi standardized interviews with open ended questions as our form of posing questions. We could have chosen for a survey, but that would only have made clear the role of the DSO and the interaction with other actors. It would not have made clear the working rules behind it. Interviewing face to face with open ended questions enables us to understand why actors act in a certain way and which rules are behind that action. The interviews will be semi standardized. This means that the major part of the questions will be determined before the interview, but during the interview additional questions can be asked. The questions will be related to the seven types of working rules as determined by Ostrom, but also to the external variables. It will question what the DSO's mean by a Smart Grid and how they perceive the function of Smart Grids. The questions will be open ended to give the interviewees the opportunity to express their views.

4.3 Shortcomings

This way of collecting data has some shortcomings. In the first place, the perspectives which the interviewees describe are only the perspectives of the DSO. How the management of the grid is going to develop and what the tasks and position will be in this management, does not only depend on the what the DSO envisions. Especially the government and the ACM are important actors in this. In the interviews the larger DSO's expressed their wish to facilitate the transition to Smart Grids. Does the government agree with this? The same goes for the consumer. The DSO's expect the consumer to become active, produce electricity and cooperate closely with the DSO. But is this what the consumer will actually do? Those are all point for further research.

Secondly, there are aspects uncertain. Although we chose for experts as our interviewees, still many things are unsure. During the interviews it turned out that the DSO's are still investigating what the Smart Grids mean to them and how the grid should be organized in the future. Some DSO's were not able to describe what a Smart Grid is in their perspective. The interviews show that the DSO's are still investigating what a Smart Grid will actually look like for them. It is still difficult for them to describe adequately what a Smart Grids is and what it looks like. The answers they gave are still vague and superficial. Furthermore, the description differed among the DSO's. The DSO's are still investigating what the right way of organizing the Smart Grid. By engaging in pilotproject, the DSO's are figuring out what their role could be and how they should cooperate with other actors in Smart Grids. The DSO's also disagree on the necessity of Smart Grids. One of the smaller DSO's stated that the IT application which are needed are not per se cheaper than enlarging or thickening the cables, while other DSO's do state this is cheaper. Those uncertainties create a limitation for our research. The answers the DSO's gave do not have to be the direction they will eventually take because they are still investigating what the right direction is.

4.4 Data analysis

The data retrieved from the interviews and the literature study will be used to fill out the IAD-framework of Ostrom. Based on the literature study and the interviews, we will describe the changing context by looking at the biophysical conditions, the attributes of the community and the rules in use. Those external variables show in what kind of changing context the DSO is operating and what is possible in the action arena. The data retrieved from the interviews will be used to determine the working rules that structure the action situation. It will show in what kind of institutional setting the DSO operates and what rules structure the tasks, position and responsibilities of the DSO and its interaction with the other actors. This will be done for the case of the management of the conventional electricity grid, but also for the management of the smart grid.

In the final section of our research, we will make a comparison between management of the conventional grid and the management of the smart grid. By comparing the working rules that structure the management of the conventional grid and the rules that structure the management of smart grid, we want to find out if and how the position and tasks of the DSO in the management of the electricity grid and the relationship with the regulator, consumer and government changes due to the Smart Grid innovation.

5. Analysis

5.1 Introduction

This chapter provides an analysis of the collected data in order to answer the main research question which stated: Does the Smart Grid Innovation change the position and tasks of the DSO in the management of the electricity grid and the interactions with the regulator, consumer and the government and if yes in what way?

The collected data consists of interviews with six Dutch DSO's, the Dutch electricity law and literature. The interviews are the most important source for the analysis. Using the Institutional Analysis and Development framework of Elinor Ostrom we will figure out which rules structure the interaction between the DSO and the regulator, consumer and government and which rules determine the position and tasks of the DSO in the current setting and in the Smart Grids setting, as stated in the subquestions. The biophysical conditions, attributes of the community and the rules-in-use form together the context in which the DSO functions and interacts with other actors. As set out in the theoretical chapter, we will mainly focus on the rules which structure the interaction in the action situation. Those rules determine what is taking place in the action situation. Therefore we will start this chapter by explaining if and how the institutional setting of the DSO changes due to the Smart Grids Innovation. The institutional setting determines what the DSO is able to do. Therefore we describe how the tasks, position and interactions of the DSO changes based on the changed institutional setting. Each of the following sections will discuss respectively if and how the position, tasks and interactions of the DSO with the regulator, consumer and government change due to the Smart Grid innovation. In the analysis a distinction is made between the larger and smaller DSO's because they interpreted their institutional setting in a different way. The larger DSO's are Alliander, Enexis and Stedin, the smaller are Cogas, Endinet and Delta Netwerkbedrijf. It is important to note that our analysis is mainly based on the ideas that the DSO's expressed during the interviews. This results in a analysis on how the Smart Grid is likely to change the position, tasks and interactions of the DSO based on the ideas of the DSO and the literature.

5.2 The expected changes under the Smart Grid

As shown in figure 1 in the theoretical chapter, the biophysical conditions, attributes of the community and the rules-in -use influence the institutional setting of the actor.

Therefore we will explain how the institutional setting of the DSO changes due to Smart Grids by discussing how each of those external variables changes due to the Smart grid innovation. The following table briefly summarizes what those variables are in the current situation and what those variables are in the Smart Grid situation. Each of the following sections will discuss one of the factors.

