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Smart Grids, the Governance of Information Management and Regulation

thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Economics

Jacobs University Bremen

by

Marius Buchmann

Defense: October 19, 2016

Supervisors:

Prof. Dr. Gert Brunekreeft, Jacobs University Bremen

Prof. Dr. Christoph Lattemann, Jacobs University Bremen

Prof. Dr. Rolf Künneke, Delft University of Technology

Business & Economics

Declaration

I, Marius Buchmann, hereby declare, under penalty of perjury, that I am aware of the consequences of a deliberately or negligently wrongly submitted affidavit, in particular the punitive provisions of § 156 and § 161 of the Criminal Code (up to 1 year imprisonment or a fine at delivering a negligent or 3 years or a fine at a knowingly false affidavit).

Furthermore I declare that I have written this PhD thesis independently, unless where clearly stated otherwise. I have used only the sources, the data and the support that I have clearly mentioned.

This PhD thesis has not been submitted for the conferral of a degree elsewhere.

Marius Buchmann

October 25, 2016

Acknowledgements

This work is based on the support of many people. First of all, I would like to express my special gratitude to Gert Brunekreeft for the guidance and support. Thank you for encouraging my research and for allowing me to grow as a research scientist. It was a great pleasure to jointly work with you. Furthermore, I would also like to thank the two other members of the committee, Christoph Lattemann and Rolf Kuenneke for providing an outside view on the thesis. In addition to the committee, my colleagues at Jacobs University provided a fruitful environment to discuss many ideas, whether they were good or not. This especially goes out to Christine and Nele for the detailed discussions on the CIP, but Roland and Martin as well, who provided helpful comments on several ideas in this thesis. Besides the professional support from the committee and my colleagues, this thesis would not have been possible without having very special people in my corner. Here, I would like to thank my parents, my grandma and my brother for their encouragement and support in all my pursuits. Last and for most, there are two very important people I would like to thank: My daughter Laura and my wife Theresa. Thank you for your love, support and especially for your patience. Thank you!

Abstract

Information management is becoming a new stage in the electricity supply chain. The term information management here refers to the collection, processing, aggregation and distribution of data (e.g. from smart metering) in the electricity system. The primary driver for the development of this new task is the increasing share of renewable electricity supply (RES). Smart grids should deploy the efficient integration of RES into the energy system, i.e. information and communication technologies should be applied to the electricity distribution grids. The information management system should facilitate the data exchange within smart grids. This thesis takes an institutional perspective and addresses four key questions related to the governance of information management. Chapter 2 provides an analysis of the institutional environment of information management and discusses which role could become responsible for this new task. Building upon joined work with my colleagues I propose in chapter 3 a stakeholder-based governance approach for information management. The fourth chapter discusses whether a central or a decentralized governance approach for information management better facilitates innovation. Chapter 5 builds on the stakeholder based governance approach introduced in chapter 3 and discusses how the decision-making process could be designed to secure governance innovation and non-discrimination of third parties.

Contents

1 Introduction

The integration of renewable electricity supply (RES) into the electricity system requires an adaptation of the existing roles in the energy sector. Among other things, two developments are currently taking place. First, electricity generation based on RES is becoming decentralized. Here, decentralization refers to the local distribution of small electricity power plants (e.g. small scale photovoltaic power plants) as well as the decentralization of ownership of these generation assets (e.g. private households installing photovoltaic power plants on the roof tops of their houses). These decentralization trends challenge the established business models of the incumbents, which are based on the centralized power generation business from conventional power plants (Brunekreeft *et al.* , 2016a). The second current development is the increasing investment requirement for network operators. This investment requirement is primarily driven by the increasing feed-in from RES on the distribution grid level, which requires an increase of grid capacity. The overall costs of the grid integration of RES will be high, which drives the question how these costs can be reduced to a minimum. At this point industry and politics are standing at a crossroad where it needs to be defined whether traditional network expansion or new approaches (e.g. smart grid applications based on data exchange) are more appropriate to integrate RES into the networks at the lowest costs.

In the following paragraphs the current developments in the electricity supply chain, the role of smart metering and information management will be described. Section 1.2 focuses on the motivation of this thesis and section 1.3 provides an overview about the methodology and the theoretical background of the thesis. Section 1.4 summarizes the main contents of the thesis and provides a brief abstract of each paper.

1.1 Background

1.1.1 The electricity supply chain, unbundling and the coordination problem

The electricity supply chain consists of four main parts: generation, distribution, transmission and retail. In most countries the generation sector is dominated by central power plants (e.g. nuclear, fossil). Although these conventional technologies still provide the largest amounts in generation today, RES gained large shares (more than 30% of total electricity production in Germany in 2015) within the last two decades. In most countries the RES is physically connected to the distribution grid level. The distribution grids connect the smaller electricity generators and most consumers (e.g. households and commercial consumers) to the electricity system (distribution networks work with 110 kV or less). The distribution networks are connected to the transmission grids (220 kV and above), which transport electricity over larger distances. Furthermore, the large conventional power plants (hard coal, lignite, gas and nuclear) are connected to the transmission grid in most cases as well. Retail consists of the service providers who sell electricity to the costumers.

Within the last decades this supply chain was primarily shaped by the liberalization process (Joskow, 1996). Before liberalization, a hierarchical and integrated system existed in the electricity sector. Utilities were active in all steps of the supply chain with one and the same company. However, Joskow & Schmalensee (1983) pointed out that the introduction of competition in generation could increase the overall efficiency of the electricity sector. To exploit these efficiency potentials the European Commission introduced a liberalization process, which developed in three steps (1996, 2003 and 2007). Today, network unbundling is the norm: unbundling describes the separation of the electricity networks (natural monopolies) from the competitive parts of the supply chain (namely generation and retail). This means that the unbundled networks are owned and operated by (independent) companies that are not active in generation or retail. Vice versa, generation or retail companies do not own the networks. While the networks are regulated, generation and retail are liberalized, i.e. there exist competitive markets for generation and retail (for more information see Brunekreeft *et al.* (2016b))

Notwithstanding the advantages of promoting more competition, unbundling does have drawbacks and met with criticism. Joskow & Schmalensee (1983) already stressed that the unbundling of the networks, i.e. the separation of the different steps within the supply chain, will require complex coordination mechanisms (i.e. contractual relations) to substitute the previously internal planning processes of integrated utilities. At the heart of the discussion about the coordination mechanism are the transaction costs. Basically, information exchange in integrated utilities results in lower transaction costs as does the information exchange between separated entities, as long as the market has not established efficient coordination mechanisms. Coordination becomes especially relevant at the intersection between the networks and the electricity generation market. Here, a coordination problem evolves due to missing information exchange between the generation companies and network operators (see Brunekreeft & Meyer (2009) or Brunekreeft *et al.* (2016b) for details). The result of the missing information exchange and the weak coordination mechanisms is an increase in costs and a decrease in efficiency, especially on the distribution grid level (Niesten, 2010). Although the coordination problem has originally been a consequence of the liberalization process, its relevance increases with the diffusion of distributed generation based on RES as the number of parties that need to be coordinated within the network increases.

1.1.2 The investment need on the distribution grid level and smart grids

Due to the larger shares of RES on the distribution grid level, these low voltage networks start to face a significant need for reinforcement investments. In Germany, the current estimates are that investments on the distribution grid level for RES integration could add up to 49 billion € untill 2032, if the federal governments' goals for RES diffusion shall be met (see (dena, 2012) and (E-Bridge *et al.* , 2014)). 70% of these investments will already be required untill 2022 (E-Bridge *et al.* , 2014). These costs will have to be borne by the consumers, as the network investments are financed via network charges. However, besides traditional network expansion, there are other methods to integrate RES into the distribution grid level. Most prominently, the application of smart technologies (e.g. smart local power transformers) offers the potential to reduce the investment costs for RES integration. The application of smart technologies to the distribution networks is summarized under the headline of smart grids. The idea of the smart grid concept was described by the European Technology Platform for Electricity Networks of the Future (ETP SmartGrids) of the European Commission in (ETPSG, 2010):

> "A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both - in order to efficiently deliver sustainable, economic and secure electricity supplies. A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies [...]."

For Germany, the estimates are that smart grid applications can help to reduce the costs of RES integration by more then 20% (E-Bridge *et al.* , 2014) untill 2032. To exploit this costs saving potential, data needs to be available that gives information about electricity consumption as well as electricity production with a high granularity and frequency. The key technology that is required to make this data available is smart metering.

1.1.3 Smart metering and information management

According to the US Federal Energy Regulatory Commission (FERC) in FERC (2015) a smart or advanced meter is defined as

> "[...] a metering system that records customer consumption [and possibly other parameters] hourly or more frequently and that provides for daily or

> more frequent transmittal of measurements over a communication network to a central collection point."

The European Commission requires that each member state conducts a cost-benefit-analysis to evaluate to which extent the roll-out of smart metering is beneficial in each individual country (EUCOM, 2009). Based on the cost-benefit-analysis, 16 member states are planning to have a large-scale smart meter roll-out untill 2020. Seven cost-benefit-analyses did not justify a large scale roll-out, but in three countries (among them Germany) smart metering seems to be economically justified for specific costumer groups (EUCOM, 2014). Based on smart metering, large data sets are (or will soon be) available that should be accessible for all eligible parties in a neutral and non-discriminatory way.

The process of data exchange from smart metering has so far been summarized with the term *data handling*. However, data in smart grids does not only need to be allocated, but stored, aggregated and verified as well. The discussion therefore does not only describe the physical flow of data, but needs to address the management of the data exchange as well. I.e. the question needs to be addressed who should become responsible for the management of data exchange, the ICT-system design and the required infrastructure. This broader perspective on the design of the data exchange in smart grids can be summarized under the concept of information management. Information management is defined by (Voß & Gutenschwager, 2001). In the context of smart grids the information management system serves as an intermediary between the different actors in the energy system (consumers, produces, service providers etc.) and the physical layer of the electricity system, which consists of the electricity and ICT infrastructure (Jagstaidt *et al.* , 2011). The focus of this thesis is on the governance of information management, i.e. I take an institutional perspective and discuss who should become responsible for information management. An important issue in this context is the integration of third parties into smart grids and the data exchange related to the distribution grids. The governance of information management should facilitate the introduction of third parties in the data exchange.

1.1.4 Third parties

From an economic perspective, the primary goal of the governance approach for information management is the neutral and non-discriminatory access to data for all eligible parties. Besides the incumbent actors who might be eligible to receive and process data from smart metering, there are new market parties (e.g. from the ICT sector or startups) that can become eligible parties as well. Third parties are all those actors that are non-incumbents in the electricity sector. Furthermore, incumbents from the energy sector can be third parties as well, if they become active in a new business area or a new part of the supply chain. These new market participants emerge in different parts of the energy supply chain, but most prominently in electricity generation. Private as well as institutional investors focus on investments in renewable electricity supply (RES). In Brunekreeft *et al.* (2016a) my colleagues and I argue that the emergence of third parties has already started to alter the energy sector in Germany. We show that similar developments take place in other European countries as well. As third parties become active in every step of the electricity supply chain, they gain relevance for the data exchange in smart grids, too. On the one hand, some third parties might be in the position to provide data, e.g. on generation from RES, consumption and flexibility potential. On the other hand, third parties might as well offer new services and products to the market based on the data about energy consumption and generation. For example, virtual power plant operators are currently emerging in the energy market. Virtual power plants make use of distributed generation and consumption by aggregating their joint capacities (sometimes together with conventional generation capacities) and by selling them on the electricity markets. In 2013, already 20 medium-sized companies (most of them third parties) operated virtual power plants in the German electricity market (Brunekreeft *et al.* , 2015). One key issue for the governance of information management in smart grids then is to secure that the innovation potential of third parties can be exploited. Within the thesis I discuss how the governance approach can address this challenge.

1.2 Motivation

This thesis was mainly motivated by discussions on the European level on how to organize the data exchange from smart metering. The European Commission recognized that the mandatory roll-out of smart metering requires a discussion to define how the data from this metering infrastructure shall be exchanged and managed. Therefore, the Commission delegated this task to the European Commissions Task Force Smart Grids. Within this Task Force, an expert group discussed potential concepts on how to govern the data exchange from smart metering. The following three competing models were eventually considered most promising (SGTF, 2013):

1. Third Party Market Facilitator, i.e. a regulated national data hub
2. DSO as Market Facilitator, which delegates the responsibility for information management to the distribution grid operators.
3. Data-Access Point Manager: A standardized IT-interface which should secure data security and privacy, but leave everything else to the market.

These three concepts rely on several assumptions, but these assumptions have not yet been analyzed from an academic perspective. However, such an academic view is required as the proposed governance approaches are so far based on very different assumptions and result in very different outcomes. Therefore, this PhD project strives to address some of these assumptions and provide academic backup on them.

First of all, the question evolves whether information management needs to be a regulated task. This is an important question as two out of the three proposed models actually are regulated approaches. However, regulation is not always the best solution to secure efficiency. Therefore, in chapter 2 of this thesis this specific question will be addressed.

Second, even though the DSO is an important party in the context of smart grids, this does not imply per se that the network operator needs to be in charge of the information management system. So far, there have been two detailed studies about the role of the DSO in the context of information management Ruester *et al.* (2013) and van den Oosterkamp *et al.* (2014). Both studies point at the important role of the DSO in the given context of smart grids, but also raise important concerns of discrimination. Within chapter 2 and chapter 3 the analysis picks up the status quo of the current debate and goes a step further by discussing how the different governance approaches for information management (which might not include the DSO) can help to increase coordination on the distribution grid level (between the market and the network operators, for details see section 1.1.3) and facilitate the development of competitive markets based on the data available in the information management system.

Third, even though the consumers are going to be an important part in the future smart gird, the governance approaches described above do not directly involve them. In this context the question is raised whether it is possible to define a governance approach that incorporates all relevant stakeholders (including the consumers) into the decision making process. Chapter 3 addresses this question in greater detail.

Fourth, the first two models introduced above (Third Party and DSO as Market Facilitator) imply a restriction on the size of the information management systems. The third party model a national information management system, while the DSO approach can result in a very fragmented system (e.g. in Germany exist nearly 900 DSOs) or a very concentrated system with very few management systems (e.g. in the Netherlands are eleven DSOs active). The Data-Access Point Manager, however, takes a different perspective by leaving the decision about the size of the management systems to the market. Within chapter 4 the discussion focuses on the specific issue of how the optimal size of the governance approach for information management can be determined.

Fifth, smart grids as well as information management are new concepts in the energy sector. Therefore, both face significant potential for innovation. The question then is whether the different governance approaches are capable to facilitate these innovations. Here, I refer to governance innovation, i.e. the flexibility of the governance approach to adapt to changing circumstances. In chapter 5 of this thesis the potential for governance innovation is analyzed in greater detail for the stakeholder-concept as it was introduced in chapter 3.

1.3 Theoretical Background and Research Approach

This thesis has a micro-economic approach and applies an institutional perspective to the evaluation of the governance of information management.

The research presented in chapter 2 and 3 is based on New Institutional Economics. In chapter 2 the specific focus is on the institutional environment of information management and how it relates to the governance approach of information management. Chapter 3 picks up this analysis and evaluates how a governance approach could be designed. Based on the results of the analysis in in chapter 2 and 3 the research in chapter 4 and 5 then extends the theoretical perspective to Public Choice Theory. In these chapters the primary focus is on the decision processes that shape the governance design of information management in smart grids. Chapter 4 analysis the size of the governance approaches for information management based on the insights from Fiscal Federalism (Oates, 1972). Fiscal federalism is applied to define the size of the governance approaches based on the consumers preferences. In Chapter 5, the analysis focuses on the decision-process within the governance of information management. Here, the Veto-Player Theory (Tsebelis, 2000) is applied to understand how decisions are made within the specific governance approach that was designed in chapter 3. In the next paragraph the theoretical approach is described in greater detail.

New Institutional Economics was structured by Williamson (2000) into four levels of social analysis. These four levels are social embeddedness (norms, traditions), the institutional environment (formal rules like laws), governance (contractual relations) and resource allocation and employment (prices and quantities). The institutional environment can be understood as the formal rules of the game, e.g. laws. The institutional environment sets the scene for the discussion of the governance of information management. There are several aspects, which need to be defined on this level, for example privacy policies for data exchange from smart metering etc. Furthermore, the current structure of the energy sector, which separates the electricity networks (as they are natural monopolies) from the competitive parts of the supply chain (namely generation and retail) is defined within the institutional environment. Therefore, in chapter 2 the current institutional environment of information management in smart grids is analyzed in greater detail.

For the analysis in this thesis it is of particular importance how the institutional environment influences the governance level. The governance of contractual relations is the third level of social analysis in New Institutional Economics. The governance can be defined as the play of the game. On this level Williamson (2002) puts vertical integration at the heart of his discussion about the governance of firms, which face the decision to make or buy, i.e. integration versus purchase. His approach is based on transaction cost theory, which goes back to Coase (1937). I pick up the discussion about transaction costs in chapter 2 and discuss how the transaction costs on the distribution grid level (specifically the transaction costs for the coordination between the network operator and the network users) might be affected by different governance approaches for information management. This analysis takes into account the institutional environment as well and discusses potential changes within the institutional level to reduce the transaction costs on the governance level. Chapter 3 builds on this analysis and provides a stakeholder-based concept that strives to reduce transaction costs (related to coordination) given the current institutional environment of the energy sector.

Chapter 4 applies insights from Public Choice to define the size of the governance approaches for information management. Here, the theory of Fiscal Federalism (Oates, 1972) provides the basis. First, information management is characterized as a club good/local public good (Buchanan (1965) and Tiebout (1956)) to evaluate different design options for the size of the governance approach for information management. Then, the analysis focuses on the relation of the size of the governance approach and the level of innovation on the governance level (i.e. governance innovation). Here, the insights from laboratory federalism (Oates, 2008) are applied to define the optimal size for the governance of information management.

In chapter 5 the analysis focuses on the process of decision making within the governance layer. The evaluation in this chapter applies the Veto-Player Theory (Tsebelis, 2002), which has its roots in the analysis of political institutions. The Veto-Player Theory allows to analyze the influence of voting processes on the potential for governance innovation (i.e. the ability of the governance approach to adapt to changing requirements). Governance innovation is of particular importance in the case of information management, as the information management system itself as well as the environment of information management (namely smart grids) are still in their introduction phase. Therefore, the governance approach needs to be able to adapt to the changing environment and requirements for information management to secure efficiency.

1.4 Contents of the Thesis

Driven by the need to reduce CO_2 in the energy sector, the diffusion of RES is accelerating. Projections are that by 2040, RES will account for a share of 50% in the European Union, around 30% in China and Japan, and above 25% in the United States and India (IEA, 2015). Most of these renewable capacities will be connected to the distribution grids. Driven by the RES expansion, the investment requirement on the distribution grid level will increase significantly as well. The case of Germany currently illustrates that there are two options to address this investment requirement: copper (i.e. grid expansion/reenforcement) versus smartness. First, distribution grids could be reinforced and extended in the traditional way: the copper solution. This is going to be very costly as has been described in the first part of this introduction. Alternatively, smart grid technologies could be applied to integrate RES at lower costs. Basically, the idea behind the smart grid applications is that the integration of ICT into the electricity networks (e.g. via smart metering) makes more data available and that this data can be used to operate the electricity system more efficiently. Thereby, the exchange of data gains significant relevance in the context of smart grids. Actually, data exchange is going to be the enabler of smart grids. The management of the data exchange in smart grids therefore becomes a new and important step in the electricity supply chain. This new task is summarized under the before mentioned term "information management system".

The thesis focuses on this new task within the supply chain. Basically, the idea behind the information management system is that it should secure that data is available for all eligible parties at low transaction costs. In order to meet this demand, three aspects have to be considered: First, the information management system needs to facilitate the coordination between the network operator and the network user. Thereby, the information management system will increase coordination in the electricity supply chain, especially between the networks and the market. Second, the information management system needs to create a level playing field for the market to develop new products and services based on the data available in smart girds. These new products will then increase efficiency in the energy system, i.e. they will help to reduce costs. The level playing field approach implies that the new market parties (third parties) do not face market entry barriers that keep them from providing their service. This is especially important for the level of innovation within smart grids, as third parties might offer a high potential for new products and services that might not be developed by incumbents. Therefore, the governance of information management should foster innovation to secure that the information management system can adapt to future developments. This aspect pays special credit to the high uncertainty related to the future development of smart grids. This then is the third aspect which will be addressed in this thesis.

The analysis in this thesis is subdivided into four parts, each of which is addressed in one of the following chapters. Each chapter is based on a research paper.[1] First, the institutional background of information management is analyzed in detail. Against this institutional background, the governance models currently discussed in literature are evaluated. The evaluation specifically focuses on two criteria: the influence of the different governance models on the competition-coordination trade-off on the distribution grid level. This analysis leads to the conclusion that none of the currently discussed concepts reaches a balance between coordination and competition. Therefore, the second part of the thesis focuses on the development of a new governance model, which can provide this balance. The proposed governance model is based on a stakeholder-based decision making body, which my colleagues and I named Common Information Platform (CIP) (Brandstaett *et al.* , 2017). Within this part of the analysis we define what such a governance approach could look like and discuss its strengths and weaknesses compared to the existing approaches in literature. In the third part, I focus on the question of how many governance approaches might be required for information management (central vs. decentralized governance). This evaluation focuses on the relation between the size of the governance approach and the potential for innovation. Innovation here refers to the capability of the governance system to adapt to changing circumstances. The analysis concludes that neither central nor pure decentralized governance approaches are optimal for the case of information management. Therefore two options of how the optimal degree for decentralization can be determined are discussed. The final part 4 discusses how the decision making process within a governance approach can be designed to secure governance innovation and non-discrimination of third parties at the same time. The basis of this analysis is the CIP, the governance model proposed in part 2 of this thesis. The fourth part of the analysis develops a decision-making process based on collective veto players.

[1] Paper 2 (basis for chapter 3) is already accepted for publication, the other papers are under revision at different peer-reviewed journals.

Within the following each step of the analysis is summarized in more detail.

1.4.1 The current governance approaches for information management in smart grids

Chapter 2 introduces the concept of information management and addresses the question of what a governance approach for information management could look like, i.e. it is discussed who should become responsible for this new task in the electricity supply chain.

Based on an analysis of the institutional environment of information management I identify four different roles that could become responsible for the governance of information management. For each role it is being discussed what a governance model could look like. This then leads to the definition of three potential concepts for the governance of information management:

1. Information management as a monopoly provided by an established or new party in the energy sector.
2. Information management as a task of the (distribution) network operators
3. Information management as a new service provided by the market, i.e. provided by the actors (incumbents or third parties) from the competitive parts of the energy supply chain (generation, retail).

For each of the three concepts I discuss the following question: Does the governance approach increase coordination (between the network and the network users) and promote competition?

I conclude that neither of the identified roles within the energy sector governing information management could secure both coordination and competition, at the same time. Therefore, new governance approaches (or new roles) are required if we stick to the assumption that the governance for information management should enable both coordination and competition.

1.4.2 Balancing between competition and coordination in smart grids - a Common Information Platform (CIP)

In chapter 3 my colleagues and I pick up the challenge (identified in chapter 2) to define a governance approach for information management that balances between coordination and competition in smart grids.

The starting point of our analysis are the current European discussions about the governance of information management. Three different governance concepts are at the heart of this discussions:

- Third Party Market Facilitator (national monopoly with one facilitator)
- DSO as Market Facilitator (DSOs govern information management)
- Data Access Point Manager (market-based concept with standardization)

Based on the inputs from the analysis in chapter 2 of this thesis, we evaluate these European models against three criteria: coordination, competition and the requirement for regulatory oversight. Again, my colleagues and I conclude that neither of the proposed governance models fulfills all of the three criteria.

Therefore, we propose a new governance approach, the Common Information Platform (CIP). Basically, the CIP is a rule-making institution for information management. It ensures neutrality by involving all eligible stakeholders. The CIP unbundles information and data management from all other activities in the energy sector, not the network. The basic outline of the CIP is derived from the Independent System Operator (ISO) model. Based on the ISO model we define the basic functionalities of the CIP and describe how this approach can fulfill the above mentioned three criteria. Thereby, we provide a first overview about additional design options which need further specification. Among these are

- membership and eligible stakeholders
- decision-making and voting rules
- scale and scope of the CIP

These issues are specified within the following chapters in this thesis.

1.4.3 Information Management in Smart Grids - the need for decentralized governance approaches

In chapter 4 I address the question of the scale and scope of the governance approaches for information management. Here, the analysis focuses on the relation between the size of the governance approach, i.e. the number of users connected to an information management system or the region covered by it, and the level of governance innovation. Governance innovation here refers to the ability of the governance system to adapt to changing requirements.

The analysis in this chapter is based on insights from the theory of fiscal federalism. This theory postulates that decentralized governance approaches better facilitate innovation than central governance approaches, as long as preferences are heterogenous and economies of scale are not relevant. For the case of information management I show that both exist, heterogenous preferences and economies of scale. Therefore, neither a centralized nor a purely decentralized governance approach for information management is the optimal choice. Therefore, we need to find the optimal degree of decentralization (the balance between the two extremes). I discuss two options to find the optimal degree of decentralization: governmental decision and a market-based approach.

Importantly, there needs to be a link between the network and the information management system, as the benefits from information management with respect to coordination can only evolve if the network operator and the network users share the same information management system. To address this issue I analyze the conditions which need to be met if the size of the governance on information management shall be linked to the operation area of the distribution grid operators.

I conclude that the network operator needs to be able to incentivize the network users participation in the same information management system to increase efficiency within smart grids.

1.4.4 Integrating stakeholders into the governance of data exchange from smart metering - How the voting process can balance between non-discrimination, transaction costs and innovation

Chapter 5 addresses the decision-making process within a collaborative governance approach (like the CIP model in chapter 3) The primary question here is how a decision process needs to be designed to secure governance innovation and non-discrimination of third parties at the same time.

To answer this question I apply the veto player theory to show for the case of information management that unanimous voting (based on *individual veto power* like the one-man-one-vote approach) is likely to hinder governance innovation. Therefore, I propose to apply the concept of *collective veto players* for the decision making within the governance of information management. Furthermore, I discuss how the collective veto players decide on their veto. To avoid third party discrimination I propose that each collective veto player requires a qualified majority from its members to vote on a veto against an issue.

For the case of a collaborative governance approach for information management I conclude that governance innovation and non-discrimination of third parties can only be secured at the same time if the decision making process is based on *collective veto play-*

ers that make use of their veto power based on a qualified majority vote.

1.5 Conclusion and Outlook

This thesis provides an institutional analysis of the governance of information management in smart girds from a micro-economic perspective. Within the thesis I apply insights from New Institutional Economics and Public Choice to the research area of information management. Based on the analysis in this thesis I conclude the following:

- If one of the existing roles (i.e. one actor from these roles) in the electricity supply chain (generation, network, retail) becomes responsible for the governance of information management, then this will in every case result in a tradeoff between coordination and competition.
- This tradeoff could be addressed by a collaborative governance approach, the Common Information Platform. The CIP is a stakeholder-based decision body that unbundles information management from the other stages in the electricity supply chain.
- Governance innovation for information management requires a certain degree of decentralization. The optimal degree of decentralization should be defined by the market and not the government.
- The decision-making process within a collaborative governance approach (like the CIP) should be based on collective-veto players to secure governance innovation. To avoid third party discrimination the collective-veto players choice to vote a veto should be based on a qualified majority vote.

The discussions within this thesis are not conclusive. Further research is required to specify how the governance of information management in smart grids should be designed. Importantly, I did not discuss other than institutional aspects in my thesis. However, there are other relevant issues that need further investigation, e.g. privacy issues etc. However, even from an institutional perspective there are many open questions that need further elaboration. I just want to stress some of the topics that directly evolve from the work in this thesis. For example, the CIP concept needs further specification with respect to membership rules and its tasks. Especially, it should be discussed how the public agencies and the CIP could cooperate and where the authority of the CIP ends. Another interesting question evolves in the context of the size of the governance approaches. Here, it needs further evaluation under which conditions the market will succeed to define the optimal size (i.e. the optimal degree of decentralization) on the governance level. Furthermore, the incentive the network operator could use to incentivize network users to join the same information management systems needs further elaboration: Can we use network tariffs for this? Another question that I could not address in this thesis relates to the decision-making process within the CIP or other collaborative governance approaches: Do we need to define a uniform decision rule for the collective-veto players to decide on a veto or can we think of a more differentiated process that allows to apply different voting schemes depending on the importance of the issues under decision?

This thesis provides the first institutional analysis of the governance of information management. The results derived within the analysis shall provide a basis for the further investigation of this issue, especially in the scientific debate, which starts to evolve right now.

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2 Who should govern information management to balance between coordination and competition on the distribution grid level?

Marius Buchmann

Smart grids should increase the coordination on the distribution grid level and facilitate new market opportunities (I.e. competition on a level playing field). Information management is becoming a new task in the electricity supply chain. It is an enabler for the development of smart grids. Therefore, the governance of information management should as well efficiently balance between coordination and competition. Within this paper we analyze which role from the energy sector could govern the information management system. We conclude that neither of identified roles within the energy sector governing information management could secure both coordination and competition at the same time. Therefore, new governance approaches (or new roles) are required.

Keywords: Smart Grid, Information Management, Governance, Integration, Unbundling

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2.1 Introduction

To reduce the costs of the integration of renewable generation into the distribution grids the exchange of data about demand, supply and potential flexibilities needs to be organized in a neutral and non-discriminatory way. This insight is derived from the current discussions in Germany about the costs related to the energy transition. Among others, a key driver for these costs are the distribution networks. Significant investments are required for these networks to secure the integration of renewable energies within the next decades. However, network expansion is costly. Alternative approaches that secure the integration of renewables into the distribution grid are based on information and communication technologies (ICT). These ICT-based approaches are discussed under the headline of smart grids. Though there are various definitions for smart grids, it is the definition of the European Technology Platform for Electricity Networks of the Future (ETP SmartGrids) of the European Commission which underlies the current scientific discussion. It states:

> "A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both - in order to efficiently deliver sustainable, economic and secure electricity supplies. A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies [...]." (ETPSG, 2010, p. 6)

The concept of smart grids is applied to the distribution grids, i.e. the low-, medium- and high-voltage grids[2]. dena (2012) calculated that smart applications based on ICT could reduce network investments on the distribution grid level till 2032 by 45%[3]. Similar results were developed by E-Bridge *et al.* (2014). They calculated that the total costs for distribution network expansion in Germany could be reduced by 60%.

The results of these studies illustrate that the implementation of ICT in the distribution grids can secure the integration of RES at lower costs than traditional network expansion. Our analysis focuses on two important effects of smart grids: First, smart grids should increase coordination

[2] in Germany distribution grids are defined as the networks up to 110kV, transmission networks operate at 230 kV or 400 kV

[3] this number does not include the costs for the operation and maintenance of additional components in the distribution grids. Therefore, the cost reduction potential will in total be lower than 45% but still significant

between the network operator and the network user. Thereby, investments in the network should be avoided as long as there is a cheaper alternative, e.g. load shifting. Second, smart grids are supposed to facilitate new business opportunities for market parties. I.e. it is expected that smart grids will increase competition in the electricity sector.

With an increasing share of ICT in the distribution grids the amount of data exchanged to operate the system increases as well. At the same time, more parties become active in the data exchange, e.g. distributed generation owners, storage providers or consumer participating in demand side management programs etc. These parties might be incumbents from the energy sector, but new market entrants as well.[4] The data exchange between the participants in smart grids, i.e. the data handling, is becoming a new and important step in the electricity supply chain. From an institutional perspective the primary task of data handling is to secure that all eligible parties have the same access to the same data, i.e. data handling needs to secure a level playing field. The question then becomes, who should become responsible for this task? We address this question in the following sections.

We acknowledge that several aspects need to be addressed in this context, from sustainability issues, to privacy concerns and IT operations. Our analysis focuses on an economic evaluation from an institutional perspective and on the question which party should become responsible for the operation of the information management system. The paper is structured as follows: In section 2 we pick up the current discussion on data handling and define information management in smart grids. Section 3 specifies the institutional environment of information management in the energy sector. Here, we will introduce the liberalization process that took place in the energy sector to define the different roles that could become responsible for the information management in smart grids. Section 4 discusses resulting governance approaches for information management based on the identified roles. Specifically, we discuss three cases:

1. Information management as a monopoly provided by an established or new party in the energy sector
2. Information management as a task of the (distribution) system operators: For the network operators we discuss two options; either information management as part of the regulated

[4] These new market parties can be defined as third parties. A detailed analysis of the increasing role of third parties in smart grids was developed by Brunekreeft *et al.* (2016)

business (i.e. an integrated task) or in the responsibility of the network operator, but separated from the regulated business, e.g. via firewalls as we know them from the unbundling process.

3. Information management as a new service provided by the market, i.e. the actors (incumbents or third parties) from the competitive parts of the energy system (generation, retail) could become responsible for information management.

For these three cases we will discuss how they affect the coordination process between the distribution system operator (DSO) and network users in smart grids. We show that from a transaction cost perspective the case that the DSO integrates the information management into his regulated business seems favorable. However, this might result in incentives for the DSO to discriminate non-associated market parties. Here we identify a tradeoff between coordination and competition. To address this tradeoff Ruester *et al.* (2013) propose further unbundling of the DSOs. We will pick up this proposal and discuss potential shortcomings of such a governance approach for information management. Section 5 concludes that neither of the identified roles in the energy sector could govern information management and at the same time balance between coordination and competition.

2.2 The Current Discussion on Data Handling from Smart Metering and the Definition of Information Management in Smart Grids

The research about the governance of information management is evolving from the discussions about the smart meter rollout in Europe. The European Union requires each member state to rollout smart meters to at least 80% of all costumers, if a cost-benefit analysis reveals the economic potential of this rollout (EUCOM, 2009). In Europe, only Sweden and Italy have finalized the roll-out so far. Sixteen other member states are planning to roll-out till 2020, though the targets for the roll-out differ between 80% till 15% (CEER, 2013a).

Basically, two concepts are discussed to govern the smart meter rollout: a regulated approach, with the DSO being responsible for the rollout and a competitive (i.e. unbundled) approach, which leaves the rollout to the market. Haney *et al.* (2009) present a summary of the analysis of the two institutional designs for the smart meter rollout. They conclude that the institutional design can have a significant effect on the cost-benefit analysis and the distribution of benefits. While most European states introduced a regulated model where the smart meter rollout is an integrated task of the network operators (e.g. in the Netherlands), some have established an unbundled solution with a competitive metering market (e.g. UK and Germany have unbundled solutions that differ significantly from each other) (Wissner & Growitsch, 2010).

Similar to the debate about the smart meter rollout a discussion evolves about different models concerning the handling of data from smart meters. The EU Commissions Task Force Smart Grids proposes two regulated and one market based concept for data handling (SGTF, 2013). The regulated models delegate the responsibility for data handling either to the DSO or to a new regulated third party. The competitive approach is based on standardized market roles. Both the regulated and the market-based approaches are supposed to secure neutral and non-discriminatory data management to establish a level playing field in smart grids. Ruester *et al.* (2013) investigated in greater detail how the regulated concept with the DSO being responsible for the data management fits into the current institutional framework. From their point of view a further unbundling of DSOs is required to secure non-discriminatory data management, if the DSO is responsible for this task (Ruester *et al.* , 2013).

The discussion about the data exchange in smart grids has its roots in the debate of the smart meter rollout. Due to this fact, the term data handling was applied to summarize the ICT-related processes to transport the data from the provider (smart meter) to the recipient. However, the term data handling falls short to include relevant aspects within the discussion. Data in smart grids not only needs to be allocated, but stored, aggregated and verified as well. The discussion therefore does not only describe the physical flow of data, but needs to address the management of the data exchange as well, i.e. who should become responsible for this task, the ICT-system design and the required infrastructure. This broader perspective on the design of the data exchange in smart grids can be summarized under the concept of information management.

According to Voß & Gutenschwager (2001) information management is the economic efficient planing, purchasing, processing, distribution and allocation of information as a resource for the preparation and support of decision making processes. As well, information management implies the design of the required framework to efficiently process these tasks. By applying the information management concept to the data exchange in smart grids we follow Jagstaidt *et al.*

(2011), who specified the concept of a smart meter information management system from an ICT perspective. They use the Smart Grid Architecture Model (CEN-CENELEC-ETSI, 2012) and define information management as the intermediary between the different actors in the energy system and the physical layer, which consists of the electricity and ICT infrastructure. Based on this perspective Jagstaidt *et al.* (2011) specify the required processes within the information management system to support the data exchange from smart metering.[5]

Information management in smart grids is a new task in the energy system. So far the exchange of data was limited to the bilateral data exchange between two parties, e.g. in the process of supplier switching. Several questions evolve in the context of this new task. From an institutional perspective it becomes especially relevant to define who should become responsible for the new task of information management. Different governance approaches could be applied to define this responsibility. We put special emphasis on the institutional environment in the electricity sector that defines the different roles that could become responsible for information management. We briefly describe this institutional environment in the next section. Afterwards, we will address the different governance approaches for information management based on the identified roles (section 4).

2.3 The Institutional Environment of Information Management in Smart Grids - Status Quo

The institutional environment of smart grids is mainly characterized by regulation and the results of the liberalization process in the energy sector. Joskow (1996) points out that the electricity sector went through a significant change within the last decades. Prior to the liberalization a hierarchical system existed in the electricity sector. Integration was mainly motivated by the gains from vertical and horizontal coordination within the utilities, which operated the monopolistic networks (national and transnational transmission networks and local distribution networks).[6]

[5] Jagstaidt (2014) adds further detail to this discussion and specifies for different use cases which data needs to be exchanged between different agents in a smart grid.

[6] Transmission (high voltage) networks are operated by one or a few Transmission System Operator (TSO) per country. The distribution (medium and low voltage) networks connect the endusers to the electricity network and are more fragmented in many European states (Germany has more than 900 distribution system operators).

Thereby, the network monopolies served as a basis for the expansion into the other stages of the electricity supply chain. While this market structure was generally supported in the scientific discussion, the analysis of Joskow & Schmalensee (1983) specified the efficiency potential that could be realized through introducing competition in generation, i.e. unbundling of the network monopolies. Though the arguments for the introduction of competition were manifold, Joskow & Schmalensee (1983) stressed the complexity of required coordination mechanisms (i.e. contractual relations) to substitute formally internal planning processes of integrated utilities. In the given context these contractual relations can be characterized as information exchange between the different stages of the electricity supply chain.