Table 2: Overview of the variables of the IAD framework in both the current and the Smart Grids context

	Current Situation	**Smart Grid situation**
Biophysical Conditions	-centrally organized generation -few sources of electricity -demand driven system	- a more decentral organized generation based on an increased number and diversity of resources -multiple sources of electricity -supply driven system
Attributes of the community	-each actor has a specific task -Limited participation of the consumer -Supportive sector and government	-active participation of consumer -each actor does not have a specific task
Rules-in-use:		
- Boundary & Position rules	-benchmarked tasks which are related to the management of the grid -only allowed to be fulfilled by the assigned DSO	-broader tasks, not only related to management tasks anymore -also allowed to be fulfilled by other actors
- Choice rules	-Large DSO's: freedom in how to fulfil those tasks, but reach goals of stability, reliability and affordability -possible to negotiate how to fulfil those tasks -Small DSO's: stricter interpretation of tasks -not much space to negotiate	-more freedom in how to fulfil those already broader tasks -larger DSO's have more influence on how the tasks are fulfilled -Smaller DSO's leave it up to government
- Scope rules	-geographical domain -management domain - no side activities -no trading, providing or producing of electricity	-same geographical domain -broader management domain -operate at local and governance level
- Aggregation rules	-non-discriminatory principle -consumer protection -permission needed from ACM to engage in side-activities	-non-discriminatory principle -consumer protection -more lenient in granting permission
- Information rules	-transparency about activities	- increased transparency
- Payoff rules	-financial incentives based on quality of performance -binding judgement by ACM	- financial incentives based on quality of performance, same criteria, but norms adjusted to Smart Grids

5.2.1 Biophysical conditions

The changing biophysical conditions have a lot of influence on the institutional setting of the DSO.

Firstly, the organization of the grid changes due to the inclusion of sustainable resources. The current grid is mainly centrally organized generation of electricity with already a number of decentral and distributed resources. When electricity is based on renewable resources for the generation of electricity, the organization of the grid changes. The number and diversity of electricity resources will increase further. The electricity will be generated from even more different and decentral sources such solar panels and windmills which lead to a more distributed generation(Scott et al., 2008). This leads to a bigger challenge for the DSO, since they have to distribute the electricity from an increased number of diverse and decentral resources in the Smart Grid setting.

Secondly, the system changes from a one directional to a two directional system due to the Smart Grids innovation (Delft, 2012). The ICT technologies enable the bidirectional flows between the consumers and producers of electricity. Those flows concern electricity, but also the flow of information. Through smart meters which function as hubs of data, information is exchanged between the consumers and producers to make sure that the demand and supply of electricity are matched. This means that the DSO gets an extra tasks in distributing the flows of information. Furthermore their tasks in distributing the electricity gets more complicated since the flows of electricity are coming from two ways instead of one.

Thirdly, the whole system of generation, transmission and distribution changes from mainly demand driven into a mainly supply driven due to the tools and functionalities such as the smart meter and Demand Side Management. The conventional system supplies electricity when we demand it. Smart grids is mainly focussing on making sure that the demand follows the supply in order to match the two (G. Verbong et al., 2013) This shifts also the way of distributing of the DSO from demand driven to supply driven.

In sum, the biophysical conditions change due to Smart Grids and this has influence on the institutional setting in which the DSO functions and interacts. The institutional setting changes due to an increased number of diverse and decentral sources of electricity. It shifts from a mainly demand driven system based on one directional flows to a mainly supply driven system based on two directional flows.

5.2.2 Attributes of the community

The attributes of the community are the aspects of the community that influence what can be done in an institutional setting. The community in which the DSO operates is characterized by an electricity cycle in which each actor has a different task, low participation of the consumer, and a government and branch association which are in favour of Smart Grids. Each aspect will be discussed below.

The electricity community in which the DSO functions is organized in such a way that each task within the electricity cycle is executed by a different actor. The following tasks can be distinguished : distribution of electricity, trade in electricity, and the provision of electricity. When one actor is committed to executing one of the tasks, it is not allowed to execute one of the other tasks (electricity law, art. 10. B)

The DSO is responsible for the distribution of the electricity. A distinction has to be made between the regional and national netoperators. The national netoperator is responsible for the national transmission of electricity, while the regional netoperators(also called Distribution Network Operators) are responsible for distributing the electricity to the consumers. Due to Smart Grids the regional netoperators will turn Distribution System Operators (Veldman, 2013). This means the regional netoperator will have the responsibilities which it already had when it was still a DNO, but will also have additional tasks which belong to the DSO[2]. This will be elaborated in the section about the tasks of the netoperator. Those additional tasks are also tasks which currently belong to other actors in the electricity community. This shows that the actor in the electricity cycle will no longer have one specific task due to Smart Grids.

Another major change which will take place in the community of the DSO due to Smart Grids is the increased involvement of the consumer. The DSO's expressed in the interviews that the majority of the consumers is not interested in energy, as long as it works properly and is cheap. One interviewee described consumers as passive. Currently the DSO's are trying to engage the consumer more in energy transition. They are offering the consumer smart metering which enables the consumer to get more knowledge about their electricity use. Moreover the DSO's invite consumers to participate in pilotprojects. This increases the active participation of consumers in the electricity process. This means the connection between the DSO and the consumer is getting a bit closer. The introduction of Smart Grids will increase this even further. Due to smart applications the consumer will be more involved in electricity. They will get insight in the demand and supply of electricity and can adjust their behaviour to it.

Although the individual consumer is not very interested in Smart Grids according to the DSO's, the Dutch government and the electricity sector are exploring the possibilities of Smart Grids. In 2011 the government of the Netherlands already stated that the implementation of smart grids is necessary in order to benefit optimally from sustainable energy (energie akkoord, 2013). With an eye on the development of smart grids, the Dutch government has made available 22.5 million euro for pilot projects of smart grids (Energy Report, 2011). Netbeheer Nederland (the overarching organization for Dutch DSO's) published a Roadmap for Smart Grids in which they portray the implementation of Smart

[2] As explained in the introduction, we decided to use the term DSO for the sake of international understanding.