The main argument against the separation of the network from the other parts of the electricity supply chain is based on transaction costs. The exchange of information within an integrated utility can be more efficient than the information exchange between separated companies, as long as the market has not established efficient coordination mechanisms as well. With separation coordination of the competitive parts of the supply chain and the networks becomes especially relevant for investment decisions into the network infrastructure. Here, a coordination problem evolves due to missing information exchange between the generation companies and network operators (see Brunekreeft & Meyer (2009) or Brunekreeft (2015) for details). However, an efficient market-based coordination mechanism could solve the coordination problem. Brunekreeft & Friedrichsen (2015) analyzed different market based coordination mechanisms in this context. Their analysis revealed that at least some instruments, e.g. locational pricing, could establish an efficient market based coordination mechanism (Brunekreeft & Friedrichsen, 2015).[7]

Following up on the evolving discussion in the late 90s about cost and benefits of vertical separation the European governments came to the conclusion that for the transmission level the coordination gains from integration did not compensate for the losses from missing competition (EUCOM, 2007). This is the root of the unbundling discussion, which primarily focused on the transmission level. We will shortly introduce this discussion, as it serves as a blue print of the current discussions about the institutional framework on the distribution grid level.

The liberalization process on the transmission level involved three steps, starting with the First

[7] However, exactly those instruments that could increase market-based coordination are not applied in Europe.

Electricity Directive of 1996, which as followed the Second Electricity Directive in 2003 and the Third Directive in 2009. The Commission pursued four goals by liberalizing the electricity market (for details see Meyer (2012)): The main goal of the liberalization process in the EU was to establish a single European electricity market. Second, liberalization was established to secure third-party-access to the markets in generation, trade and retail. Third, third-party-access to the network infrastructure was regulated to prevent discriminatory behavior by network owners against other generation companies. Fourth, final customers should be allowed to choose their electricity supplier.

The current institutional framework is based on the 3rd legislative package of the EU. Thereby, the Commission introduced three different options for unbundling on the transmission level. The three options proposed by the 3rd legislative package were

- ownership unbundling
- the (deep) Independent System Operator (ISO)
- Independent Transmission Operator (ITO)

Full ownership unbundling prohibits joint ownership of network and generation or retail assets within one firm. The ITO model allows companies to retain both network ownership and management, but it puts strong limitations on cross involvement of employees to assure independence of the network. The ITO is in effect a stronger form of legal unbundling. The ISO requires that an independent entity takes over operational activities (system operation) in the network, separate from transmission asset ownership. With an ISO the network ownership can stay with the integrated firm, also owning generation assets.[8]

The regulations within the Third Electricity Directive were motivated by the prior experiences with weaker forms of unbundling. Especially the experience with legal unbundling did not fulfill the expectations of the Commission. Legal unbundling was introduced in the Second Electricity Directive in 2003 and requires that the network operator is independent at least in terms of its legal form, organization and decision making from other activities not relating to transmission (i.e. generation and retail) (EUCOM, 2003). This includes unbundling of accounts, operations and information. The idea behind this is to ensure that no relevant information is exchanged

[8] The ISO model has been applied in several countries, e.g. UK, Ireland, Switzerland, the US and Canada (Pollitt, 2012).

between the network and other parts of the supply chain within one utility. One can think of legal unbundling as "firewalls" or "Chinese walls" which prohibit such a flow of information within one integrated company (Brunekreeft & Keller, 2001). Still, a legally unbundled network operator can be part of a holding company that owns generation and retail subsidiaries as well.

Evaluating the outcomes of the unbundling process in 2007 the Commission concluded that legal unbundling did not sufficiently secure competition in the electricity sector. Therefore, the Commission stated that

> "[...]transmission ownership unbundling is the most effective tool to promote investments in infrastructure in a non-discriminatory way, fair access to the grid for new entrants and transparency in the market." (EUCOM, 2007)

Importantly, the Commission focused strongly on the benefits of ownership unbundling, while the costs were neglected to some extent (Brunekreeft, 2015). Though the Commission was in favor of ownership unbundling on the transmission level it did not become mandatory in the EU. Rather, ownership unbundling became one out of three options within the Third Electricity Directive, due to the opposition of some member states. Today, the Commission seems to be rather satisfied with the achievements with the ITO model (EU COM 2014). Further unbundling on the TSO-level is therefore not an issue for now.

The institutional environment on the distribution grid level is different compared to the previously described framework on the transmission level. Distribution networks are currently subject to legal unbundling (EUCOM, 2009). However, legal unbundling is only applied for those DSOs that have more than 100,000 customers. DSOs with fewer costumers do not have to unbundle and can remain an integrated part of an utility. This exception is known as the de-minimis rule (specified in (EUCOM, 2009, Art.26)). Out of the roughly 880 DSOs in Germany only few (about 150) have such a large customer base, which in turn means that roughly 80% of all DSOs are still part of integrated utilities (EUCOM, 2011). It needs to be noted that the legally unbundled DSOs, which are not subject to the de-minimis rule, own large parts of the overall network in most member states of the EU. Typically, these larger DSOs own roughly 95% of the national markets (even though their number is quite low), exceptions are Denmark (43% market share of small DSOs) or Austria (12% market share in the hands of small DSOs) (Cossent *et al.* , 2009).

Though a stronger unbundling regime for the distribution networks was discussed in 2009 as well, it did not became mandatory in the EU. Still, some countries introduced ownership unbundling on the distribution grid level, for example the Netherlands. Even in countries where ownership unbundling is not mandatory, some DSOs are in fact fully unbundled from the electricity supply chain, e.g. in Belgium, Bulgaria and UK (CEER, 2013b).

Figure 1 summarizes the institutional environment of information management in the electricity sector.

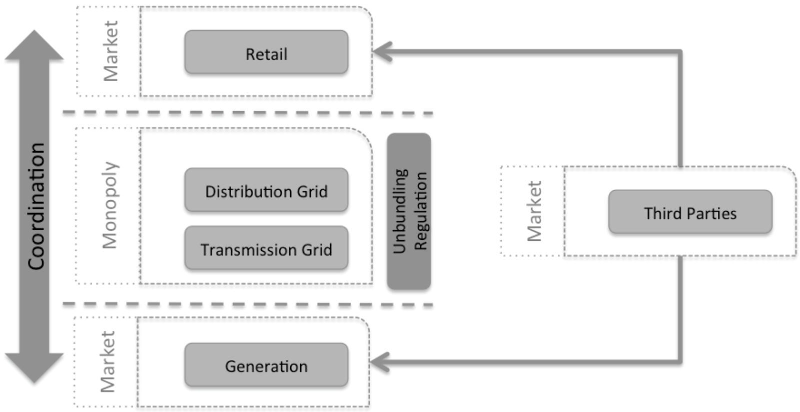


Figure 2.1: The different roles defined by the institutional environment of information management

On a general level the institutional environment in the electricity sector defines 4 roles that could become responsible for information management. Either the regulated entities from the network monopolies, established incumbents from the generation or retail segment, third parties that are already active in the electricity sector or enter the electricity sector specifically to become responsible for information management. In the next section we pick up these roles and discuss different governance approaches that assign the responsibility for information management to either of them.

2.4 The Different Governance Models for Information Management: Can They Secure a Balance Between Coordination and Competition?

Information management could become a task of an actor that belongs to either of the four roles defined above. We can differentiate between three basic approaches to govern information management:

1. One institution from the 4 roles defined above could become responsible to govern the information management system for a specific region (e.g a whole country or one part of the country). This would result in a monopoly for information management.
2. The network operators could become responsible to operate the information management systems for their networks.
3. The roles from the competitive parts of the energy system (generation, retail) could become responsible for information management.

The first group of governance approaches focuses on a monopolistic structure. One institution from either of the four roles or a new party could become responsible to provide the information management system for a specific region. Importantly, information management itself does not qualify for a monopoly or a monopolistic bottleneck. This becomes clear when we take a look at the definition of monopolistic bottlenecks. Knieps (2006) defined two criteria, which define a monopolistic bottleneck:

1. "If the facility is necessary for reaching consumers, that is, if no second or third such facility exists, that is, if there is no *active* substitute available. This is the case if there is, due to economies of scale and economies of scope, a natural monopoly situation, so that one supplier can provide this facility at a lesser cost than several suppliers.
2. If at the same time the facility cannot be duplicated in an economically feasible way, that is, if no *potential* substitute is available. This is the case if the costs of the facility are irreversible" (Knieps, 2006, p.53).

Irreversibility describes an investment that cannot be recovered within a reasonable amount of time, i.e. the network can not be sold once it was built.[9] For new market entrants the existence and extent of irreversible costs determine whether or not they are willing to enter a market. In contrast, the incumbent player already incurred these irreversible costs. Therefore, the incumbent is no longer affected by the these costs and has an incentive for strategic behavior, because the irreversible costs secure a certain state in which inefficiencies of the incumbent do not directly increase competition (Knieps & Zenhäuser, 2010).

Taking a closer look at information management reveals that there exist economies of scale,

[9] Irreversibility was analyzed in greater detail with respect to decisions, see Henry (1974)

e.g. with respect to the storage capacities for the data exchanged in smart grids. Still, it is very likely that there are at least potential substitutes for information management. Though there is no specific data available that would help to proof this statement, the experiences with the market for storage capacities for private data, so called cloud-computing, might serve as an example for a similar market structure. Today, cloud-computing mainly consist of hardware, i.e. different servers which are connected to a network, and data or services which can be accessed via these servers from every internet connection (Markovic *et al.* , 2013). Though this market is still in its introduction phase, it is anticipated that there is a huge potential for economies of scale (Pal & Hui, 2013).

The current market for cloud storages is quite small. Nevertheless, there already exists competition between different IT companies, e.g. Google, Amazon, Microsoft etc. The services provided by cloud-computing and information management are at least partially based on comparable systems. Both require large data storage facilities that can be accessed externally from eligible service providers and costumers. Furthermore, cloud-computing as well as information management require huge data transfers from the costumer to the storage provider. Therefore, it seems likely that the developments within the cloud-computing market might serve as a first approximation for potential developments of information management in smart grids.

Taking the developments in the cloud-computing sector into account reveals that though economies of scale might exist, potential substitutes for the provision of information management in smart grids are likely to evolve. Therefore, information management does not qualify as a monopolistic bottleneck and it does not seem necessary to establish a monopolistic governance approach for information management.

Independent from the evaluations above information management could become an institutional monopolistic bottleneck. This requires that a governmental decision defines that there is only one information management operator available in a specific region. This region might cover a whole nation or just a part of a country. This governmental decision would then de-facto eliminate potential substitutes. Therefore, such institutional monopolies are also known as governmental-granted monopolies. In the UK the government assigned the responsibility for data collection and processing to an independent service provider (DECC, 2013).[10] Following from such a jurisdiction information management becomes a local monopolistic bottleneck by law. This is true for all the roles identified in section 3.

The second group of governance models delegates this task to the network operators that already operate monopolistic infrastructures. Here, we differentiate between two concepts given that the network operators become responsible for information management. Either, information management is provided as an integrated task by the operator of the electric distribution (or transmission) networks. I.e. information management would become part of the regulated business of the network operator and would be subject to the respective regulation scheme of the network operator. Alternatively, information management could be a task of the network operators, but separated from network operation. This could be done by introducing firewalls between these two businesses (network operation and information management) within one company. The separation of network operation and information management would then require a process like "(legal) unbundling of information management" to secure that the network operators do not misuse their market power on the network side to influence the information management business.

Given that the separation of information management from the regulated tasks of the network operators is effective, then the network operators could become active in a competitive market for information management, where different parties from different roles compete with each other (e.g. some retailers compete with the network operates and third parties in the market for information management). However, several issues would need further specification to define how such a system with network and information management operators could look like.[11] Third, all roles from the competitive realm (incumbents as well as third parties) could become responsi-

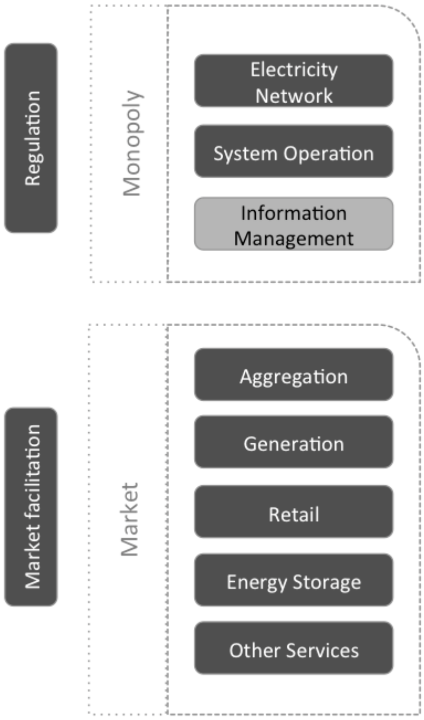
[10]The CEER (2012) stressed that the central approach in the UK creates a new monopoly, while a market-based approach might have been possible as well.

[11]Such an approach requires quite some effort to secure the separation of the regulated from the commercial business. The question then is: What are the gains from such a system that would justify the efforts to separate the regulated tasks from the information management? Furthermore, why should the firewalls that separate information management from network operation be more effective then the already existent firewalls of legal unbundling? Germany currently takes a step into this direction by unbundling (accounts and information) the metering operators from network operation. Some interesting insights might be derived from this process for the institutional design of information management.

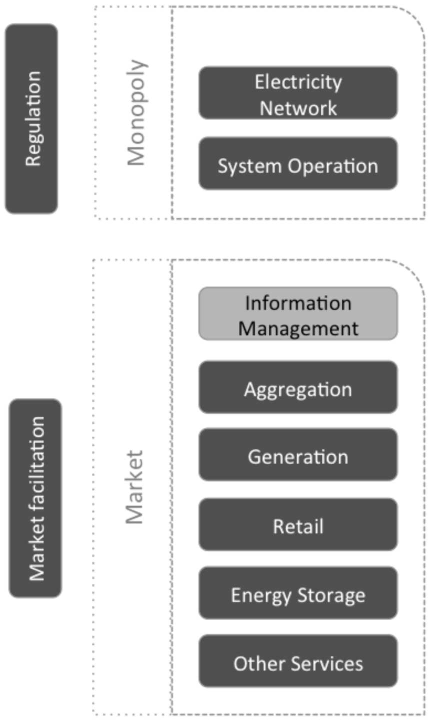
ble for information management. A market would exist where different providers of information management could compete.

Based on the previous evaluation two basic approaches to establish information management as a new task in the electricity supply chain can be differentiated. On the one hand, regulated concepts where information management either becomes an integrated task within the monopolistic elements of the electricity sector, i.e. the networks, or is operated as an institutional monopoly granted by the government. On the other hand, information management could become a separated task from network operation. Thereby, information management would be independent from the monopolistic infrastructure and belong to the competitive realm. In the competitive model any other party than the operators of the monopolistic bottlenecks could be responsible for this task. This includes incumbents from the electricity sector, as well as third parties (e.g. from the telecommunication sector), which are not yet active in the energy business. Alternatively, information management could be a task of the network operators as well, but separated by firewalls from the network operation. Theoretically, the network operator could then become active as a provider of information management in a competitive environment.

Given a separated solution (information management separated from the networks), the access to the electricity infrastructure would be regulated based on the established regulation schemes. Additionally, information management itself would be part of the competitive environment and therefore either subject to competition law or a regulation scheme independent from the monopolistic bottlenecks of the network industries. Though it is possible to think of competitive approaches for information management that do not require regulation (e.g. the DAM-concept of SGTF (2013)), regulation might still be needed if the separated solution results in an institutional monopoly (e.g. if there is only one data management system for a whole country like in the UK). The following figures illustrate both cases, the integrated and separated approach:



(a) Information management integrated within the regulated operation of the electricity networks



(b) Information management separated from the regulated operation of the electricity networks

Figure 2.2: Information management as a separated or integrated task from/within the regulated operation of the electricity networks

For both governance approaches we need to discuss how they relate to the existing institutional setup. Our analyses focuses on two specific criteria:

1. Coordination: Do the different governance approaches for information management have an effect on the coordination on the distribution grid level?

2. Incentives: Do the governance approaches secure that the relevant parties have the incentive to develop the information management system in an economic efficient way?

2.4.1 The governance of information management and coordination on the distribution grid level

In the given context coordination describes the exchange of information within the electricity supply chain. Before liberalization this coordination was a hierarchical process, i.e. coordination took place within a utility that operated departments for retail, the networks and generation within one company. After liberalization, the former integrated departments of the utilities were separated into different companies. Now the network company needs to coordinate externally with retailers and generation companies (Brunekreeft & Ehlers, 2006). Market based coordination mechanisms could substitute the former integrated coordination process, potentially even at similar transaction costs. However, today the coordination between the network and the rest of the supply chain is weak. If at all, then this coordination is currently based on network charges, which are criticized to be imperfect (Brunekreeft, 2015).

Consider the case of an unbundled distribution system operator (DSO) and a generation company that wants to invest into distributed generation (DG) as an example. The DSO could implement locational differentiated network charges to give incentives to the investor to install the DG at a specific location where the installation of DG would not require investments into the network. However, this can only result in efficient outcomes if the network charges reflect all costs related to the installation of DG. Brunekreeft & Ehlers (2006) argue that shallow network charges, which is the most common model in Europe, do not reflect all these external effects from DG investments on the electricity network. Therefore, coordination based on shallow charges would result in an inefficient investment into DG (similar results were found by de Joode *et al.* (2009)).

Coordination is flawed between generation and network companies in further respects as well. While investment into DG might quite often require investments into networks as well, the investor in DG does not need to consider the DSOs plan for network expansion. Here, the missing exchange of information between DG and the network creates a coordination problem. More recently Niesten (2010) stressed that the coordination problem in the Netherlands already slows down the development of DG, which supports the argument raised by Brunekreeft & Ehlers (2006). With an increasing share of RES the coordination problem gains relevance in the current discussion (Ropenus *et al.* , 2011)(Cossent *et al.* , 2009).

In Germany it is currently discussed to introduce a mechanism to reduce the costs of the missing coordination between the network and distributed generation. The idea is to allow the network operators to curtail 3% of annual electricity production of the connected DG. The calculations of E-Bridge *et al.* (2014) reveal a potential to reduce the network expansion costs by 30% when the curtailment approach is applied. The Federal Government is planning to introduce a rule to allow the curtailment by the DSO within 2015. The necessity of the curtailment rule delivers proof for the existence of the coordination problem in Germany.

So far, the discussions about the coordination problem mainly focused on DG and the resulting network expansion costs. Presumably, coordination will become more complex with the introduction of smart grids. Complexity will be driven by at least two effects.

First, the number of stakeholders in the electricity system increases. These actors need to be coordinated to balance demand and supply. New stakeholders can evolve on the production side, as more DG is owned by small investors (even by households) or on the consumption side, where more consumers actively participate in the electricity system (e.g. based on demand response mechanisms).

Second, information in smart grids needs to be exchanged at a higher quantity as well as with a higher resolution. While grid operation might not need every data set per second of every costumer connected to the grid, services on the market might have an interest in this detailed data and costumers might demand these services. These new services are likely to have direct effects on the operation of the distribution grid. For example, demand response mechanisms aim at an adaptation of consumers demand according to price signals. So far, these price signals change over the day, but they do not take into account the balance of load and production on the distribution grid level. Today, the effect of these new services might be marginal as most of the instruments are only in the pilot phase. Nevertheless, a growing market for these services might significantly increase the coordination problem between the DSO and network users. Information management then needs to solve this problem efficiently, e.g. by reducing transaction costs.

The question then is: Can information management reduce these transaction costs between the network and the other parts of the supply chain, i.e. has information management a positive effect on the coordination problem on the distribution grid level? To answer this question we need to take into account two assumptions:

First, we can expect that the introduction of information management as a new task in the electricity supply chain will reduce transaction costs, independent from whether it is governed as an integrated or separated task. This is due to the fact that the service offered by information management, the collection, aggregation, storage and distribution of data, itself will reduce transaction costs for the DSO. Especially the collection and aggregation of data offers potential for economies of scale and scope. Transaction costs will be reduced as the DSO does not need to contact each user of the network individually to gain information about current and anticipated grid usage, but can access this data at the information management provider. This might even be true if several different information management providers are active in the grid area of one DSO. However, with an increasing number of different information management providers in one network area the coordination gains from the introduction of information management might be reduced, as the DSO then again needs to exchange information with several different parties. Therefore, we argue that the introduction of information management, independent from its governance structure, offers the potential to reduce transaction costs.