Grids as desirable and necessary (Netbeheer Nederland,2012) They also stress the importance of cooperation between the different actors.

Those changing characteristics of the community due to Smart Grids influence the institutional setting of the DSO. The consumer becomes more involved, an actor has no longer one specific task and Smart Grids are supported by the government and overarching organization for Dutch DSO's.

5.2.3 Rules-in-use

The rules which have been distinguished by Ostrom influence the institutional setting of the DSO. By describing how those rules change due to Smart Grids, we will explain how the institutional setting of the DSO changes due to Smart Grids. Those rules govern the institutional setting, therefore also determine what is possible in the institutional setting.

Position and boundary rules: Those rules determine what the position of an actor is and what this position means. Those rules can be found back in the Dutch electricity law (elektriciteitswet 1998) which is the backbone of the institutional setting of the DSO. The details of this law determine the position of the DSO in the electricity cycle. The law clearly describes what a DSO is and which tasks belong to this position. Those tasks are all related to the management of the electricity grid. The law benchmarks those management tasks for the DSO and protects the position by only allowing the assigned DSO to fulfil those tasks. Other DSO's or actors are not allowed to fulfil those tasks. Each actor in the electricity cycle has its own tasks and is not allowed to take up tasks from other actors. An actor can become a DSO if the actor is assigned by the owner of the grid as the DSO. This assignment is for ten years and has to be approved by the Dutch minster of economic affairs (art. 12 electriciteitswet, 1998).

The Smart Grid will change the boundary and position rules. Those rules will become broader. One the one hand, this is due to the fact that Smart Grids will create more tasks for the DSO than in the conventional grid. Those tasks will not be only related to the management of the grid anymore. So the rule that the DSO is only allowed to fulfil tasks related to the management of the grid seizes to exist. On the other hand the boundary and position rules become broader due to the fact that the tasks of the DSO will not only be allowed to fulfilled by the assigned DSO anymore. For example, one of the interviewees from a smaller DSO saw the possibility to transfer IT related tasks to companies which are specialized in IT applications.

Choice rules : Those rules have been understood as the rules which determine to what extent an actor is free to fulfil its tasks in a way they want. A distinction has to be made between the larger and the smaller DSO's view on what the appropriate way is to fulfil their tasks, as turned out during the interviews. The larger DSO's feel free in how they fulfil their tasks as long as they meet the goals as set by the ACM. They see the reliability, affordability and stability of the electricity grid as their main goals for the management of the grid. As long as they are able to reach those goals, they can fulfil their tasks in any way they want. The larger DSO's also negotiate with the ACM about how they are fulfilling their tasks. The smaller DSO's interpret the choice rules differently. They see the description of the tasks in the electricity as strict and binding. They do not feel the freedom to fulfil their tasks in any way they want as long as they meet the criteria of the ACM. They also do not negotiate with the ACM directly on how to fulfil their tasks.

In the Smart Grids context the DSO's will have more freedom in how to execute their tasks, but they still have to meet the goals of stability, safety and affordability. This enlarged freedom is based on two developments. Firstly, Smart Grids provide the DSO with more tools to fulfil its tasks. This enables the DSO to execute its tasks in different ways. Secondly, the DSO's want to provide more input on how the smart grid should be managed in the best way. Before the implementation of Smart Grids, the DSO's frequently engaged in pilotprojects which taught them many lessons on what the best way is to organize a Smart Grid. Based on this knowledge and experience, the larger DSO's will have more freedom in how to manage the grid, meeting the goals of stability, safety and affordability, according to the expectancy of the DSO's themselves. The smaller DSO's encounter this in a different way. They want to share their experience with the government and the ACM, but leave it up to them to decide how the tasks should be fulfilled. So the choice rules become broader.

Scope rules: Those rules determine which potential outcomes may and can be affected (Ostrom, 2011). We are looking at what the scope is of the DSO and which rules delimit that. This scope can be understood in two ways. On the one hand the scope can be seen as the geographical domain in which the DSO manages the grid. This is determined by contracts which are the result of fusions and take-overs in the past. On the other hand the scope of the DSO is its domain in the electricity cycle. Formally the DSO has to stick to tasks as written in the electricity law and has to refrain from activities which makes them compete with others or take advantage of their position(electriciteitswet 1998, art 10b). However, the government can give the DSO permission to engage in side-activities through a so called Besluit Decentrale Experimenten. Furthermore, the scope of the DSO is limited to the management of the grid. The DSO is not allowed to trade, produce or provide electricity or to belong to groups to which also companies belong which trade, provide or produce electricity (electriciteitswet 1998, art. 10b). But the informal rules regarding this are understood in different ways by the smaller and large DSO's, as turned out during the interviews. The smaller DSO's understood the formal rules as if they are not allowed to engage in any side activities from the prescribed tasks of ACM, while the larger DSO's understood it as if they could decide together with the ACM what they are going to do. So the informal scope rules are different for the larger and smaller DSO's.

The introduction of Smart Grids will make some changes in the scope rules. The geographical domain of the DSO will remain the same. However this does not mean that this whole geographical area will be covered by Smart Grids. The DSO's want to determine per case if smartening the grid is the best solution. The domain of the DSO in the electricity cycle does get broader due to the broader amount of tasks. Those tasks are not only related to the traditional management of the grid anymore. On the one hand the DSO's are going to operate on a more local level at which they are responsible for matching local demand and supply. On the other hand the larger DSO's also want to operate on a higher level. They want to have a role in facilitating the transition and operationalisation of Smart Grids, as shown in the interviews. This means they will also operate on a governance level. The current rule which states that DSO's cannot engage in side-activities outside their tasks as described in the electricity law should also be more loosen. Smart Grids is an ongoing development which needs constant research from the DSO to find out what is the best way to use it. This research has to be done in experiments which are on top of their traditional tasks.

Aggregation rules: Those rules show whether the tasks which the DSO fulfils are dependent on rules. The tasks which the DSO fulfils are indeed dependent on rules. DSO's have to take into account the non-discriminatory principle. This means they are not allowed to provide goods and services which makes them compete with others (art. 17). This non-discriminatory principle also means that the DSO is obliged to connect the consumer to the grid. Consumer protection is covered in the electricity law. It makes for example sure that the DSO sets fair conditions which are reasonable and enables the consumer to easily lay down a complaint about the DSO (art. 95).

Moreover, when the DSO's want to engage in activities which do not belong to their main tasks, they have to get permission to do that from the ACM. The perspective of the larger DSO's is completely different from perspective of the smaller ones. The larger DSO's feel more freedom with regard what they are (not) allowed to do. They do not encounter the tasks as described in the electricity law as strict as the smaller DSO's do. The larger DSO's have a broader interpretation of those tasks and they do not see obstacles to engage in side activities. One of the larger DSO's admits in an interview that they officially have to stick to the electricity law according to the ACM, but they overstep those boundaries. They see stepping outside the benchmarks as a necessary thing to do in order to prepare for the future. By engaging in activities which are outside the prescribed tasks such a storing electricity enables the DSO to explore what might be necessary in the future. It enables the DSO to prepare for the future. The DSO has to ask permission from the ACM in order to engage in activities outside its legal tasks, but one of the larger DSO deliberately does not do that. They assume to get permission afterwards. As the interviewee stated: " legislation follows us, we don't follow the legislation".

Those aggregation rules will only partially change due to Smart Grids. The non-discriminatory principle will remain. The DSO's agreed that this principle should remain, as turned out during the interviews. It should avoid the DSO from abusing its monopoly position. The rules about consumer protection will also remain. The main aggregation rule which is changing is related to the side activities of the DSO. In the current situation the DSO needs permission from the ACM in order to engage in activities outside their traditional tasks. The DSO's acknowledge that there should be an institution which checks the activities of the DSO, but they see it as necessary to get permission easier. They want the freedom to explore the possibilities of the Smart Grid which is developing continuously. A Smart Grid is a vision with certain goals which can be reached in different ways. The DSO's want to have the freedom to discover which innovation will help them in the best way to reach those goals.

Information rules: The electricity law refers to transparency. The law prescribes that the DSO has to be transparent about its activities. The DSO is obliged to provide information about its activities to the ACM and the government. It has to keep track of its qualityindicators in order to send it to the ACM. It has to be transparent about its investments and capacities (Electriciteitswet, art.21).

The transparency in the institutional setting will increase due to the introduction of Smart Grids. Firstly, the innovation of Smart Grids consists of several tools which will enhance the transparency in the setting. Due to tools such as the Smart Meter, both the DSO and the consumer get more insight in the demand and supply of electricity. This makes it more transparent. Secondly, the transparency in the institutional setting has to increase to enable the DSO to determine which smart applications are needed. The DSO wants to determine per part of the grid which smart tools and technologies are needed. By getting insight on the demand and supply of electricity, the DSO is able to determine which smart tools and technologies fit best.

Payoff rules: As mentioned before, the ACM is the regulator which monitors the tasks of the DSO. The rewards for the performance of the DSO are the tariffs which can be charged. The ACM has to check and approve the financial activities of the DSO. The DSO has to send its tarifstructures to the ACM(art.27). The ACM determines the tariffs based on criteria as described in article 36, taking into account the sustainability, efficiency and quality of the energy system. They have to keep in mind the importance of the quality of the service of the DSO's (electriciteitswet, art. 36.e). The ACM determines by which percentage the tariffs are allowed to increase or have to decrease. The DSO's who perform their tasks well are allowed to charge higher prices than the less well performing DSO's. This way the ACM stimulates the DSO's to perform in the best way they can. Furthermore, the ACM is able to make a binding judgement in case of conflict or to charge a fine in case of misbehaviour. When an actor has a complaint about how a DSO fulfils its tasks or duties, she can turn to the ACM. The judgment of the

ACM is binding (electriciteitswet, art. 51). When a DSO breaks the electricity law or one of the related regulations, the ACM is allowed to impose a penalty.

The Smart Grid only slightly changes those payoff rules. The DSO's agree with each other in the interviews that ACM should remain a monitoring regulator who should prevent them from taking advantages of their monopoly position. This monitoring should be based on the same criteria as before, according to the DSO's. Thus the ACM should look at the how the DSO's manage to ensure the reliability, safety and stability of the electricity net for a safe price. The norms which have to be kept in mind to measure this should be adjusted to the Smart Grids situation. Since it is still unsure what a functioning Smart Grid will look like, it is also not possible to determine what the norms would be. One of the smaller DSO's expects that the norms in the smart grids context to be higher than in the conventional situation because he expects the consumers to expect more since they have through the smart application more insight in the process of electricity.

Combining the biophysical conditions, attributes of the community and the rules in use shows that the institutional setting of the DSO changes due to Smart Grids. The number and diversity of resources of electricity will increase further. It shifts from a mainly demand driven system based on one directional flows to a mainly supply driven system based on two directional flows. The consumer becomes more involved and each actor does not have a specific task anymore. The rules become broader and more lenient, which gives the DSO more freedom.