Second, transaction costs for coordination between the DSO and the network users in smart grids are the lowest if the distribution network operator integrates the information management into its regulated business. In this situation the information management becomes one integrated department of the network operator. Therefore, the department for network operation can directly access the required data via the internal processes. However, this is only true for the case that information management is integrated into the hierarchy of the network operator and becomes part of the regulated business as well.

This changes if information management is a task of a separated department of the DSO, that is "unbundled" from the network business via firewalls. If we suppose that these firewalls effectively separate the regulated activities of the network operator from its information management business, then transaction costs for coordination might not be lower then compared to a case with an external company providing the information management for the network operator. In both cases the network operator needs to contract with the information management company to access the relevant data.

To conclude, coordination becomes more important in smart grids and we see some evidence that an integrated approach that delegates the new task information management to the regulated network operators might reduce coordination costs.

2.4.2 The governance of information management: Do DSOs have the right incentives?

The solution to integrate the information management into the regulated business of the network operator might reduce coordination costs, but it could result in inefficient incentives. Though information management would become a new task for the DSOs, the arguments against this solution are similar to those raised prior to the liberalization process. Back in the 90s, Joskow (1996) pointed at the risk that a regulated firm, which owns the network infrastructure and wants to be active in the competitive parts of the supply chain, might be able to discriminate against competitors or even restrict access of third parties to the system to increase own profits. In addition, a grid owner that takes part in the competitive sectors could be able to cross-subsidise its activities in the market through the regulated network tariffs in the natural monopoly part of its business. Newberry (1997) raised similar concerns with respect to integrated utilities that have the ability to control information and thereby discriminate other parties.

This criticism gains importance with the introduction of smart grids. Many benefits of smart grids are related to the innovation potential that comes from third parties (Erlinghagen & Markard, 2012). An integrated utility might therefore have the incentive to restrict access of third parties to the information in smart grids to protect its market share. If an integrated utility is responsible for information management, we can suppose that competition might be hampered. Within an unbundled world, these incentives to discriminate should be eliminated. Whether legally unbundling eliminates the incentives to discriminate sufficiently is still under discussion. Hoeffler & Kranz (2011) argued that legal unbundling might be the golden mean between integration and full ownership unbundling. However, Ruester *et al.* (2013) are skeptical whether legal unbundling efficiently eliminates incentives to discriminate. As far as the transmission system is concerned the European Commission seems to be satisfied with the effects of strong legal unbundling (EU-COM, 2014).

On the contrary, a fully ownership unbundled DSO that is responsible for information management should have no incentive to discriminate. Though there are doubts whether ownership unbundling would be an efficient solution overall (see de Nooij & Baarsma (2009); Hoeffler & Kranz (2011); Brunekreeft (2015)), it could solve inefficient incentives to discriminate and thereby might over a solution for information management in smart grids. This solution will be discussed in greater detail in the next subsection.

Compared to the integrated solutions the separation of information management from the monopolistic bottlenecks has the primary advantage that it reduces incentives to discriminate third parties. However, this is only true if the task of information management is assigned to a third party that is independent from all monopolistic bottlenecks and parties with market power.[12]

From the above we can extract two important implications for the governance of information management in smart grids. First, the coordination problem on the distribution grid level could be reduced if information management would be delegated to the electricity distribution system operators. Transaction costs could be reduces as well, if any other party than the DSO becomes responsible for the information management. Still, the effect of information management on the coordination problem is the stronger, if it is governed as an integrated task of the DSOs. Second, given the current institutional environment with legal unbundling of DSOs the integrated approaches that assign information management to the DSOs might result in incentives to discriminate third parties. In these cases regulatory oversight would be required to secure competition on a level playing field. Therefore, we face a tradeoff between coordination and competition: we can not secure both at the same time for information management given the current institutional environment.

It needs to be questioned whether a change in the institutional environment of smart grids could reduce the tradeoff between coordination and competition. Ruester *et al.* (2013) stress that the governance approach for information management based on an ownership unbundled DSO could result in an efficient balances between coordination and competition.[13] Based on the current regulation ownership unbundling is not mandatory in the EU. So far, mandatory ownership unbundling on the distribution grid level was so far only applied in New Zealand, where

[12] This includes that the operator of the information management is not an affiliated company of either the same holding as a legally unbundled DSO.

[13] Though we focus on the relation between information management and ownership unbundling, we are fully aware that the unbundling discussion is much broader and complex.

ownership unbundling of the distribution grid was introduced in 1998, and the Netherlands, where (most) DSOs are ownership unbundled since 2011.[14] The evaluation of Nillesen & Pollitt (2011) showed that in the case of New Zealand ownership unbundling had a positive effect on retail competition, but that this effect was limited to a short time period. Therefore, it might even be questioned whether ownership unbundling was the reason for this temporary increase in retail competition. There might have been other effects that influenced the retail market at that time as well. Nillesen & Pollitt (2011) conclude that ownership unbundling might not be considered as the primary solution to introduce competition in the electricity sector.

For the case of the Netherlands different cost-benefits analysis evaluated the effects of ownership unbundling on the distribution grid level, but come to different results. The analysis of SEO (2006) resulted in a welfare loss from ownership unbundling. These results are supported by de Nooij & Baarsma (2009). Based on these investigation it seems likely that the costs of ownership unbundling might exceed the benefits derived from it. Potentially, ownership unbundling on the distribution grid level might even result in decreasing competition given the case that generation and retail are still integrated, which could hinder independent retailers to enter the market (de Nooij & Baarsma, 2009). More recently, PWC (2013) evaluated the status quo of ownership unbundling in the Netherlands and concludes that so far the expectations were not met. On the contrary, the evaluations of Mulder *et al.* (2005) and Kuenneke & Fens (2007) revealed a potentially positive effect of ownership unbundling on the distribution grid level under certain circumstances.

The results from the described case study in New Zealand and some (but not all) of the cost-benefit analysis for the Netherlands support the decision in 2007 of the European Commission not to introduce ownership unbundling on the distribution grid level. Up to now, legal unbundling seemed to be sufficient to secure neutrality and non-discriminative access of third parties to the infrastructure.

Ruester *et al.* (2013) picked up the discussion about ownership unbundling in the context of information management. As information management is a new task in the electricity supply chain it might add some additional aspects to the cost-benefit analysis of ownership unbundling.

[14]Though not required by law some DSOs in other countries like Belgium, Bulgaria, Romania, Portugal, Italy and UK are ownership unbundled as well (CEER, 2013b).

Still, whether a cost-benefit analysis would become positive for ownership unbundling depends on many factors and therefore needs to take into account more than just the information management debate. Nevertheless, two arguments from the information management debate support the introduction of ownership unbundling for DSOs.

The first argument relates to the neutrality of the unbundled DSO, who is not allowed to be active in the competitive realm of the electricity sector. Therefore, the ownership unbundled DSO would have no incentive to restricting access of third parties to the information in smart grids. Competition based on information management could evolve. Second, the coordination problem could be reduced with an ownership unbundled DSO being responsible for information management. If the DSO manages both, the network and information this is likely to lower transaction costs. Similar arguments were raised by Ruester *et al.* (2013).[15]

However, the introduction of ownership unbundling might result in inefficient incentives for the DSO. The DSO might have the incentive to hamper the development of information management. Similar concerns were raised by Brunekreeft & Ehlers (2006) with respect to the incentives of ownership unbundled DSOs to support the development of DG. We will show that their argument gains relevance if it is applied to information management in smart grids. The argumentation of Brunekreeft & Ehlers (2006) is based on the potential of DG to substitute network investments. However, given an incentive regulation scheme network investments are the main driver for the DSOs revenues. The diffusion of DG would lower the DSOs revenues, because the need for network investments would be reduced by DG.

Similar effects can be expected from information management. Information management provides a platform for new services. Some of these services could in effect substitute network investments by the DSO. Examples for such services are peak-shaving mechanisms or energy-efficiency services. Peak-shaving would have a direct effect on network investments, as lower peaks in demand reduce the need for network reinforcement. Services that increase energy efficiency would reduce the income from network charges as these are related to the electricity consumed, at least in the case of private households. Both services would reduce the DSOs income. These

[15] van Werven & Scheepers (2005) point in the same direction when they stress that an efficient development of DG and related services can only evolve under an ownership unbundling regime on the distribution grid level.

are only two examples for services that could reduce the revenue of an unbundled DSO under an incentive regulation scheme. A profit-maximizing DSO being responsible for information management therefore might have an incentive not to support the development of services based on the information management. Therefore, it can be concluded that the arguments raised against ownership unbundling by Brunekreeft & Ehlers (2006) gain relevance with the introduction of information management. Following this argumentation the introduction of ownership unbundling might hamper the development of information management and thereby reduce efficiency.

Importantly though, the argumentation above is not applicable to every regulation scheme but only refers to the case of the incentive regulation scheme based on a cost-based approach.[16] Other regulation schemes might better align the incentives of an unbundled DSO with the support of information management.

This short evaluation is not exhaustive and therefore should not be considered as a final evaluation of the effect between information management and ownership unbundling. Still, given a cost-based incentive regulation scheme it seems not economically efficient to introduce ownership unbundling for information management in smart grids.

2.5 Conclusion

The development towards smart grids requires not only a technological but an institutional change as well. With an increasing number of active parties in smart grids, from small DG operators to services providers for energy efficiency measures, the need for the exchange of information is increasing. So far, information processing was an integrated task of the DSO as they were the only parties interested in the information. This is changing.

Information in smart grid serves at least two purposes: First, information is needed to balance the increasingly distributed generation and consumption. Second, information can be used by commercial parties to develop new services and products for costumers, i.e. households and commercial/industrial businesses. Therefore, the collection, storage and exchange of information is becoming a new task in the electricity supply chain. We defined this task as information management.

[16] For details about the different incentive schemes see Joskow (2008)

In this paper it was discussed how the institutional environment of smart grids looks like in Europe and how different governance models for information management could fit into this environment. Based on the existing roles in the energy system (generation, network operation, retail, third parties) we differentiated two general governance approaches (integrated vs. separated from the operation of the monopolistic distribution networks) and evaluated both concepts with respect to coordination between the network operator and other parts of the supply chain as well as their effects on competition.

Our analysis revealed that delegating information management to either of the existing roles in the energy system results in a tradeoff between coordination and competition on the distribution grid level. Neither the integrated solution (information management as an integrated task of the DSO) nor the separated concepts result in an efficient balance between coordination and competition. For the integrated solution the regulatory effort to secure competition will be high, while the separated solutions will require significant efforts to develop a market based coordination mechanism to align network operation with the commercial activities within the electricity sector.

Based on these findings we conclude that to achieve an efficient balance between coordination and competition additional governance structures for information management are required (for example see Brandstaett *et al.* (2017)). Further research is necessary to define how these new governance approaches might be implemented to establish a level playing field in smart grids based on a neutral and non-discriminatory information management.

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3 Information Governance in Smart Grids - A Common Information Platform (CIP)

Christine Brandstaett, Gert Brunekreeft, Marius Buchmann & Nele Friedrichsen

The commercial value added in electricity distribution networks and smart grids is increasing. Concerns about competition on a level-playing field are raised and the debate on vertical network unbundling is beginning to address the level of the distribution net-works. With regard to the unbundling discussion for distribution networks, we introduce a new approach: the Common Information Platform (CIP). The CIP tries to balance better between competition and coordination. The CIP adds two new dimensions. First, it "unbundles" information and data management as the key step in the value chain, not network ownership or system operation. The other stages of the value chain can remain integrated. Correspondingly, the CIP avoids such drastic measures as network ownership unbundling. Second, it does not "separate" information and data management from the sector, but rather involves third parties in the rule-making process; the governance structure is "common" instead of "independent".

Keywords: power systems, power distribution, information and data management, smart grid

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3.1 Introduction

With large-scale integration of decentralized renewable electricity generation, the value added to the distribution network is rapidly increasing. Accordingly, concern whether competition is on a level playing field intensifies. In other words, the debate on unbundling of monopoly parts from commercial stages, which dominated the EU directive 2009 for the transmission networks, has now reached the distribution level (CEER, 2014). However, what should unbundling of smart distribution grids look like? How do we balance between competition and coordination in smart distribution grids? We argue that information and data management is the key task in smart grids that should increase coordination and enable competition and propose a Common Information Platform (CIP) to govern this task.

Distribution networks are becoming smart grids[17] driven by advanced information, communication and automation technology. Within these smart grids, the use of decentralized flexibility will gain importance in optimizing network management. New market opportunities open up for service companies that pool consumers and generation resources to provide this flexibility to the network. Hence, information and data management (IDM) is the inter- face between network and commercial side. IDM is at the heart of coordination in smart grids. This has a technical (i.e. data transfer protocols and formats) and an organizational component. We focus on the organizational part of IDM.

IDM should provide access to the existing data for those actors that need it and are entitled to it. Such actors can be in the regulated business of network operation as well as commercial service operators. IDM is thus the interface between the unbundled activities of network operation, power supply and demand; between competitive and regulated activities. The governance of IDM in smart grids needs to balance between coordination needs across the electricity value chain and competition. Competition is desired at the commercial stages. Concerns primarily relate to equal access to information and data and non-discrimination, e.g. of new market participants that enter the information-based market in smart grids. In the context of Directive 2009/72/EC, unbundling was intensely debated for the transmission network level. Some form of unbundling seems to be necessary at distribution level to ensure a level playing field, if the distribution grid

[17]Smart grids are also emerging in other sectors such as health, living, and production logistics, which is not discussed in this paper. We focus on electricity distribution networks.

operator (DSO) is responsible for the IDM (CEER, 2014). But we argue that distribution networks and the corresponding unbundling debate are different from the debate for transmission networks.

The CIP, which we propose in this paper, focuses on IDM as a crucial stage in the value chain of smart grids. In our opinion, a CIP can be a key step towards an optimal governance structure for IDM. The CIP is a rule-making institution for IDM. It ensures neutrality by involving all eligible stakeholders; there is no need for independent, separate actors to level the playing field because of the common structure. The CIP unbundles information and data management, not the network. Hence, the current regime of legal unbundling of the distribution networks (perhaps with moderate adjustments) can be retained and drastic further steps towards network ownership unbundling can be avoided. Network and commercial business might stay integrated, as it currently is under legal unbundling, securing coordination and alignment of incentives of the network and commercial businesses. The main idea of the CIP is to balance between competition and coordination at distribution grid level.

The paper is structured as follows: In section 2 we define the information layer in smart grids. Section 3 describes potential governance models for IDM, as currently discussed in Europe and evaluates them against four criteria. In section 4 we discuss the Common Information Platform (CIP) as a new governance model for IDM in smart grids in more detail. Section 5 concludes.

3.2 Information as a Base for Coordination and Competition

The decentralization in smart grids and the diffusion of information and communication technology (ICT) create a growing amount of information available in electricity distribution networks[18]. For example, from smart meters installed at the consumers' sites or with distributed generators. Smart metering systems reflect their customers' actual energy consumption or generation and provide time-of-use information. Thereby, they enable value-added services, such as demand side management and generation management. This offers opportunities for new market participants to pool and commercialize decentralized resources. Indeed, the European Commission outlines

[18] We focus on electricity distribution networks. The link to heat and gas supply networks is growing since these can provide flexibility to the electricity system via intelligently operating heat pumps, combined-heat-and-power or power-to heat installations.

that "DSOs would need [. . .] to deal with local network constraints through markets where flexibility is traded in a transparent way with a level-playing field for all who offer it." (EUCOM, 2014).

Figure 3.1 below depicts the value chain of a smart grid. The upper part of the value chain contains the traditional network elements (network ownership, system operation, IDM and possibly, market facilitation). As long as these tasks are exclusively associated with the network, they are monopoly elements. On the lower part of the value chain, we find commercial activities associated to the market. The commercial activities require access to the monopoly network parts. To secure competition among the commercial activities on the market, a governance system must secure non-discriminatory equal-access to the monopoly elements for all eligible parties. Furthermore, the monopolist must have incentives to provide the quality required for the commercial activities.

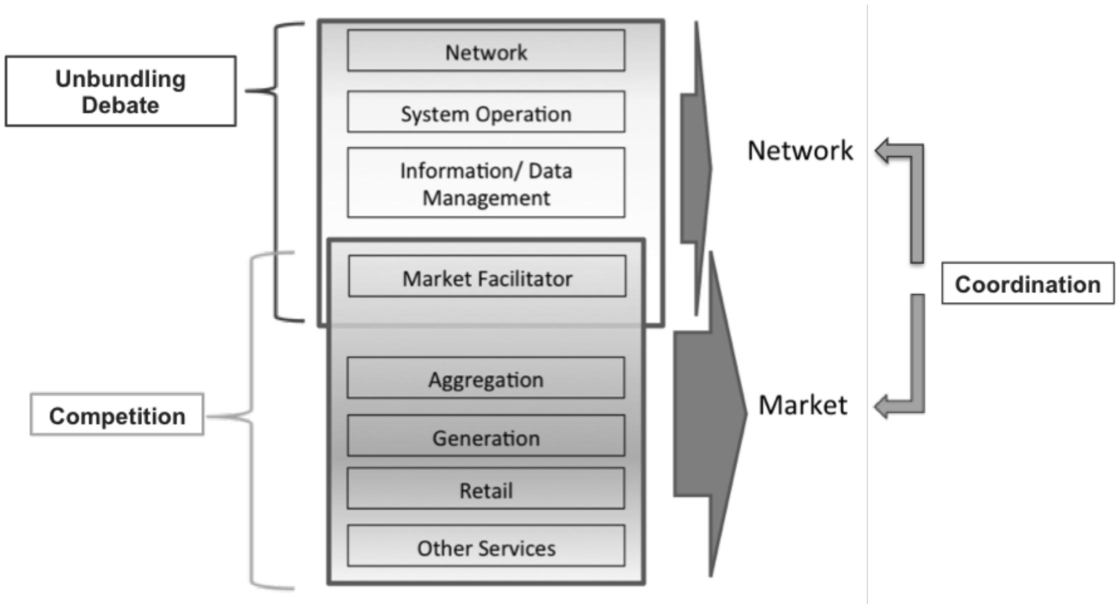

Figure 3.1: The governance dilemma at a glance

In smart grids, information and communication technology is the key infrastructure. It enables recording and transmitting information on consumption, feed-in, network conditions, prices or control signals. We argue that the management of this information and data evolves into a new, separate stage in the value chain in smart grids. The infrastructure has to be built, operated and the information and data have to be managed efficiently in a way that serves all different actors. Furthermore, since the users of the IDM need the information for different purposes, they have different requirements concerning the data's type and quality, e.g. with regard to real time availability and aggregation level (see Table 3.1).

Table 3.1: Data requirements by different actors

Information Type	**Actor**	**Information Use**	**Required Quality**
local system condition, generation and consumption of subnetworks	DSO	network operation (failure tracking, demand and generation management)	real time, low latency, supreme availability, high aggregation (level: network node, feeder or substation)
generation and consumption contracted resources flexibility prices	flexibility/ energy service providers	offer, realize, and bill flexibility and energy services	near real time, high availability, low aggregation level (individual installation, groups of installations)
individual consumption, supply prices	suppliers, consumer	end user participation of end users in electricity markets	some latency, low aggregation

IDM can be separated into three aspects a) infrastructure for data transmission (which is described under the headline of advanced metering infrastructure e.g. in Roemer *et al.* (2012)), b) data management and c) access for stakeholders. So far, it is not clear how these activities should be governed and who should carry them out.