5.3 Smart Grids and the tasks of the DSO

Based on the changed institutional setting due to Smart Grids, we will now draw conclusions on how the tasks of the DSO change due to Smart Grids.

The number of tasks which the DSO will be fulfilling in the smart grid setting increases compared to the current setting, as the overview below shows. The tasks which have to be fulfilled in the current setting are the same tasks as described the electricity law, while the tasks in the smart grid go beyond what is described in the electricity law. This is based on what the DSO's stated during the interviews.

Table 3: Overview of the tasks of the DSO in both the current and the Smart Grid setting

Tasks in the current setting	**Tasks in the Smart Grid setting**
-Its main task is to make sure the grid is working and to maintain it. -It has to ensure the safety and reliability of the grids and the transport of electricity in the most efficient way. -It is responsible for (re)placing and fixing the grid.	All DSO's agreed on the following tasks -The tasks they already have under the current electricity law -Matching the local demand and supply on a local level -Providing data on the supply and demand of energy

-It has to connect users to the grid. -It has to protect the grid for external influences. -Making sure that there is sufficient back-up capacity for the transportation of electricity.	The majority of the DSO's also added the following tasks: -Facilitating the transition to Smart Grids. This is mentioned mainly by the larger DSO's -Smartening the consumer. Some added some specific tasks -Storing energy in the grid -Facilitating price regulation. -Assessing the quality and the origin of energy

Not only the amount and the content of tasks changes but some other related changes take place.

Firstly, the way those tasks are fulfilled changes. In the Smart Grids setting, the DSO's will get more freedom in how to fulfil those tasks. As distinction has to be made between the smaller and the larger DSO's. In the current situation, the smaller DSO's see the tasks as described in the electricity law and the rules which the ACM applies to those tasks as strict and binding. The larger DSO's interpreted this in a different way. They feel more freedom in how to fulfil their tasks, as long as they meet the goals of the ACM. They see the reliability, affordability and stability as their main goals for the management of the grid. As long as they are able to meet those goals, they are free in the way they fulfil this, according to the expectancy of the DSO's themselves. Furthermore, they see the opportunity to discuss with the ACM how they are going to fulfil their tasks. This distinction between the smaller and larger DSO's will remain in the Smart Grids setting, but both the smaller and the larger DSO's will get more freedom in how to fulfil their tasks. This enlarged freedom is based on two developments. Firstly, Smart Grids enables the DSO to execute its tasks in different way because Smart Grids provide the DSO with more tools to fulfil its tasks. Due to Smart Grids they have smart tools and technologies available to them to fulfil their tasks. Secondly, the DSO's want to provide their input on what the best way is to organize the grid. As a preparation for Smart Grid, the DSO's frequently developed and cooperated in pilotprojects which provided them with knowledge on what the best way is to organize a Smart Grid. Based on this knowledge and experience, the larger DSO's expect to have more freedom in how to manage the grid, meeting the goals of stability, safety and affordability. The smaller DSO's encounter this in a different way. They want to share their input with the government and the ACM, but leave it up to them to decide how the grid should be organized and how the tasks should be fulfilled. This change in how the tasks are being fulfilled by the DSO's can also be found back in the changing choice rules.

Secondly, the tasks of the DSO are not only fulfilled by the DSO only anymore. In the current situation, the tasks of the DSO are only allowed to be fulfilled by the assigned DSO, not by other actors or DSO's. This is protected by the electricity law. Nevertheless, this will change due to the introduction of Smart Grids. The enlarged amount of tasks create the opportunity for other actor to take up tasks of the DSO. One of the smaller DSO's gave an example of this: DSO's can decide to make small IT companies responsible for applying smart technology of the grid. This can also be found back in the changing boundary and position rules.

Thirdly, the tasks will be taking place at multiple levels, instead of only on the regional level of the management of the grid. In the current setting, the DSO only fulfils management tasks which are related to the regional grid. In the Smart grid setting, this will take place at multiple levels. On the one hand, the DSO will be involved in matching local demand and supply on a local level. On the other hand, the DSO will be working on a governance level. Based on the experience and knowledge about organizing a smart grid gained during pilot project, they want to share their knowledge with the government and the ACM and have influence on how the grid is going to be organized.

Lastly, the tasks of the DSO become more complex. The Smart Grid changes the biophysical conditions. The DSO has to deal with a system that shifts from demand driven to supply driven. Due to smart grids they have to deal with an increased number and diversity of sources of electricity. Furthermore, in the current setting the DSO's are responsible for the distribution of a one directional flow of electricity. In the Smart Grids setting, the DSO becomes responsible for the distribution of a bidirectional flow of not only electricity but also data.

To sum up, the tasks of the DSO get broader and more complex due to smart grids; the tasks will take place at multiple levels, will also be executed by other actor and the DSO's have more freedom in how to execute them.

5.4 The Smart grid and the position of the DSO

The introduction of the Smart Grid innovation has influence on the position of the DSO. Due to the Smart Grid, the position of the DSO becomes more complex, powerful and closer to the other actors than before. The DSO shifts from being in an executive position in which he manages the electricity network to a facilitator who actively contributes to how the grid is organized and who is now responsible for different levels of the electricity system.

Currently the larger and smaller DSO's already encounter their position in a different way. The larger DSO's describe themselves in the interviews as a manager and service provider who discovers new possibilities in energytransition. The smaller DSO's also describe themselves as managers and serviceproviders, but stress that they are dependent on what the government, ACM and society wants. The larger DSO's are in a more leading position, while the smaller DSO's are in a more following position. The larger DSO's are more equal to the government; they negotiate with the ministry directly, while the smaller DSO's leave this up the Netbeheer Nederland (overarching organisation which represents the DSO's in the Netherlands).

The position of the DSO becomes more complex due to broader tasks. In the current setting, the DSO is mainly the manager of the grid who fulfils the tasks which has been assigned to him by the government and the ACM. Those tasks are related to the management of the regional grid. He ensures the stability of the grid, distributes the electricity and connects the consumer to the grid. This changes due to Smart Grids. The DSO gets more tasks which take place at multiple levels. The DSO is now responsible for a system of electricity, not only for the network anymore. The position shifts from a distribution network operator (DNO) to a distribution system operator (DSO)[3]. The DSO is not only involved in the management of the grid and the distribution of electricity anymore, but also in matching the local demand and supply and in contributing to the way the grid is going to be organized. This shows a complex position which covers multiple levels of the system.

The position of the DSO also becomes more powerful. Not only because the DSO becomes responsible for a whole system, but mainly because they see themselves as the facilitators of the Smart Grid. The larger DSO's envision a more leading position for themselves in which they both facilitate the transition to Smart Grids and the operationalisation of the Smart Grids. The smaller DSO see a more modest role for themselves. They leave it up to what the government or the society expects from them. They are engaging in pilotprojects to gain experience with the organizing the smart grid. Based on this experience, they provide information and options to the government which can be used to make a decision. In this transition the DSO's want to closely cooperate with the actors in order to jointly transfer the conventional grid to a smart grid. Therefore, position wise they will be closer to the other actors than before. This will be elaborated in the next section of the DSO and its interactions. Another reason why the position of the DSO becomes more powerful is because the DSO's have more freedom in how they are going to fulfil their tasks as explained in the previous section.

To sum up, the Smart grid changes the position of the DSO's. The position becomes more powerful, more complex and closer to the other actors.

5.5 Smart Grids and the interaction of the DSO with government, regulator and consumer

The Smart Grid innovation does change the interactions of the DSO with government, regulator and consumer. The DSO is going to cooperate closer with the government in order to facilitate the transition to Smart Grids. However, there are some differences between the smaller and larger DSO's.

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[3] As mentioned in the introduction, we decided use the term DSO to ensure international understanding. Despite the fact that the regional netoperators in the Netherlands cannot be called DSO's yet.

5.5.1 The interaction with the government

The government in the institutional setting of the DSO can be both the national or local government. The national government is represented by the minister and the ministry of economic affairs, while the local government concerns the municipality in the region of the DSO.

In the current situation the interaction with the government differs between the larger and the smaller DSO's, as turned out during the interviews. The larger DSO's are more equal to the government than the small operators. The larger DSO's discuss with the ministry about what they want to do and how the energy transition should continue, while the smaller DSO's leave this up to Netbeheer Nederland. This way the smaller DSO's are not able to promote their individual interest because Netbeheer Nederland represents all the Dutch DSO's. The government is able through decision and policies to give the DSO more freedom or to allow the DSO to do other activities than prescribed. The smaller DSO's see the government as the leading actor. One of the smaller DSO's described during an interview: the government is the one who makes decisions, we provide the options and do what the government asks us to do. The local government also influences the DSO. Municipalities and provinces are stakeholders of DSO's. What their influence is on the DSO's is point of disagreement among the DSO's. Some say that the local government influence the DSO's by setting goals which the DSO has to meet. Other mentions that the local governments do not try to influence them.

The implementation of Smart Grid requires some changes in the interaction with government. However, there is a difference between the perspective of the smaller and larger DSO's. Since policies and laws need to be adjusted to the Smart Grids situation, a close cooperation between the government and the DSO is necessary. Especially the larger DSO's see an important role for themselves in leading the transition, facilitation and operationalisation of Smart Grids. By engaging in different pilot projects, the DSO's are gaining experience with what the best way is to organize the Smart Grid. They want to share this knowledge with the government. How they are going to do this, differs between the large and the small DSO's. The larger DSO's want to lead the government during the transition to Smart Grids. They want to provide input and expect the government to adjust the policies and relevant directives to the wishes of the operators. The same goes for the working Smart Grids. The DSO wants to be the facilitator with the help of the government. This means that they need to have more freedom than that they have now. The tasks which has been described currently in the electricity law are insufficient to perform the role of facilitator of Smart Grids. As shown in the previous section, the DSO's expect to fulfil more tasks in the smart grids context than in the conventional grid. According to the larger DSO's, it is up to the government to change the laws and policies in such a way that the

DSO can facilitate and manage the Smart Grid.

The perspective of the smaller DSO's is different from the larger DSO's. The smaller DSO's also engage in pilot projects and gain in this way experience with organizing the smart Grid. They also want to share their experience with the government. However they want to organize the cooperation in a different way. They want to provide options based on their experience to the government. It is then up to the government to choose which option should be followed and how the government wants to organize it.

Therefore, based on the necessity to change policies and regulation due to Smart Grids and the wish of the DSO's to facilitate the implementation and the operationalisation of the Smart Grids, the interaction with the government changes. The DSO's will have more influence on the government and will closer cooperate than before.

5.5.2 Interaction with the ACM

The interaction of the DSO with the ACM only partially changes due to Smart Grids. The ACM will remain the regulator who approves the tariffs of the DSO and monitors the activities of the DSO, but the norms on which this is based will change.

Currently the ACM has a lot of influence on the DSO based on the tasks which the ACM has with regard to the DSO's. Those task have been described in article 36 of directive 2009/72/EG

- Approving the distribution tariffs.
- Making sure that the DSO is fulfilling its duties.
- Providing information to government about the activities of the ACM.
- Monitoring the execution of rules regarding the tasks and responsibilities of the DSO.