In view of the diverse actors and their data demands, the task is to provide each user with the relevant information, i.e. information that benefits him and that he is entitled to receive, in the quality needed. The main challenge within the traditional framework of the electricity system is, that the network company can also own and operate commercial departments, which compete with independent commercial third-parties. The obvious problem with this integrated structure is, that the network company would have incentives to discriminate third parties to create a competitive advantage for its own commercial businesses. Network unbundling (or vertical separation in US terms) addresses precisely this problem.[19] In its most rigorous form, "ownership unbundling" prescribes a mandatory ownership split of the monopoly network business from the commercial businesses: this removes the incentives to discriminate against third parties. A less rigorous form is "legal unbundling"; under legal unbundling cross-ownership of the network and commercial businesses is allowed but an extensive set of administrative rules try to isolate the network from the commercial business (cf. for details eg. Brunekreeft (2015)): the incentives to discriminate third parties would still be present, but the possibilities to exploit these incentives are curbed. In Europe, the Directive 2009/72/EC requires legal unbundling for distribution systems with more than 100,000 customers; smaller DSOs can apply for the de-minimis rule with substantially less severe unbundling requirements. Given that the commercial interests in smart grids are rapidly increasing, the debate on DSO unbundling is heating up; the question is whether the current arrangement of legal unbundling suffices or stronger forms, notably ownership unbundling, should be implemented (see esp. CEER (2014)).

Network unbundling addresses incentives to discriminate third party network users and thereby promotes competition. Yet, unbundling may result in misaligned incentives between the network and commercial businesses. In other words, unbundling may cause flawed coordination between the network and network users (Brunekreeft, 2015).[20]

This is even more important since smart grids still need to be developed further. Basically, smart grids aim at a stronger interaction between network operation and network users. Unbundling may jeopardize whole-system coordination in smart grids. The following two examples illustrate coordination issues on the distribution grid level and how IDM can help to increase coordination in the specific cases. Furthermore, the examples stress the importance of a neutral and non-discriminatory provision of IDM.

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[19] Note that the situation is different in the US and the EU in terms of retail restructuring. In the US local distribution and retail are still often integrated. In contrast most European countries feature free supplier choice and hence competition at the retail stage.

[20] A prominent example is the analysis of the British Rail system in McNulty (2011) for the British government. The report studies the efficiency of the UK-railway system with two main conclusions: 1) the UK railway system is significantly less efficient than comparable peers, 2) the main cause of the inefficiency is far-reaching fragmentation of the system leading to misaligned incentives. The same principles apply to electricity systems as well.

3.2.1 Curtailment of distributed generators

At distribution level increasing feed-in of intermittent and distributed generators starts to congest the network. By shaving the feed-in peaks, the network operator can defer network expansion quite substantially (cf. Figure 3.2). In other words, selective curtailment of distributed generation by the DSO can contribute substantially to overall system optimization (dena, 2012).

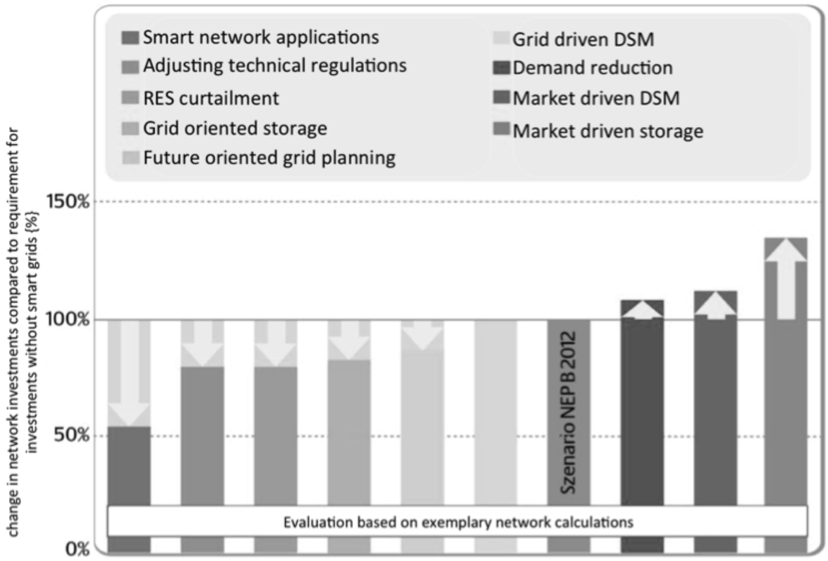

Figure 3.2: Effects of different smart grid aspects on distribution network investment (dena, 2012)

The network operator then relies on information and data to efficiently balance between network expansion and curtailment. Given that the DSO can curtail distributed generation the IDM can support transparency and non-discrimination concerning who will be curtailed or dispatched in which circumstances.

3.2.2 New energy services

With broader diffusion of e.g. electric vehicles, heat pumps, on-site generation, the demand for electricity from the network becomes more flexible. Energy service companies can develop new business models for the benefit of the customer, such as optimizing their power demand. They can also pool the decentralized flexibility commercially and sell it to the market or potentially to the network operator, if there were pricing mechanisms to reward this. In some cases, the commercial operation of decentralized resources has negative effects on the network, i.e. it creates congestion.

In other cases, flexibility could be used to relieve the network, but is not deployed, because the network operator cannot access the resources and the flexibility operator does not gain. This has been analyzed for the case of decentralized storage by dena (2012). On the one hand, network-based storage defers network expansion, but on the other hand, market-based storage requires more network expansion (see Figure 3.2).

3.3 The Current Debate on Organization and Governance

Different concepts for the governance of IDM are currently discussed and address several aspects of the emerging challenge in smart distribution grids.[21] In the paper we assess different governance approaches mainly according to their effect on competition and coordination within the distribution system, as well as the regulatory effort they induce.[22] For our evaluation we define four criteria:

First, it is central for competition that IDM ensures equal access for all eligible parties. We note that equal access does not require uniform access for all parties. Rather, equal access here means that all eligible parties can access the data they are entitled to receive in the same way. The data access might therefore differ between the different actors.

Second, it should guarantee non-discrimination in operation. This ensures a level playing field for service operators and may thus encourage competition.[23]

Third, efficient operation of the power system requires coordination of generation, demand, and other flexibility options. Most importantly, network operators need to carry out balancing as a critical technical function in the electric power system to ensure reliable power supply and system stability. Coordination means efficiently integrating all actors across the electricity value chain with respect to system and network operation. This includes the coordination of competitive actors and network management.

[21] The following criteria are partially based on the evaluation of Ruester *et al.* (2013).

[22] Other important evaluations, e.g. with respect to privacy concerns, need further evaluation and are not part of this paper.

[23] Competition in turn is not desired as an end in itself, but it is expected to motivate incumbents and new entrants to develop innovative services and to exploit new opportunities offered by smart grids to enhance customer benefit and system efficiency.

Fourth, the administrative and regulatory effort that is necessary to administer IDM in smart grids should be minimal. It has a user component, for example when consumers are switching supplier or service provider or when suppliers seek to offer their products in another areas. It also has a public authority component, such as regulatory or supervisory effort.

Governance of IDM should address the challenges of coordination and competition simultaneously, while at the same time minimizing administrative and regulatory effort. Table 3.2 summarizes these criteria on information governance in smart grids.

Table 3.2: Criteria for an institutional framework of IDM in smart grids

Criterion	**Short description**
Equal Access	Open access to information for all eligible parties, especially non-incumbents
Non-Discrimination	Non-discrimination in daily operation
Coordination	Vertical coordination of related operations (generation, network, consumption, etc.) within the electricity supply chain
Administrative and Regulatory Effort	Minimize effort that is necessary to administer IDM in smart grids both for the users and for regulators

The European discussion about potential governance mechanisms for information management in smart grids is based on the insights from the European Commission's expert group on smart grids. This expert group discussed two regulated (Central Data Hub, DSO as Market Facilitator) and one market-based (Data Access Point Manager) approach to govern information and data management (SGTF, 2013). So far, to our knowledge, only two studies analyzed these models from a scientific perspective: Ruester *et al.* (2013) and van den Oosterkamp *et al.* (2014). The former discusses the three governance approaches defined in the EU expert group and evaluates them against the background of the current regulation on the distribution grid level. The analysis of van den Oosterkamp *et al.* (2014) focuses on the regulated DSO as Market Facilitator model. We extent these first discussions with an evaluation of the governance models against the before mentioned economic criteria.

Central Data Hub: The first of the two regulated concepts delegates the responsibility for IDM to a new regulated institution that manages the information as a central monopoly separated from the electricity supply chain (Central Data Hub).[24] This model can be referred to as the central concept for IDM, as there is only one provider for IDM in the energy system, e.g. one Central Data Hub per country.

The concept is based on the separation of IDM from all other areas of the electricity supply chain. Therefore, incentives to either restrict access of market entrants or to discriminate against other parties in the daily operation of the IDM are low. Since new players, such as telecommunication firms, might also have commercial interest in smart grids, the Central Data Hub should also be independent from the competitive parts of the telecommunication sector.

In the end, the Central Data Hub model establishes a new monopoly. Hence, efficient operation heavily depends on its regulation. The regulator, however, is less informed about market requirements than the market parties themselves. Therefore, it needs to be specified how the regulator will address this information asymmetry to secure an economically efficient provision of information management.

Furthermore, the Central Data Hub separates information management from the other tasks in the electricity supply chain. Market mechanisms need to secure vertical coordination with the other steps in the electricity supply chain. Importantly, network operators need secured access to system relevant data to fulfill their legal obligation to stabilize the grid. This is true for both, the transmission and distribution grid operators. However, with an increasing decentralization of electricity production especially the requirement for information and data in the distribution grid will increase. This market based information exchange results in transaction costs.[25] These costs are likely to be higher than in the case that the information management separated from the existing supply chain. Therefore, an efficient implementation of the concept needs to define market-based coordination mechanisms that minimize the costs of coordination.

[24]This approach is currently applied in the UK. Here,a new monopoly was established which is independent from the regulated electricity networks and other stages of the electricity supply chain.

[25]The discussion in the railway sector in the UK pointed at high transaction costs resulting from separation, i.e. flawed coordination (for details see Brunekreeft (2015))

DSO as Market Facilitator: The second regulated concept discussed at European level proposes to delegate IDM to the distribution grid operators. The concept is known as the "DSO as market facilitator" model. The key advantage of this approach is that the DSO has direct access to the data required to stabilize the network and does not need to coordinate externally to gather this data.[26] To establish a high security in data exchange of the DSO with an external IDM, as it would be the case with the Central Data Hub, high transaction costs might evolve. Delegating the task of IDM to the DSO thereby reduces transaction costs for coordination. Still, transaction costs will occur for the information exchange with other parts of the electricity supply chain and third parties. In sum, the transaction costs are likely to be lower for the DSO-model compared to the Central Data Hub, mainly because the DSO has direct access to the relevant data.

With legal unbundling the incentive for the DSO to misuse its power over information and data to restrict access of third parties or market participants from retail should be low. However, there are doubts whether legal unbundling sufficiently secures neutrality of DSOs (Hoeffler & Kranz, 2011). Therefore, neutrality and discrimination concerns are the major shortcomings of the DSO as market facilitator concept, at least given the current regulation scheme. This is especially true for small DSOs that fall under the de-minimis exception and whose neutrality cannot be secured (van den Oosterkamp *et al.* , 2014). In other words, the competition concerns depend on the effectiveness of existing unbundling regulations.

Due to the neutrality concerns other regulation schemes are discussed for DSOs that are responsible for information management. For example, Ruester *et al.* (2013) conclude that the DSO as market facilitator model should ideally be combined with ownership unbundling, if such a regulation scheme is politically feasible. Though we generally agree with Ruester *et al.* (2013), we doubt whether the gains from ownership unbundling for information management are in balance with the potential costs that might evolve from an introduction of ownership unbundling. The acceptability and adequacy of such a measure raised a debate during the discussion of unbundling at transmission level (e.g. Pielow *et al.* (2009) or Talus & Johnston (2009)).[27]

[26]Since the DSO only required network data every 15 minutes it needs to be secured, e.g.. via command and control mechanisms, that the DSO collects all market relevant data at the granularity the market requires.

[27]Other regulation schemes could be applied as well to secure neutrality of DSOs so that they can

Data Access Point: As an alternative to the regulated models the EU expert group also discusses a market-based model, the "Data Access Point Manager (DAM)". This concept focuses on a competitive market for information management and proposes to establish independent and unregulated service providers. Each consumer can choose its DAM, which builds up the necessary information infrastructure. Importantly, the DAM does not store the data centrally. Storage remains decentralized with the users. Thereby, consumers have full control over their data. The DAM only acts as an interface that allows consumers to decide which commercial party can access their data (SGTF, 2013). The potential competition evolving under this approach is its key advantage. However, the DAM approach has at least two weaknesses. First, the effort to establish standardization will be quite high for the DAM concept to secure the interoperability of the different systems in the market. Second, and more important for our analysis, the DAM concept might result in very high transaction costs for coordination. For example, a DSO that needs specific data to secure network operation might need to coordinate with several DAMs in its operation area. The higher the number of DAMs active in a network area, the higher the DSO's costs for coordination.

Summing up, each of the concepts currently discussed has several advantages. However, either competition might be reduced (e.g. given a DSO as market facilitator model with incentives for discrimination), or transaction costs for coordination might increase (as it might be the case for the Central Data Hub and DAM model). Table 3.3 gives an short overview about the main differences between the three concepts.

3.4 A Common Information Platform in Smart Grids

We argue in this paper that a good governance system for IDM secures non-discrimination and neutrality. Neutrality might be challenged in the case that the legally unbundled DSO becomes responsible for IDM, which can increase coordination. Instead of further unbundling of network ownership and system operation, we suggest to involve all relevant actors in the governance of the IDM to secure non-discrimination. A common IDM, i.e. what we call a common information

become responsible for information management. For example, one could introduce an independent system operator (ISO) for both system operation (network) and IDM (for details on the ISO concept see Friedrichsen (2015); Balmert & Brunekreeft (2010)).

Table 3.3: Characterization of governance models for information in smart grids

	integrated with other stages	**network ownership**	**network operation**	**data processing**	**regulated business**	**central data storage**
DSO as Market Facilitator	X	X	X	X	X	X
Central Data Hub	-	-	-	X	X	X
Data Access Point Manager	-	-	-	-	-	-

platform (CIP), aims to secure a level-playing field for all eligible stakeholders and thus aims to promote competition. At the same time, a CIP does not require ownership unbundling of the network and commercial businesses and thus promotes whole-system coordination by re-aligning incentives. In sum, a CIP approach, concentrates on the IDM and balances between competition and coordination.

The central aspect in the debate as outlined above is the responsible party in charge of IDM. Arguments in the discussion evolve around a trade-off between discrimination concerns and synergies from having one integrated supply chain, i.e. coordination versus competition. Actors that are not financially involved in other steps of the value chain are assumed to be more neutral. In contrast, adding IDM to the tasks of experienced actors such as the DSO has certain integration synergies from combining IDM with an existing network operation.

We argue that the benefits of neutrality and efficiency need not be mutually exclusive. Discrimination can be avoided, while at the same time securing coordination and neutrality by pooling responsibilities in an institution that represents not just one but all interested stakeholders. Following this logic, we suggest a CIP that represents all eligible stakeholders rather than assigning the task of IDM to just one party. Thereby, the CIP creates institutional neutrality and ensures efficiency.

Within the unbundling debate, the approach resembles the Independent System Operator (ISO) (for more detail Balmert & Brunekreeft (2010)). However, the CIP adds two new dimensions to the ISO concept. First, it "unbundles" IDM as the key step in the value chain, not network ownership or system operation. Thereby, it avoids ownership unbundling of the distribution networks. The current legal unbundling regime of the networks can be retained. Second, it does not "separate" IDM from the sector, but rather includes third parties; the governance structure is "common" instead of "independent".

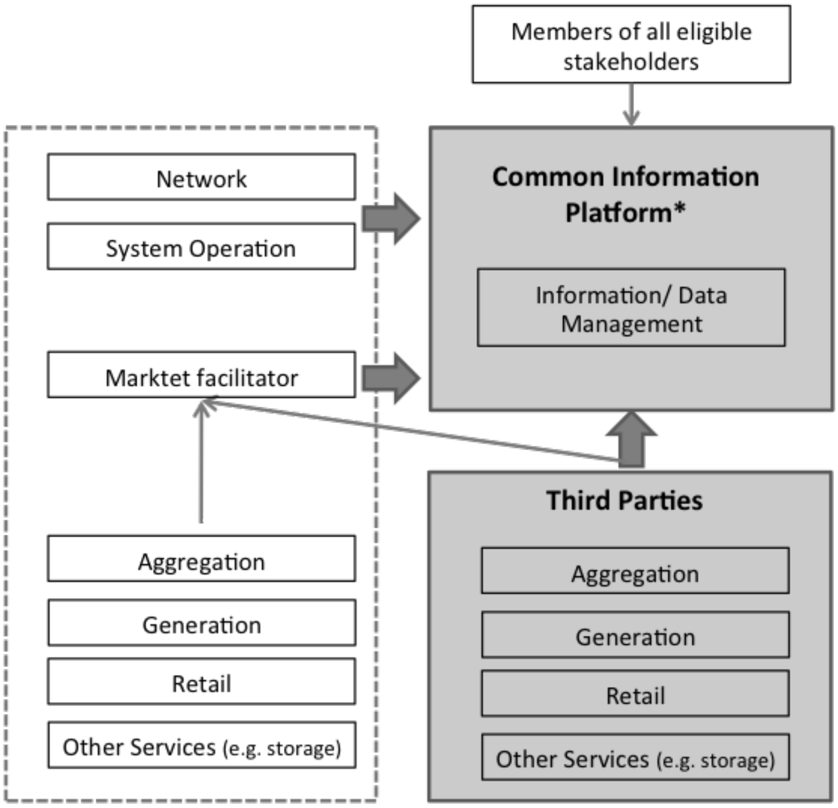

Figure 3.3: The common information platform

In more detail, the CIP has the following key characteristics:

- It is a decision-making and rule-setting body; it does not actually operate the smart grids itself. It designs the rules for IDM.
- It defines and delegates the necessary tasks for IDM to different parties (e.g. for data

storage, information infrastructure etc.). There will be different instruments to assign these tasks, most prominently tendering.

- It consists of (representatives of) all eligible stakeholders that are affected by smart grids.
- Rule-making and task-assignment are supervised by all stakeholders, which ensures non-discrimination.

With the CIP we propose to separate the operational part of IDM, i.e. development of necessary infrastructure and reliability for the system, from the organizational level, which focuses on the institutional process to decide about specifications and requirements.

The CIP is a cooperative, not-for-profit organization constituted by the relevant stake- holders of smart grids, namely generators, consumers, network operators, state agencies, consumer associations, service providers, information and telecommunication companies and others. Network and system operation can remain in the hands of the incumbents. The CIP takes over solely responsibility for IDM. The CIP does not have to carry out the functions of information processing and data management or operate any assets itself. Neither does the CIP require a central data storage system. It is merely a rule-making body. It sets the framework and delegates operation. The framework will likely include specifications for privacy and data protection requirements. By involving all eligible stakeholders, the CIP supervises the operation of the IDM and thereby serves technology and supplier neutrality as well as non-discrimination with regard to access to and operation of the IDM. Hence, the CIP enables both, new and incumbent actors, to provide services based on this information to the consumers. The CIP is an important foundation for competition on a level-playing field. In case of disputes, the CIP can offer mediation.