Especially the tasks of approving the tariffs gives the ACM a lot of influence on the DSO. The ACM determines by which percentage the tariff are allowed to increase or have to decrease. DSO's who perform their tasks well, are allowed to charge higher prices than the less well performing DSO's. This way the ACM stimulates the DSO's to perform in the best way they can. This can also be found back in the section about the payoff rules.

Furthermore, the monitoring of the execution of rules regarding the tasks and responsibilities give the ACM influence on the DSO. An example of this is the statement the ACM made about the side-activities of the DSO. The ACM stated that they do not want DSO's to engage in commercial activities which could have done by the market. Actors from the commercial market should exploit the opportunities of sustainable energy resource, according to the ACM. The DSO has benefits which commercial actors do not have, which would make the DSO engage in unfair competition(ACM, 2015).

Regarding the ACM, there is a difference between how the large and the smaller DSO's perceive the relationship between the DSO's and the ACM. They all see the regulator as an institution which monitors their activities. The DSO's perceive this as necessary to avoid abuse of their monopoly position. The way how the DSO's perceive the rules, role and demand of the regulator to give up side activities differs among the DSO's. The larger DSO's feel more freedom to do what they want. They accept the rules of the ACM and the fact that they are not allowed to engage in side-activities. However the larger DSO's negotiate with the ACM about what they want and they are sure to work it out. They are sure the ACM understands the necessity of energy transition and willingness of the DSO to play a role in this transition. This can also be found back at the payoff rules.

The smaller DSO encounter the role and rules of the ACM as more strict. One of the smaller DSO's described the ACM as a police officer watching us. The tasks which has been described in the law determine the what the small operator does. One of the smaller DSO's does engage in side-activities but actually want to quit it because they are afraid that the ACM will forbid them to continue which makes the turnout unsure. Another smaller DSO does not want to engage in those activities because they think they cannot carry the social responsibility. Another smaller DSO only engages in side-activities when the government gives them explicit permission.

This interaction with the ACM will only partially change due to Smart Grids. The DSO's agree with each other in the interviews that there should still be a regulator who prevents them from taking advantages of their monopoly position. The ACM should remain the regulator who monitors the DSO's. This monitoring should be based on the same criteria as before, according to the DSO's. Thus the ACM should look at the how the DSO's manage to ensure the reliability, safety and stability of the electricity net for a fair price. The norms which have to be kept in mind to measure this should be adjusted to the Smart Grids situation. One of the smaller DSO's expects that the norms in the smart grids context to be higher than in the conventional situation because he expects the consumers to expect more since they have through the smart application more insight in the process of electricity. Those changing norms can also be found back at the changing payoff rules. Nevertheless, the interaction with the ACM will still be determined by ACM's tasks to approve the tariffs and monitor the activities of the DSO's. In the conventional situation there already is a distinction between the perspective of the smaller and the larger DSO's on their relationship with the ACM. Both the smaller and the larger DSO's stated that its relationship with the ACM should remain the same, so the difference also remains the same. The smaller DSO's will be following what the ACM says and stick to the laws and regulations, while the larger DSO's will negotiate with the ACM what they are going to do.

To be able the fulfil the role and tasks as envisioned, the DSO's need more freedom from the ACM. They need the permission from the ACM to fulfil more tasks than they currently do. As the larger DSO's have the freedom to negotiate with the ACM, this is possible for the larger DSO's to reach. The smaller DSO's follow what the ACM wants. Therefore, a shift should take place at the ACM to enable the DSO's to do the tasks which they envisioned

5.5.3 Interaction with the consumer

The Smart Grids innovation changes the interaction of the DSO with the consumer drastically. It shifts from limited interaction to close cooperation.

In the current setting is a lot of distance between the DSO and the consumer. The DSO is obliged to connect the consumer to the grid. The majority of the consumers is not interested in energy, as long as it works properly and is cheap, according to the DSO's. One interviewee described consumers as passive. Currently the DSO's are trying to engage the consumer more in energy transition. They are offering the consumer smart metering which enables the consumer to get more knowledge about their electricity use. Moreover the DSO's invite consumers to participate in pilotprojects. This increases the active participation of consumers in the electricity process. This means the connection between the DSO and the consumer is getting a bit closer. On the one hand, the consumer does not have much influence on the DSO since they cannot chose them. On the other hand, the consumer does have influence on the DSO through the ACM. The regulator organizes consumerpanels through which consumers can rate the quality of the service of the DSO.

The interaction between the consumer and the DSO will change drastically due to Smart Grids according to the DSO's. This will happen for several reasons. Firstly, all the DSO's agreed in the interviews that closer cooperation between them and the consumers is necessary in case of Smart Grids. They expect a more active role of the consumer who takes more initiative. The DSO also claimed to be willing to listen to the wishes of the consumer. If the consumer want PV panels, the DSO is going to facilitate this. They want to help the consumer to deal with energy in a smarter way. Secondly, the DSO will be involved in matching the local demand and supply. Close cooperation with the consumer is needed in order to reach that. The system shifts from demand oriented to supply oriented. Therefore the DSO has to make sure that the consumer is using the electricity when the supply is high. To manage this, the DSO has to cooperate with the consumer closely. Thirdly, the smart grids enables the consumer to feed its produced electricity to the grid. The DSO has to cope with this supply. Lastly, the Smart Grids also facilitates the cooperation with the consumer. Due to the Smart applications the consumer has access to data about the supply and demand of energy and therefore can adjust its behaviour to it. The DSO is responsible for distributing those flows of data and electricity and the DSO is responsible for matching the local demand and supply.