Based on the stakeholder-process the CIP will have to ensure non-discriminatory access to information through certain processes and rules. Our concept follows the insights on collaborative governance. Collaborative governance can be defined as a stakeholder-based decision making process with public and private participants (Ansell & Gash, 2008). Whether such a collaborative stakeholder approach secures neutrality and non-discrimination depends on several factors. Ansell & Gash (2008) evaluated 137 studies where stakeholder-based decision-making has been analyzed. Based on these insights they conclude that two criteria are most relevant for the success of a stakeholder process that should secure neutrality and non-dis- crimination. First, the approach must be inclusive, i.e. all relevant stakeholders need to participate. Second, rules for participation need to be transparent and decision-making (e.g. consensus vs. majority voting) needs to be defined properly. These are two main criteria that need further elaboration for the CIP. We will pick up these issues later on, however, a detailed analysis is out of the scope of this paper and needs further research.

Delegating decisions to stakeholders and thereby empowering decentralized actors and activating their knowledge has several benefits. First, the smart grid benefits from the creativity and innovation of competitive actors. Second, the information layer remains institutionally neutral. Third, the need for regulation of the operational part reduces. Including the interests of eligible stakeholders at an early stage of rule-making secures a system of checks and balances.

While some members of the CIP will be biased against competition, others such as the consumers will support competition. Given that decisions are consented by all interested stakeholders the need for regulation decreases: a system of checks and balances supports self- regulation; the stakeholder committee can mediate in case of disputes without intervention of the regulator. Regulation can likely be reduced to oversight of the design and implementation of the CIP as such.

While the CIP will not be unregulated, it allows a lighter, retracted role for regulation: stakeholders get the chance to take over responsibility to negotiate agreements among them- selves and self-defend their individual interests. This fits the idea of smart grids as enabling platforms for a diverse set of interlinked services and solutions. Negotiations can foster relations among the stakeholders, strengthen cooperative outcomes and tap the different parties' creative potential. Furthermore, cooperation and coordination of stakeholders are necessary, as system development no longer depends solely on the network operator. By including case- specific preferences and circumstances as well as joining different perspectives, a common stakeholder decision may enable tailored, individual solutions that one single actor could not have come up with or would not have realized.

Given the general concept of a CIP as presented so far, there is some scope for the design of a specific CIP. This paper gives a first rather general impression of the design options. We discuss

- demarcation of roles and responsibilities within the CIP,
- membership and eligible stakeholders,

- decision-making and voting rules,
- scale and scope of the CIP, and,
- regulatory effort.

This set of options is not exhaustive but sums up those aspects most relevant in the present debate. Each of these options needs further elaboration which is an issue of further research.

3.4.1 Roles and responsibilities

The CIP combines different tasks that may well require different approaches. Figure 3.4 illustrates one possible inner structure for a CIP.

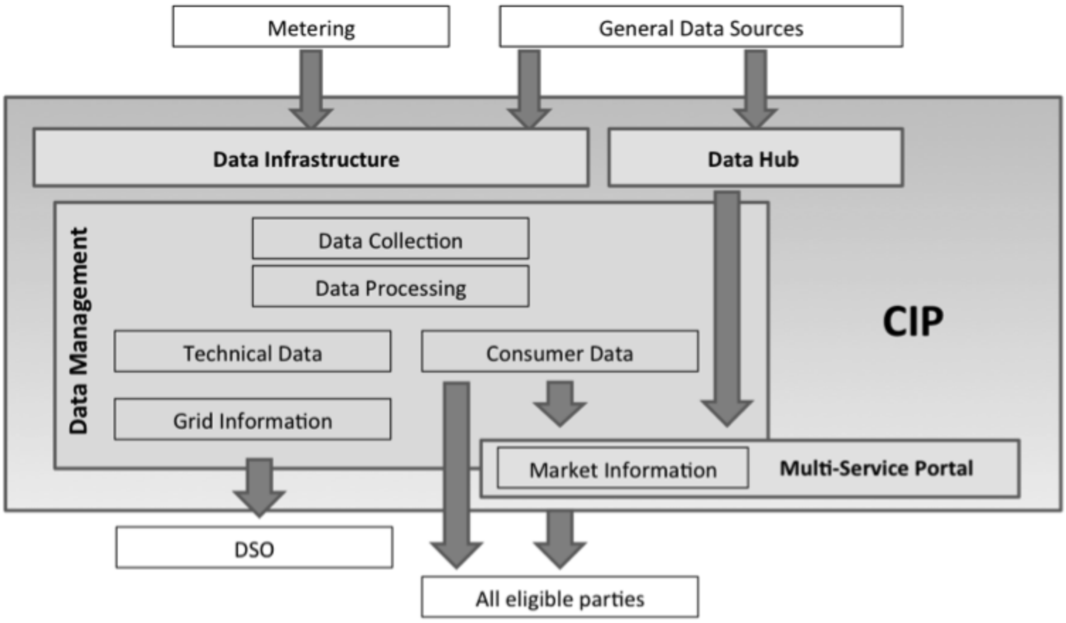

Figure 3.4: A first concept of the tasks within the CIP

We have distinguished four tasks supervised by the CIP: 1) data-infrastructure, 2) the data-hub interface, 3) data-management and 4) a multi-service platform. Within the field data-management we distinguished different types of data or information as briefly sketched in section 2. It is beyond the scope of this paper to go into detail here; it should be stressed though, that these fields differ in many respects and require a different approach in decision-making and task-assignment (for further details see BremerEnergieInstitut & WUWien (2014)).

The CIP is a decision-making body that tenders tasks to secure efficiency. Tendering serves provider neutrality since the tasks can be allocated to the best bidder, be it a stakeholder or a third party. Decisions on tender conditions are taken cooperatively and non-discriminatorily within the decision making process of the CIP. This also applies to the definition of requirements on the specific technologies that are applied. The stakeholders in the CIP will have to define technological requirements such as latency, bandwidth, or security, but not define the technology to be offered per se. Technological neutrality, that serves to allow the market to discover and offer the best technological option or a mix of technologies depending on the specific needs with respect to location, users, and purpose, is likely high in the CIP.

3.4.2 Membership

Membership should be open to all eligible stakeholders. All stakeholders should have a say in the requirements and desired outcomes of the IDM in order to make their interest count. Eligible are all those actors which either provide information or require the information for their business. The exact number of stakeholders depends on the size of the CIP. While the membership structure requires a more detailed analysis, it seems reasonable from today's perspective that at least the following stakeholders should be represented in the CIP, independent from its size: residential consumers, industrial consumers, generation companies, network owner, distribution companies, metering entities, retailers, ICT companies, service developers. Each group might have more than one representative, depending on the size of the CIP and the importance of a stakeholder group.

3.4.3 Decision-making and voting rules

Another central design aspect is the decision-making process including voting rules. Designing representation while at the same time maintaining the capacity to act and decide is a challenge. With an increasing number of stakeholders the necessity to establish a democratic system of representation for each stakeholder group gains relevance. The representatives then participate in the negotiations within the CIP. Hence, with regard to the design of the CIP, membership rules as well as voting and decision rights need to be specified. In many studies unanimity voting is the preferred concept to secure Pareto improvements (e.g. Wicksell (1869), Buchanan & Tullock (1962)). Unanimity is the preferred model in the context of collaborative governance as well (Ansell & Gash, 2008). However, unanimity comes with high transaction costs to define consensus. On the other hand, majority voting reduces transaction costs for decision-making, but does not result in Pareto optimal outcomes (Mueller, 2009). Further research is required to discuss an appropriate decision making process for the CIP.

Importantly, depending on the precise CIP-field (see figure 3.2 above), membership and voting rules may differ; it is easy to imagine different working groups for different fields. In total, the design of the rules on decision-making is a wide and complex field; yet, the basic notions on voting rules are well-known from political theory.

3.4.4 Scale and scope

In general, each service area could have a CIP. Sometimes this will be inefficiently small and cooperation or merger with another service area may be efficient. On the other hand, one nationwide CIP covering all service areas may also be inefficient. In particular, it would not take regional particularities into due consideration. For example, the optimal choice of data- infrastructure depends on local parameters. These could impact the optimal size of the CIP.

The number of CIPs influences several efficiency criteria: the CIP concept fosters efficiency by tendering the different tasks within the IDM to those actors best suited to realize them. These providers on the other hand can specialize on the respective tasks and potentially reach economies of scale by supplying several CIPs. Synergies between the ICT and electricity sector can be reaped, since both sectors are represented in the CIP. This is likely to lead to lower cost.

Yet, since each CIP tenders these tasks, transaction costs increase with the number of CIPs. The number of CIPs also reflects in the need for coordination: with fewer CIPs less coordination is necessary.[28] One single, large CIP can also help to maintain the interoperability of different local smart grids and the mobility of service concepts between them. Interoperability is important for service developers, since only one smart grid area might not offer enough market potential. However, as long as the different information systems are compatible, the potential to attract service providers increases. Generally, interoperability benefits when suitable standards are set (regionally, nationally, European, global) by regulation or by the CIP(s).

Coordination within the traditional electricity system is likely high in a smart grid with a CIP,

[28]Self governance is likely easier in smaller CIPs that cover more homogeneous stakeholders.

since the DSO and other actors are actively involved in the CIP and ownership unbundling of networks is avoided. Importantly though, a large part of coordination is determined by market design and price formation, which influence incentives and behavior of market participants to a large degree.

In case the DSO is a small municipal company that is also active in other utilities such as gas or water, multi-utility aspects are present in the CIP. More generally, the CIP concept offers the chance to foster such multi-utility synergies since gas operators, water network operators, and ICT firms can be included in the CIP if desired. This has to be weighed against the increasing complexity of coordinating the group of stakeholders. The larger the group and the more diverse the stakeholders become, the more difficult it will become to reach a consensus. Generally, in small network infrastructures stakeholder involvement in decision-making and organization is considered desirable (CEPA, 2011), while it has been questioned for larger and more complex systems (Muzzini, 2005).

3.4.5 Regulatory effort

Likely, the regulator needs to set the general framework in which the CIP can act, supervise the CIP and provide for dispute settlement. Furthermore, end-consumers, especially small ones that are unlikely to get involved, the interests of future generations and other unvoiced concerns need to be carefully considered when designing the CIP. The decision-making process within the CIP needs to ensure that these interests are duly considered. Furthermore, the regulator has to retain the responsibility to check whether this is the case. Furthermore, it needs to be secured that the CIP does not discriminate with regard to membership (e.g. deny membership to future new market participants). In particular self-interests pushed forward by a small group of stakeholders within the CIP should not result in discrimination of non- members of the CIP.

3.5 Conclusions and Outlook

In this paper we have presented a novel governance approach for information and data management (IDM) in smart electricity grids: a Common Information Platform (CIP). Our proposal emerges from the debate on network unbundling at distribution level and the responsible party in charge of IDM. Arguments in the discussion evolve around a trade-off between discrimination concerns and synergies from having one integrated supply chain, i.e. competition vs. coordination.

Governance models, which currently dominate the discussion, are unbalanced between coordination and competition. Adding IDM to the tasks of the distribution system operator has benefits for coordination, but may not secure non-discrimination. Keeping IDM and system operation together, but jointly separated from the competitive activities is an alternative. At the upside, this creates independent network operators for information and electricity benefiting non-discrimination. At the downside, this requires either ownership unbundling or a separation of network ownership and management. In both cases, this is to the disadvantage of coordination. A third class of models, i.e. Data Access-Point Manager and Central Data Hub, suggests IDM by third parties. While this can also be expected to effectively guarantee independence and neutrality, it is likely to result in weak coordination and efficiency losses in the smart grid.

We argue that the benefits of neutrality and efficiency need not be mutually exclusive. Neutrality can be secured by pooling responsibilities in an institution that represents not just one but all eligible stakeholders. The know-how of a larger group of stakeholders may even surpass that of just one, albeit long experienced, company. Following this logic, we suggest a CIP that represents all eligible stakeholders rather than assigning the task of IDM to just one party. Thereby, the CIP creates institutional neutrality and ensures efficiency.

The proposed CIP balances between competition and coordination with two central features: first, it focuses on "unbundling" of IDM, not unbundling of network ownership or system operation; all other activities can remain integrated, i.e. the current regime of legal unbundling of the distribution networks can be retained. Second, it does not "separate" the IDM, but rather "involves" third parties on rule-making level. The CIP is a club in which members collectively determine the rules for IDM. The CIP:

- secures non-discriminatory access to data
- allows third party stakeholders to have a voice
- determines the rules and the players of the game
- secures data security and privacy
- can be arbitrator and mediator in cases of conflict
- demarcates and tenders the various tasks of data-processing

We briefly discuss design options for a CIP approach. This includes (1) the demarcation of roles and responsibilities within the CIP, (2) the question of membership and eligible stakeholders, (3) the design of decision-making and voting rules, (4) the scale and scope of the CIP and (5) the regulatory effort that comes with the CIP. Within the scope of this paper we could only touch upon these issues and clearly a lot more work is required to work out the details of these design options.

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4 Information Management in Smart Grids - the need for decentralized governance approaches

Marius Buchmann

Information management secures the efficient exchange of data (e.g. from smart metering) in smart grids. Currently, national as well as regional information management systems are being developed. We discuss how the size of an information management system, i.e. the region covered by and the number of users connected to it, has an influence on the level of innovation in the process of the data exchange. Based on insights from the theory of fiscal federalism we argue that neither of the extremes of national (central) and decentralized governance approaches for information management will be optimal. We discuss how the market can determine the optimal degree of decentralization. If information management shall enable smart grids, then we show that the network operator needs to be able to incentivize network users to join and participate in an information management system to internalize externalities. Then, the size of the governance of information management systems will be linked to the network areas on the distribution grid level.

Keywords: Smart Grid, Information Management, data exchange, fiscal federalism, size

4.1 Introduction

The roll-out of electricity smart meters triggered a discussion about different data handling and information management models in Europe (cf. Ruester *et al.* (2013) & van den Oosterkamp *et al.* (2014)). However, this discussion about the governance of information management in smart grids falls short to define how the size of an information management system should be determined. Rather, the different concepts under discussion try to define which entity should become responsible for information management. Thereby, the size of an information management system is defined implicitly by the original function an entity already fulfills within the energy system (e.g. by the service areas of the network operators, suppliers etc.). We take a different perspective in this paper. Within our analysis we strive to identify criteria that help to define the (optimal) size of an information management system, independent from the fact who actually operates the system.

Information management here refers to the collection, aggregation and distribution of data (e.g. from smart metering). Thereby, information management serves as an enabler for smart grids and innovative services, which are anticipated to evolve. The term smart grids describes the integration of information and communication technology (ICT) into the electricity distribution networks (for a detailed definition see ETPSG (2010)). The primary driver for smart grids is the cost efficient integration of renewable electricity supply (RES). The availability and exchange of data (e.g. on electricity consumption and production) is a key requirement for smart grids. Information management facilitates the data exchange between the different parties in the energy sector. This is why information management has an important role as an enabler of smart grids.

So far, the discussion about the exchange of data from smart metering focused on neutral access to information and how to avoid incentives to discriminate third parties. Besides these two aspects the facilitation of innovation becomes an important criterion for the governance of information management as well. A key driver behind smart grids is the potential of smart technologies to reduce the costs of the integration of renewable energies into the electricity system, e.g. via substituting grid investments (dena, 2012). Furthermore, local balancing of load and demand should become more flexible. Data exchange is the key requirement to unlock these flexibility options. From today's perspective, it is difficult to anticipate how these innovative services could look like. However, the governance of information management should ensure that innovation is possible (CEER, 2014). Within this paper the focus is on the latter: Innovation here refers to developments in the governance approach (a future-proof governance approach), not to the creation of innovative products based on the governed system. Based on these three criteria the task of the governance approach of information management can be summarized as follows: develop a level playing field that secures innovation as well as neutral and non-discriminatory access to information for all eligible parties.

Out of the three criteria (non-discrimination, neutrality and innovation) the first two are primarily determined by the institutional design, but rather independent from the size of the governance approach. This is different in the case of innovation. Here, the question has already been raised whether the size of a governance approach has an influence on the level of innovation within the governed system. This question is specifically addressed by the theory of fiscal federalism. This theory was developed to define how a governance approach for local public goods could secure innovation (Oates, 1972). In essence, whether a uniform governance approach, as it might evolve under a centralized regulated approach, or a more decentralized governance approach can better facilitated innovation depends on two criteria: first, the heterogeneity of preferences for the provided good and second, the existence of economies of scale. The theory of fiscal federalism postulates that with increasing heterogeneity in preferences and low economies of scale a decentralized governance approach can better facilitate innovation (compared to a central approach), and vice versa.

In this paper, we apply the theory of fiscal federalism to the governance of information management and deliver indicators that support the hypothesis that both exist: heterogeneity in preferences for the provision of information management, and economies of scale. This leads us to the conclusion that neither a pure central nor a purely decentralized governance approach for information management is optimal. Rather, a certain degree of decentralization is required. We discuss two options to define the optimal degree of decentralization: Governmental decision and a market-based process. Due to information asymmetry between the government and the stakeholders relevant for information management the governmental decision on the size of the information management systems is not likely to result in an optimal solution. Therefore, we argue that the government should define the institutional environment for information management (e.g. data security, privacy polices and standards) and then let market forces define the actual number of decentralized governance approaches (i.e. the degree of decentralization). As mentioned above, information management should facilitate the data exchange in smart grids to reduce the overall costs of RES integration of the distribution grid level. We build on this argumentation and discuss in greater detail under which conditions the decentralized governance approaches (defined by the market) will evolve around the operation areas of the distribution grid operators and can help to reduce the costs of RES integration. Our analysis shows that the network operator should to be able to incentivize the network users to join and actively participate an information management system to internalize externalities and avoid market failure. If this condition is met, then it is likely that the size of the governance approaches for information management will be linked to the operation areas of the distribution grid operators.

The paper is structured as follows: In section 2 we summarize the current literature and existing approaches for the governance of data management in smart grids. In section 3 we define information management as a club good and introduce the theory of fiscal federalism. Section 4 applies these theoretical insights to the case of information management in smart grids. Here we show for the case of information management that both heterogeneous preferences and economies of scale exist. Based on these results we discuss in section 5 under which conditions the market will define the optimal size of the governance approaches for information management. Section 6 concludes.

4.2 The Current Discussion and First Approaches

The current discussion in the context of the data exchange in smart grids strives to find an efficient institutional design to facilitate the information exchange. The governance approaches under discussion should ensure neutrality and non-discrimination of third parties, i.e. a level playing field. The Smart Grid Task Force of the European Commission identified three concepts, two of which will result in regulated models, while the third one is a market-based approach. For the regulated models it is discussed to delegate the responsibility for data management either to the network operators (distribution grid operator (DSO) or the transmission system operators (TSO)) or an independent third party (Central Data Hub). Alternatively, market parties could provide the information management based on standardized processes (SGTF, 2013). These models are subject of intense discussions. Among others, Ruester *et al.* (2013) and van den Oosterkamp *et al.* (2014) analyzed in more detail the future role of the DSO in the context of information management. While these studies focus on potential governance structures, they do not explicitly address the size of the information management system, i.e. the region covered by or users connected to an information management system. Neither do these studies focus on the relation between the size of an information management system and the level of innovation.