5.6 Conclusion

The changes which the Smart Grid causes in the biophysical conditions, the attributes of the community and the rules-in-use show that the institutional setting in which the DSO operates changes.

Based on the changing institutional setting of the DSO, we can draw conclusion on how the tasks, position and interactions of the DSO change due Smart Grids.

Firstly, the amount and content the tasks of the DSO changes. The DSO will be fulfilling more and different tasks than in the current setting. The way in which those tasks are fulfilled also changes; the DSO's will have more freedom and input in how the tasks are executed. They will not be the only actor who will be executing the tasks, it can also be done by other actors. The tasks in general will become more complex; the DSO will be operating on different levels and has to take care of more resources and bidirectional flows of both data and electricity.

Secondly, the position of the DSO changes due to Smart Grids. The position of the DSO becomes more complex, powerful and closer to the other actors than in the current setting. The DSO shifts from being in an executive position in which he manages the electricity network to a facilitator who actively contributes to how the grid is organized and who is now responsible for different levels of the electricity system. The position becomes more complex due to the broader tasks which come along with the Smart Grids. This forces the DSO to be active at multiple levels of the system. This gives the DSO also a more powerful position. The position becomes more powerful because the larger DSO's want to facilitate the transition and operationalisation of Smart Grids. The smaller DSO's also want to provide input on how the grid should be organized but leave it up to the government how to do that.

Thirdly, based on the necessity to change policies and regulation due to Smart Grids and the wish of the DSO's to facilitate the implementation and the operationalisation of the Smart Grids, the interaction with the government changes. The DSO's will have more influence on the government and will cooperate closer than before. The larger DSO's will be leading in the process, while the smaller provide their input.

Furthermore, the interaction with the ACM will only partially change due to Smart Grids. The ACM remains a monitoring regulator who should prevent the DSO's from taking advantages of their monopoly position. This monitoring is based on the same criteria as before. Thus the ACM should look at the how the DSO's manage to ensure the reliability, safety and stability of the electricity net for a fair price. The norms which has to be kept in mind to measure this should be adjusted to the Smart Grids situation. Moreover, the interaction with the consumer drastically changes. The DSO's will closely cooperate with the consumer in order to make the Smart Grids work.

6. Conclusion

Based on a changing institutional setting combined with the perspectives of the DSO, we analysed how the position, tasks and interaction of the DSO changes. This answers the main research question, which stated:

Does the Smart Grid innovation change the position and tasks of the DSO in the management of the electricity grid and the relationship with the regulator, consumer and government and if yes in what way?

Tasks

The Smart grid innovation indeed changes the tasks of the DSO in the management of the electricity grid. It changes in the first place, the amount and content of the tasks of the DSO. The DSO will be fulfilling more and different tasks than in the current setting. Distributing electricity and managing the grid will not be their only tasks anymore. The DSO will also be involved in among others matching the local demand and supply and providing data about the demand and supply of electricity, on top of the tasks they currently have. The way in which those tasks are fulfilled also changes; the DSO will have more freedom and input in how the tasks are executed. They will not be the only actor who will be executing the tasks, it can also be done by other actors. The tasks in general will become more complex; the DSO will be operating on different levels and has to take care of more resources and bidirectional flows of both data and electricity. The most important change is that the larger DSO are determined to facilitate the transition to and the operationalisation of Smart Grids.

Position

The Smart Grid Innovation indeed changes the position of the DSO. The position of the DSO does not only become more complex, powerful, but also closer to the other actors than in the current setting. The DSO shifts from being in an executive position in which he manages the electricity network to a facilitator who actively contributes to how the grid is organized and who is now responsible for different levels of the electricity system. The main reason why the position of the DSO becomes more complex is due to the fact that he has to fulfil broader tasks which come along with the Smart Grids. This forces the DSO to be active at multiple levels of the system. This gives the DSO also an powerful position. The position becomes more powerful because the larger DSO's see themselves as facilitators of the transition and operationalisation of Smart Grids. The smaller DSO's also want to provide input on how the grid should be organized but leave it up to the government how to do that.

Interactions

The Smart Grid innovation changes the interaction with the government, the interaction with the consumer drastically and the interaction with the ACM partially. The interaction with the government changes based on the necessity to change policies and regulation due to Smart Grids and the wish of the DSO's to facilitate the transition from the conventional grid to the Smart Grid and the operationalisation of the Smart Grids. The DSO's see the need to have more influence on the government and to cooperate closer than before. The larger DSO's will be leading in the process, while the smaller provide their input. The interaction with the ACM will only partially change due to Smart Grids. The ACM remains the regulator who monitors the behaviour of the DSO's and who prevents them from taking advantages of their monopoly position. This monitoring is based on the same criteria as before. Thus the ACM should look at the how the DSO's manage to ensure the reliability, safety and stability of the electricity net for a fair price. The norms which has to be kept in mind to measure this should be adjusted to the Smart Grids situation. Moreover, the interaction with the consumer drastically changes. The DSO will closely cooperate with the consumer in order to make the Smart Grids work. The consumer will gain insight in the demand and supply of electricity and will be able to produce electricity.

Despite the limitations as mentioned in the methodology, we still provided an useful analysis of the organizational changes which the Smart Grid brings about and what this means for the DSO. We showed how the Smart Grid changes the institutional setting of the DSO. Combining this with the perspective of the DSO on how the Smart Grid creates changes for them, lead to a good analysis of how the position, tasks and interactions of the DSO are likely to change due to Smart Grids. It shows a drastic change in the institutional setting and the position, tasks and interactions of the DSO. Our analysis made those changes visible and allows the policymakers, DSO's and other actors to anticipate on this.

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