Still, each of the currently discussed concepts implicitly suggests certain specifications of the size of the information management system. For example, if a model is proposed that delegates the responsibility for information management to one single central third party, then there will be one information management per country or at least the region covered by this third party. On the other hand, if the DSO shall be responsible, then it is likely that the information management system will cover the same region (which represents the connected consumers and producers), as does the corresponding DSO.[29]

So far, the current discussions in the context of the European Smart Grid Task Force focus on a uniform definition of a governance approach for information management, at least on the national level. Uniformity here refers to a central decision that one system approach is mandatory for all jurisdictions governed by the central authority, e.g. the EU. The downside of such a uniform approach, which applies one governance approach to all smart grid systems in a country or possibly even in the EU, is the potential missing link between a centralized approach and local requirements in the member states. The uniform approach is not able to adapt to local requirements. Therefore, in Brandstaett *et al.* (2017) we proposed an additional concept, which establishes neutrality, but does not require a uniform governance approach for information management. Our proposal focuses on a stakeholder-based decision approach, which should secure neutrality of data management. This concept has been labelled Common Information Platform (CIP). The CIP constitutes a common decision making body that could be responsible to decide which institution in a specific case should be responsible for data management. Thereby, the CIP is a solution to establish neutrality via the decision-making process and does not require

[29]However, the size of the different DSOs in Europe differ significantly. While Germany has roughly 880 DSOs out of which 10% have a cumulated market share of more than 90%, Greece has only one DSO for the whole country. Additionally, it can be questioned whether the smaller DSOs with less than 100.000 costumers, (roughly 2350 out of the 2600 DSOs in Europe (CEER, 2012)) will be able to bear the costs and the organization of information management. One solution to this problem could be that the larger DSOs might provide the information management infrastructure for the smaller DSOs as well.

adaptations in the institutional environment of smart grids. The basic idea of the CIP gets close to the concept of the Independent System Operator (ISO) (Balmert & Brunekreeft, 2010). The ISO delegates the responsibility for the operation of a specific infrastructure (e.g. network operation) to an independent body while the ownership of the infrastructure can remain with another party (e.g. an integrated utility). This concept therefore is primarily discussed in the context of monopolistic infrastructures to avoid discrimination, which shall be secured by the ISO. Different from the ISO concept the CIP does not separate the ownership and operation of the respective infrastructure (electricity and telecommunication), but integrates all relevant parties into the decision making process to reduce risks of discrimination. Though we did not specify the size of the CIP so far, the idea of this concept is that it can be combined with decentralized as well as centralized concepts.

Irrespective of the open questions concerning the governance of information management in smart grids, some countries already took first steps to develop information management systems. These approaches can be sorted according to the size of each system, i.e. the number of the consumers connected to, or the area covered by the system. The current approaches can be allocated to three different categories of size:

1. Decentralized DSO models, e.g. in Spain each DSO has its own data base. This results in a very fragmented system with 350 independent data management systems (CEER, 2012).

2. TSO centered models, as it is applied in Ontario, Canada. Here, the local Independent System Operator (ISO) of Ontario, named Independent Electricity System Operator (IESO), collects and manages the information of 4.8 million costumers (IESO, 2012). Similar approaches can be found in Europe, e.g. in Denmark. However, as there is only one TSO in Denmark, this concept results in a national approach. In fact, most of the TSO centered models in the EU and neighboring countries (Poland, Estonia, Norway) result in national models for information management, as in those countries that apply the TSO model only one TSO exists (CEER, 2012).

3. National model models, e.g. the Netherlands applied a nationwide approach (which results in a variation of the Central Data Hub Model discussed in SGTF (2013)). The Data Hub is called Energy Data Services Netherlands, short EDSN, and is operated by the three largest Dutch DSOs. Similar to the Dutch case the model in Belgium is based on a central data clearing house (called ATRIAS), which is administered by the government (CEER,

2012). In the UK the first official national data management and processing platform in Europe is currently developed. The approach in the UK is based on the Central Data Hub Model (SGTF, 2013). The government assigned the responsibility for data collection and processing to an independent service provider (DECC, 2013). CEER (2012) stresses that the central approach in the UK creates a new monopoly, while a market-based approach might have been possible as well.

The current academic debate, as well as the existing national initiatives for data handling in the electricity sector, point out that there is currently no clear framework to define an efficient size of an information management system in smart grids. With this paper we will shed some light on this issue.

4.3 Governance, Innovation and the Theory of Fiscal Federalism

In section 1 we already stressed that the governance of information management should secure neutrality, non-discrimination and innovation. Especially the relevance of innovation was emphasized by CEER (2014), to point at the high uncertainty with respect to the future design of the electricity sector and the corresponding information management system. Due to this uncertainty it is important that the governance approach of information management facilitates innovations. Therefore, innovation here describes the ability of the governance approach of information management to adapt to the new developments in the context of smart grids. I.e. governance innovation, the adaptation of the governance approach to a changing and uncertain environment is in the focus, not to the creation of innovative products based on the governed system. The question then is: Is there a relation between the size of an information management system (i.e. its governance) and the level of innovation incorporated by the governance approach of this system? This question has been addressed by the theory of fiscal federalism with respect to the provision of local public goods and we will apply this discussion to the context of information management.

Fiscal federalism is a concept from public economics focusing on the efficient provision of (local) public goods. Tiebout (1956) defined local public goods as being non-rivalrous (until congestion arises) and excludable. Thereby, these goods are comparable to club goods, which Buchanan

(1965) introduced as a solution for those public goods that offer the possibility to exclude consumers from it. Basically, we can think of a local public good being a club whose formation is based on geographical criteria. Therefore, some analysis applied the club approach to local public goods (e.g. Casella (2001) and Scotchmer (2002)).

Information management fulfills both criteria (non-rivalrous and excludable) of club and local public goods.[30] First, the services of information management can be defined as the non-rivalrous provision of equal access to data from different data sources for all eligible parties. For the data we can assume that non-rivalry is given, as different parties can use the data at the same time. However, rivalry might result on the executive (or hardware) side of information management as soon as the demand for information exceeds the limitations of the system, e.g. with respect to hardware resources. Congestion could evolve if too many users are asking data from the information management system at the same time. Therefore, excludability is required to avoid congestion (i.e. crowding) in the information management.

Generally speaking, a club strives to balance cost-sharing gains from an increasing number of members and the potential losses associated with congestion or crowding (Sandler & Tschirhart, 1997). For example, a consumer that does not have a smart meter cannot provide the necessary information/data that is needed for services offered within smart grids. It seems reasonable to limit access to an information management club to those parties that deliver either information/data or services. Therefore, consumers who do not provide information might be excluded from the club. In addition, excludability is required to meet data security and privacy concerns by the information providers. At least for personal data it is necessary that each provider of information can restrict the access to this data (CEN-CENELEC-ETSI, 2012). Though excludability is given, there exist externalities that are not excludable. For example, if data exchange

[30] The attempt to define the service provided by information management as a club good is different from the current approach in the literature. So far scholars (e.g. Ruester *et al.* (2013)) focused on the data that is exchanged in information management systems and define the data as an information good. Ruester *et al.* (2013) specified that the data in smart grids is a digital information good (a concept introduced by Varian (1998)), which is non-rivalrous and at least partially non-excludable (depending on the technology and regulation applied). However, based on the digital-information-good approach it is difficult to define the nature of data in smart grids. This is due to the fact that at least the excludability-criterion of data depends on the institutional design of the information management.

results in efficiency gains and reduces network investments, then all costumers can benefit from reduced network tariffs, irrespective of whether they are part of the information management or not. These externalities will be relevant for the analysis in section 5.

For local public goods and club goods (like information management) the theory of fiscal federalism analyzes whether central or decentralised governance approaches better facilitate innovation.

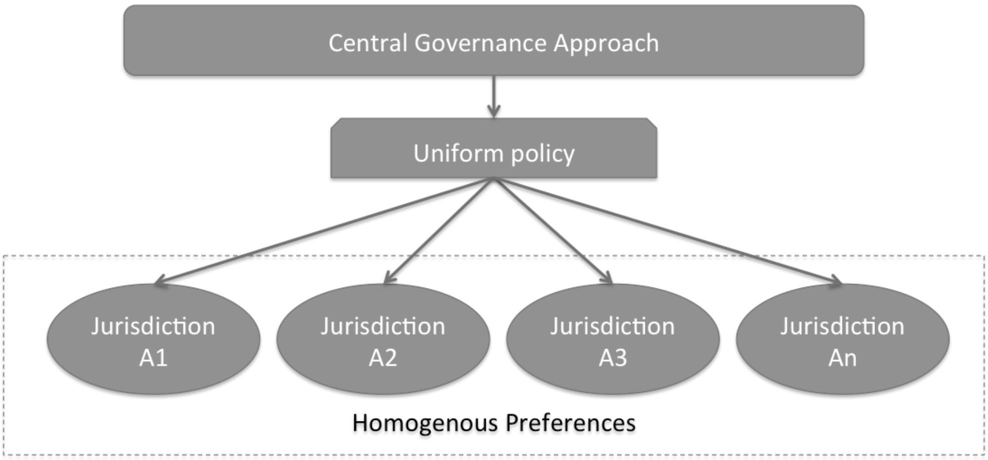
Oates (1972) defines one of the core principles of fiscal federalism, the decentralization theorem. Basically, the theorem says that a decentralized governance approach for public outputs can increase welfare compared to a situation with a centralized "one-size-fits-all" governance system, as long as economies of scale are not relevant (Oates, 1972).[31]

The decentralization theorem is based on two assumptions. First, it is assumed that the providers of the public good strive to optimize the welfare of the recipients, or that the governmental agent at least tries to reach reasonably efficient outcomes. Second, the decentralization theorem assumes that a central provision of local public goods results in a uniform provision for all regions under the central governance system. Oates (2008) provides two arguments that support his second assumption. From a political point of view, equity concerns might require a uniform provision of a good to avoid discrimination, even if this results in different costs for different regions. Strumpf & Oberholzer-Gee (2002) support this claim and stress that non-uniform policy approaches for different regions might result in local opposition from those regions that expect the most negative effects from the individual local policy. Furthermore, Oates argues that the transaction costs related to the central decision maker's effort to gain the relevant information about regional specifics are very high. Therefore, a central decision maker would always look for a uniform solution to minimize these transaction costs.

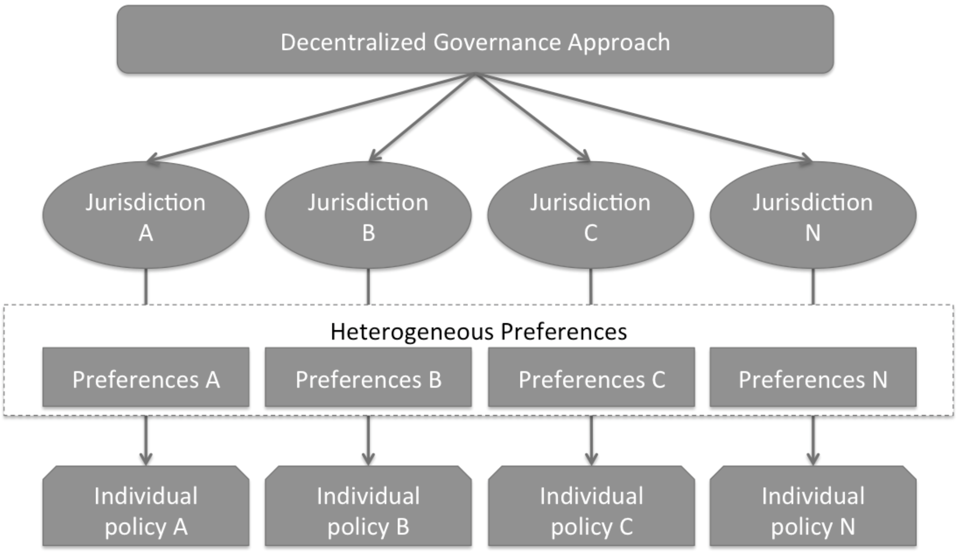
Summing up, there are several arguments that stress that a uniform policy is likely to evolve given a centralized governance approach. However, given heterogeneous preferences uniform pol-

[31] Therefore, the decentralization theorem is very close to the subsidiary principle as it is defined in the Maastricht Treaty. However, the perceptive here is a bit different, as subsidiarity means that the lowest governmental level with the required resources should proceed with a public action (for further details see Oates (1999)). A more detailed differentiation between fiscal federalism and the subsidiarity principle can be found in Bureau & Champsaur (1992).

icy approaches might result in less efficient outcomes then decentralized approaches.



(a) Central Governance with homogenous preferences



(b) Decentralized Governance with heterogeneous preferences

Figure 4.1: Central vs. decentralized governance approaches

Oates (2008) provides examples from the environmental federalism discussion to proof the validity of the decentralization theorem (e.g. based on the analysis of Dinan *et al.* (1999) on the drinking water regulation in the US).

Following Oates, these welfare losses could be avoided under a decentralized governance approach. He identifies two primary drivers for the cost advantages of decentralized governance systems. First, local demand for services and goods differ significantly between regions. Second, the costs to provide a service might differ between the regions as well. A decentralized governance approach could then better address these local specifications and thereby reduce costs compared to a uniform solution under a centralized governance approach.

The potential to foster innovation is discussed as another advantage of decentralized governance approaches. Bryce (1901) raised the idea that a decentralized approach allows to simultaneously develop different solutions and governance designs for the same issue.[32] On the contrary, central governance approaches would only focus on one policy at a time. In the context of fiscal policy the decentralized governance approach is known as laboratory federalism (Oates, 2008).[33] Several different examples in the history of the US support the hypothesis of laboratory federalism, i.e. the potentially innovative effect of decentralized governance approaches. Taxation of gasoline, the introduction of an unemployment insurance and emission standards for cars were concepts developed by individual states and have later been adopted by the federal government (Oates, 2008). More recently, several studies support the assumption that laboratory federalism results in higher economic income (For 20 OECD countries see Buser (2011), the US see Holcombe & DeEdgra (2011) and Switzerland see Feld *et al.* (2004)). In addition, several studies provided evidence that local governments tend to copy successful policies from neighboring jurisdictions, if these are applicable to the corresponding requirements (see for example Buettner (2001) for Germany, Schaltegger & Kuttel (2002) for Switzerland, Besley & Case (1995) and Freeman (1985) for the US).

[32] This is what Salmon (1987) denotes as horizontal competition and what is known as institutional competition (Siebert & Koop, 1993).

[33] Which is a specification of the more general concept of economic federalism. Other forms of federalism are cooperative federalism (where the central government decisions are based on unanimity between the representatives of all jurisdictions) and democratic federalism (where the central government decisions are based on a majority from the representatives of all jurisdictions). For more details see Inman & Rubinfeld (1997).

Strumpf (2002) provides theoretical support for the decentralization theorem, based on a model that focuses on strategic policymaking for the case of decentralized jurisdictions. Based on his model Strumpf (2002) concludes that decentralization results in a higher degree of innovation, if different policy options are available. Further empirical support for the decentralization theorem is provided by Strumpf & Oberholzer-Gee (2002). Their analysis is based on a panel dataset on the liquor control policy in the US (data from 1934 till 1970). This data is then used to model the policy maker's choice for either a central or decentralized governance approach for liquor control. Strumpf & Oberholzer-Gee (2002) conclude that the liquor policy in the US supports the central hypothesis of the decentralization theorem: heterogeneous preferences are best met with decentralized governance approaches and decentralized approaches set stronger incentives for innovation, as long as the regional preferences differ from each other.[34]

Summing up, the decision between centralized and decentralized governance approaches depends on the trade-off between heterogeneous preferences and economies of scale. With an increasing diversity of preferences decentralized governance approaches are superior of centralized approaches. Vis versa, if economies of scale are high, decentral jurisdictions should merge to exploit these economies. Basically, scale economies are always relevant with decreasing marginal costs. In the context of governmental decision making economies of scale are associated with lower administrative costs, increased purchasing power, and improved utilization of equipment (Andrews & Boyne, 2009). While many services provided by the government are labour-intensive services, e.g. police, economies of scale can be very high in the governmental context for those assets that have high fixed costs, e.g. domestic water storage and provision. The question in the context of fiscal federalism then is whether a decentralized governance approach does leave a potential for economies of scale unexploited, with the effect that the gains from decentralization (e.g. innovation) are overweighted by these additional costs from low economies of scale. Different studies (e.g. Feld *et al.* (2004) for Switzerland, Drew *et al.* (2014) for Australia) provide empirical insights revealing that unexploited economies of scale in a decentralized governance system do not necessarily result in a reduction of overall economic performance. We will investigate in the next section whether we can expect the same for the case of a decentralized governance approach

[34] This basic assumption is not without criticism. Among others, Rodden & Rose-Ackerman (1997) point at the risk that influential interest groups might be able to isolate decentralized jurisdictions from external competition, which would in effect reduce innovation.

of information management.

4.4 Heterogeneity and Economies of Scale - Implications for the Governance of Information Management in Smart Grids

As described above, the theory of fiscal federalism tells us that a decentralized governance approach can increase welfare (compared to a central governance approach), if the different regions have heterogeneous preferences. Specifically the level of innovation could be higher under decentralized governance approaches, given the assumption of heterogeneity. Furthermore, decentralized governance approaches are better capable of addressing local specifications, e.g. local preferences of the population. On the other hand, economies of scale are higher under a centralized approach. Therefore, the search for the optimal size of the governance approach for information management needs to start with the evaluation of preferences and economies of scale.

4.4.1 Heterogeneous preferences

Our analysis in the following paragraphs shows that heterogeneous preferences exist with respect to information management. We illustrate this with an analysis of the situation in Germany. Still, the results obtained can be applied to other regions as well.

Importantly, our analysis focuses on the current situation in the German electricity system. It does not apply to the system as we know it from the last decades. Different from today's energy system, which has changed due to the diffusion of distributed generation, the electricity system (not only in Germany) was rather homogenous. A high level of standardization ensured an efficient operation of the system. Ten years ago, one would have concluded that preferences for the exchange of information were rather homogenous. Especially, as only a small group of actors were actively involved in the electricity supply chain, i.e. the market was highly concentrated. Therefore, a uniform governance approach, as it was actually applied, matched with these requirements quite well. However, this is changing with the development of smart grids (Brunekreeft *et al.* , 2016).

We identify six arguments that support the assumption that the preferences in Germany with respect to information management in smart grids can be expected to be heterogeneous.

First, the technological decentralization of generation capacities is an important trend in the German (as well as other European) electricity system(s). Households as well as industrial consumers start to produce their own electricity based on RES and combined heat and power (CHP). Due to the regional differences in the availability of RES, especially for solar and wind energy, the differences in regional electricity systems are increasing. Based on these differences in RES, the regional requirements for the development of the electricity infrastructure and the resulting costs (see dena (2012) for details) differ as well.[35] Furthermore, the need for flexibility, on both the demand and the production side, might be higher in one region with a high share of RES than in those with lower RES.[36] Resulting from these differences on the technological level the requirement for the data exchange are likely to differ between these regions, too. While a region with low RES might require less extensive information management, other regions with high share of RES and/or high loads, e.g. from industry, might have a high demand for data exchange. Especially, if smart applications should substitute network investments and thereby increase overall system efficiency (E-Bridge *et al.* , 2014).

Second, rural and urban areas differ with respect to their electricity system. For the case of Germany, especially rural areas face an increase in RES, while they are currently equipped with a less capable electricity infrastructure, i.e. networks. Urban areas, on the other hand, have a higher network capacity (due to high demand density) and a smaller share of RES installed (due to limited space). Due to these differences the requirement for smart grids is less significant in urban areas (high network capacity, low RES), while smart applications could help to reduce costs for RES integration into the rural networks (dena, 2012).

Third, electricity consumers will soon be equipped with smart metering infrastructure. This metering infrastructure needs to be connected to the wide area networks to enable data exchange. Different technologies can be applied to establish this connection. Either cable based

[35] The difference between the regions in Germany have been identified in dena (2012) based on the analysis of twelve distribution grid operators with different network and supply characteristics. These network types differ significantly with respect to the installed capacities of RES and loads.

[36] The required per capita investment in the distribution networks to integrate RES will be six times higher in Mecklenburg-Western Pomerania than in North Rhine-Westphalia (dena, 2012).

technologies (e.g. Power-Line-Communication (PLC) or Digital-Subscriber-Line (DSL)) or wireless technologies (General Packet Radio Service (GPRS) or Universal Mobile Telecommunications System (UMTS)) are possible. Which technology will be applied is context specific. In the case of Germany it is again possible to clearly distinct urban areas (with a high DSL and wireless coverage) and urban areas (with a low DSL and wireless coverage).[37]

Fourth, regional electricity markets might evolve quite soon (triggered by RES expansion and the resulting need for flexibility). The concept of regional markets was introduced to allow local trade of balancing power or even local services specifically designed for the respective distribution grid. Batlle & Rivier (2012) proposed to define local and physically connected balancing areas within the networks of the DSOs. These balancing areas should allow different retailers to provide flexibility services to both, the DSOs (e.g. for voltage control) and TSOs (e.g. frequency control). The assumption is that local approaches might make better use of potential for synergies then centralized systems (Ruester *et al.* , 2013). Similarly, the requirements for data exchange will differ between these markets.

Fifth, the ownership structure in the electricity sector gets more heterogeneous as well. While former investments in generation facilities were primary made by energy utilities or other companies, local cooperatives are today relevant investors for RES (e.g. 12% of the US population is being served by an energy cooperative today (Yadoo & Cruickshank, 2010)). In Germany, more than 850 local cooperatives are active (Holstenkamp & Mueller, 2013). Furthermore, private investments in RES reached approximately 47% of all of all RES investments in 2012 in Germany (9% from cooperatives)(trend:research & Leuphania-University, 2013). Though renewable energy cooperatives evolve all over Germany, there are strong regional foci in specific regions. For example, Lower Saxony has the second highest number of energy cooperatives in Germany (Holstenkamp & Mueller, 2013). It is likely that in those regions, where cooperatives are active in electricity production from RES, the exchange and management of information will require a more active integration of regional actors into the governance process, as more people are actively participating in energy production.

[37] PLC is based on the electricity networks and therefore has a high coverage rate in Germany. However, the current state of the technology seems not be be sufficient for the data exchange from smart metering (dena, 2014).

Sixth, the regional preferences with respect to the consumption of green electricity differ significantly in Germany. While roughly 24% of all households in Bavaria had signed a green electricity contract in 2011, only 12% did so in Lower Saxony (see TNS-Infrastest (2011) and preisvergleich.de (2011)). While these numbers do not show the regional preferences for information management in smart grids, they at least indicate that the interest in renewable energies and the willingness to transform this interest into a new contract with an alternative supplier differs significantly between regions. Whether similar heterogeneous preferences exist for information management in smart grids needs further investigation, but the experiences with green electricity contracts might serve as an indication for potentially diverse preferences.

These six arguments suggest that the requirements for information management and the demand for services based on this information will differ between regions in Germany. It might be possible that some regions require a very detailed data exchange due to technical reasons, while in other regions the local identification with electricity production from RES, e.g. based on cooperatives, requires a detailed stakeholder process to adapt the data exchange to local requirements. Furthermore, the demand for new services on the local level might differ as well, e.g. with respect to local balancing products. The governance of information management should address these differences.

4.4.2 Economies of scale

According to the theory of fiscal federalism heterogeneity is a key driver for decentralized governance structures. On the other hand, with increasing economies of scale, the optimal governance structure becomes more centralized. The question then is whether economies of scale exist for the management of information in smart grids.

Following Silberston (1972) economies of scale can have different origins. First, initial fixed costs, which are independent from the scale, can be the source of significant economies.The management of information will require several investments for data collection, aggregation and distribution (trade), e.g. in data storage capacities, IT infrastructure etc. Therefore, fixed costs are likely to be high, while the variable costs of data exchange will be low (van den Oosterkamp *et al.* , 2014). The investment needs for information management are comparable to those currently made in the cloud-computing sector, which is a new market currently in the introduction phase. At least the storage capacities and the IT infrastructure to manage the exchange of data between the cloud and the user are comparable to the facilities required for information management in smart grids. The current market developments for cloud computing illustrate the potential for scale economies in the context of data storage and handling (Markovic *et al.* , 2013). Similar effects can be expected for information management with respect to fixed hardware costs.

The example of cloud computing points at two other source of economies of scale, the development of working capital[38], e.g. from massed resources, and increased size. In the case of information management the mass resources can be larger server capacities and other parts of the IT infrastructure. With an increasing size of these server capacities the costs of the information management system might not increase proportionally with scale. Furthermore, the specialization of labour can increase scale economies as well, e.g. specialist on data verification from smart metering can reduce operational costs.

Positive network effects can be a source for scale economies as well. Noam (2009) points out that due to network effects existing users gain from the integration of additional users, e.g. due to new demand or potential for cooperation. For information management network effects are likely to be important. For an established information management system the additional costs for the integration of a new data source or a new data user to an information management system is likely to be close to zero. At the same time the increase in output due to this new participant in the information management system might be huge (at least positive), as the new participant interacts with other parties in the system. One example can be the new service of aggregation, e.g. for the provision of virtual power plants. An aggregator of a virtual power plant combines different energy sources and sinks in its portfolio and sells the flexibility provided by this system to the market, e.g. to the balancing market. Integrating such an aggregator into the information management system comes at low costs. The aggregator increases cooperation between the different parties involved in the information management system, which might (significantly) increase the utility derived from the information management for all involved parties. For the case of the virtual power plant aggregator we can assume that the positive influence on the output of the information management system increases with its size, as the aggregator then gets access to more flexibility potentials. The described network effects therefore will have a positive effect with respect to economies of scale in the context of information management as well.

[38]Noam (2009) here refers to technical economies of scale.

Additionally, economies of scope might exist for information management in smart grids. Different approaches might serve to develop these potentials. For example, not only data from electricity smart meters, but also other energy meters could be managed within one system. Furthermore, already today several registers with similar data sets exist in the energy sector. It might be possible to combine these databases with the information management in smart grids to make use of the existing synergy potentials.

According to the theory of fiscal federalism the two previously discussed aspects of heterogeneous preferences and economies of scale are two important criteria that help to evaluate how the size of governance approaches can influence the level of innovation within the governed system. On the one hand, the analysis above revealed that for information management in smart grids economies of scale are relevant, which would favor a centralized governance approach to exhaust this potential. On the other hand, it seems likely that different regions in Germany are characterized by different preferences for the management of information in smart grids, e.g. with respect to the amount of data to be exchanged for the purpose of balancing etc. These heterogeneous preferences would rather support a decentralized approach to adapt the information management to the local specifications in favor of an optimal solution. Therefore, neither a purely centralized nor a purely decentralized approach seems to be an optimal solution for the governance of information management in smart grids, at least as far as fiscal federalism tells us. How can we find the optimal size then?

4.5 How to Determine the Optimal Size for the Governance of Information Management Given Heterogeneous Preferences and Economies of Scale

For the case of information management the analysis in section 4 of this paper revealed that the optimal size for the governance approaches requires a certain level of decentralization. The question then is how much decentralization is required. I.e. what is the optimal degree of decentralization?

We discuss two options how the number of decentralized governance approaches for information management can be defined: Either via governmental decision or based on market forces.

First, the government could define the number of governance approaches and the areas these approaches should cover. This is actually how it is down in most European states at the moment. However, in most cases the governments defined central, and thereby uniform, governance approaches. We have introduced these examples for central and uniform governance approaches already in section 2 (e.g. Denmark an other countries delegated the task of information management to the TSOs, which results in a central model, UK operators a national monopoly etc.). This observation supports one of the assumptions the decentralization theorem is based on (for details see in section 3 of this paper): Governments tend to apply uniform governance approaches, neglecting heterogeneous preferences.

For now, let us assume that a central government strives to define a decentralized governance design for information management (that is, we neglect the insights from fiscal federalism for now).[39] In this case, the problem is that the government does not have the information about the heterogeneous preferences of all relevant stakeholders (or it would result in very high transaction costs to gather all the information, which potentially will exceed the benefits derived from the additional information). Due to information asymmetry between the government and the network users, the governmental decision on the size of the decentralized approaches is not likely to be optimal. As an alternative to the governmental decision, information asymmetry can be addressed by a market-based approach. This is the second option we want to discuss.

Instead of a governmental decision to define the size of the governance for information management systems, the government could just define the higher-level institutional framework for the governance of information management (like standards, privacy issues etc.) and let market forces define the optimal degree of decentralization. Given this scenario, we can expect that there will evolve different governance approaches for information management that address different needs on the decentralized level. Each user will be free to choose which information management system (and thereby which governance approach) he wants to join. Thereby, each user will decide to join a specific information management system based on an individual cost-benefit

[39] In this scenario, with regional information management systems implemented by the government, the different governance approaches can still compete with or learn from each other. Such a system would get close to a system of institutional competition. Under these circumstance concepts like sunshine regulation (McCraw, 1984) could be applied to secure that efficiency potentials on the decentralized level are exploited (at least to a certain extend).

analysis. In other words, the stakeholders will decide which club for information management they want to join. Furthermore, each decentralized information management system will decide within its governance approach which users and how many of them can join their system (i.e. the information management club). Buchanan (1965) illustrated that the optimal size of the clubs is defined by the costs and benefits from sharing a resource. I.e. the costs for having an additional consumer must equal the average costs required for the provision of the respective good (Casella & Frey, 1992). This cost-benefit evaluation will be done by the individual governance system for information management, which should (according to Buchanan (1965)) result in optimal solutions for the size of the clubs.

Given the second option, a market-based approach to define the optimal size of the decentralized governance approaches for information management, it might happen that either a very fragmented or very concentrated landscape of decentralized governance approaches evolves. However, we think that the size of the governance approaches for information management will (and should) be linked to the balancing areas on the distribution grid, i.e. the area covered by a distribution grid operator. In section 4 we introduced six indicators that describe the heterogeneous preferences with respect to information management in Germany. Out of these, the regional differences in RES and the resulting requirement for flexibility and network investments is very important in the given context of smart grids. Recall that the primary purpose of smart grids is the efficient and flexible local balancing of demand and supply (especially from RES) to reduce the requirement for grid investments. Therefore, the different services anticipated to evolve in smart grids focus on a local/regional scale (SGTF, 2010). The exchange of data between different regions that are not connected on the distribution grid level is therefore not a necessary requirement for smart grids. Though there might evolve other requirements for interregional data exchange in smart grids, the primary task of an information management system in smart grids is to ensure efficiency on the local level.[40] Importantly, this does not imply that the DSO necessarily is in charge of the information management system. Rather, the DSO is one important stakeholder for the governance of an information management system (Brandstaett *et al.* , 2017).

We argue that under a market-based approach, where users can freely choose their governance system, the size of the information management systems and their decentralized governance approaches will evolve to the network areas of the DSOs under one important condition: The

[40] Importantly, the exchange of information with the TSOs needs to be secured.

network operator needs to be able to *incentivize* network users to actively participate in an information management system.

This condition needs to be met to address the externalities related to information management systems. In section 3 we discussed that information management will result in such externalities. Among these externalities are reduced network charges, which can result from efficiency gains and reduced network investments based on the data exchange in the information management system. If different network users interact with the DSO via the information management to efficiently manage the distribution grid, then these actions should reduce the overall network costs. Now, if these reduced costs result in an overall reduction of the network charges for all network users, then this is an externality. In this case, the externality motivates free-riding. To illustrate this, think of a network operator who exchanges data with some network users via an information management system. Based on the data available some network users are asked to adapt their consumption or production according to the network operator's requirements. This will result in costs for the network users that react to network operators demand. The network users adaption of consumption and/or production of electricity should increase efficiency (in network operation) and therefore should result in reduced network operation costs. Now, these benefits are socialized via the overall network charges. I.e. the network charges for *all* network users, and not only those who bore the costs, are reduced. Next, lets assume that the network users might have other incentive (e.g. derived from a specific service only available in one information management system) to join an information management system that does not include the regional DSO to which they are physically connected. Under this assumption the network user would still gain from the externalities accomplished by the information management system that involves the local DSO (via the reduced network charges), without being a member of that system and bearing its costs. Under this assumption, the market will not provide the necessary service of information management, which is a market failure. One option to address this market failure could be governmental intervention (regulation). As discussed before in this section, this governmental solution is not likely to result in an optimal solution.

The situation changes if the network operator is able to incentivize the relevant network users to join the same information management. This incentive is required for the coordination between the network operator and the network user via the information management system. The goal of this coordination is the reduction of the network operation costs. Several studies revealed the potential to reduce the costs of RES diffusion based on to the active integration of network users as providers of flexibility for the network operation.[41] To unlock the efficiency potential related to the flexibility provision by network users data needs to be exchanged between the network users and the network operators (Brandstaett *et al.* , 2011). This data exchange should be facilitated by the information management system. Based on the data available in the information management system the network operator should be able to offer incentives (e.g. in form of payments) to the participants to adapt their consumption or production of electricity according to the network operators needs. It is reasonable that the network operator financially rewards the users adaptation to the networks requirement, as the adaptation of the user (at least) avoids additional costs for all users for the network integration of RES. Obviously, the network operator should only incentivize flexibility that has lower cost than network expansion. The information management system provides the basis for the network operator and the network users to exchange data and incentives (e.g. via a regional market). This implies that both the network operator and the network user need to be physically connected and part of the same information management system to be able to exchange information, incentives and flexibility (i.e. electricity production or consumption, demand side management etc.).

Under the assumption that the network operators can offer incentives to the network users being part of the same information management system, it seems reasonable to expect that the decentralized governance systems for information management will somehow (driven by the market) evolve around the DSOs. Nevertheless, network users would still be free to choose which information management system they want to join. Different information management systems with different governance approaches can compete on the decentralized level. This competition should increase efficiency. But, under the assumptions described above, the DSO will be able to incentivize those network users that offer a relevant flexibility potential (and thereby the potential for cost reduction) and are connected to the DSOs grid, to join the same information management system(s) as does the DSO.

Under these conditions it might turn out that for each network area owned by a single DSO an individually governed information management will be applied. However, it is possible as well that an information management covers more than one DSO, if the preferences for the information management system are similar (homogenous) in the network areas of the different DSOs.

[41] for Germany see dena (2012) and E-Bridge *et al.* (2014), more general for Europe see EUTFSG (2015)

Then economies of scale can be exploited as well.

4.6 Conclusion

In this paper we analyzed how we can define the optimal size of an information management system in smart grids. Information management here refers to the collection, aggregation and distribution of data (e.g. from smart metering). The governance of information management needs to secure neutrality, non-discrimination and innovation. Our analysis shows that the size of the governance approach for information management can have an influence on innovation within the information management system.

As a basis, we illustrate that information management can be defined as a club good and apply the theory of fiscal federalism. This theory addresses the question under which circumstances a decentralized or centralized governance approach results in higher levels of innovation. To determine which governance approach could be applied in a given context one needs to evaluate the heterogeneity of preferences between regions and potentials for economies of scale.

We focus our analysis on the case of Germany to show how the theory of fiscal federalism can be applied to define the size of a governance approach for information management in smart grids. Based on these insights we find that both exist, heterogeneous preferences and economies of scale. Therefore, neither a central nor a purely decentralized governance approach will result in an optimal size.

The heterogeneous preferences suggest a decentralized governance approach to adapt the information management to local specifics. Therefore, our analysis results in the recommendation not to apply central governance approaches to information management in smart grids. Still, there exist potentials for economies of scale as well, which will not be exploited given a purely decentralized governance design.

We discuss two options how the size of the governance approaches on the decentralized level could evolve. First, the government could define the size of the decentralized governance approaches. This is unlikely to result in optimal solutions due to the information asymmetry between the government and the users of the information management. This information asymmetry will either result in high transaction costs to gain the required information or leave efficiency potentials unexploited. Furthermore, it was discussed in this paper that governments tend to apply central and uniform governance approaches, which will reduce innovation and efficiency given heterogeneous preferences. The second option to define the size of the decentralized governance approaches is a market-based approach. Here, the government defines the high-level institutional environment (e.g. standards, privacy policies etc.), and given this environment market-forces should define the optimal size of the governance approaches. For the market-based approach we point out that the network operator should be able to incentivize the network users to join and actively participate in the information management system, if the network users interaction with the DSO via the information management system increases efficiency (i.e. reduces the costs of network operation). It is necessary that the DSO can incentivize the participation and interaction in the information management system to avoid free-riding based on the externalities of the information management system (e.g. reduces network charges for all network users).

Provided that the DSO can incentivize the network users to join and actively participate in the information management system we conclude that economies of scale might be exploited as well, if an information management system covers more than just one DSO and its network area.

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5 Integrating stakeholders into the governance of data exchange from smart metering - How the voting process can balance between non-discrimination, transaction costs and innovation

Marius Buchmann

The electricity supply chain is changing due to the integration of renewable energies. Two developments are in the focus of this paper: First, the emergence of third parties and second, the requirement for information management (i.e. the management of data exchange from smart metering) as a new step in the supply chain. Information management needs to secure the neutral and non-discriminatory integration of third parties into smart grids. This can be accomplished by a collaborative governance approach. Based on veto-player theory we identify two key issues for the voting process within a collaborative governance approach for information management. First, we show that a voting process based on "individual veto players" will result in governance lock-in situations, where governance innovation will be impeded. Second, we discuss that "collective veto players" can secure governance innovation for information management, but that the non-discriminatory integration for third parties might be at stake, if less than a qualified majority is required to vote on a veto.

Keywords: Smart Grid, Information Management, Data Handling, Voting, Veto Player

5.1 Introduction

Involving stakeholders into the governance of smart grids is a major requirement to align two important developments in energy systems with increasing shares of renewable energies: The rise of third parties and the emergence of information management as a new step within the electricity supply chain. In this paper we provide a first approach to define how the voting process within a stakeholder approach for the governance of information management can be designed to secure the efficient (i.e. non-discriminatory) integration of third parties.

Driven by the introduction of smart metering in the electricity distribution networks the management of digital information about electricity production and consumption is becoming a new task in the existing energy supply chain. The collection, aggregation and distribution of data from smart metering is called information management (Buchmann, 2016). Information management is required to enable the development of smart grids. The term smart grids summarizes the approach to implement information and communication technology (like smart metering) into the electricity distribution grids to reduce the overall costs of the integration of renewable electricity supply (RES) (ETPSG, 2010).

Parallel with the development of information management, third parties gain relevance in the electricity sector. Third parties are all those actors that are non-incumbents in the electricity sector. These new market participants emerge in different parts of the energy supply chain, but most prominently in electricity generation. Private as well as institutional investors focus on investments in RES. Brunekreeft *et al.* (2016) revealed that the emergence of third parties already starts to alter the energy sector in Germany. They show that similar developments take place in other European states. As third parties become active in every step of the electricity supply chain, they gain relevance for the data exchange in smart grids. On the one hand, some third parties might be in the position to provide data, e.g. on generation from RES, consumption and flexibility potential. On the other hand, third parties might as well offer new services and products to the market, based on the data about energy consumption and generation, e.g. virtual power plant operators.

These two developments, the rise of third parties and the emergence of information management, are not independent from each other. Rather, information management needs to secure that all eligible third parties have the same access to the data in smart grids as have the eligible incumbents from the energy sector. To address this task different governance approaches are currently discussed on the European level (SGTF, 2013). Among the currently discussed models there are few which do not require regulatory oversight.[42] Brandstaett *et al.* (2017) as well as Buchmann (2016) analyzed different governance concepts for information management and point at the potential of a stakeholder-based governance approach to balance between two main criteria: coordination (the transaction costs related to information exchange between grid operators and grid users) and competition (i.e. a level playing field).

Based on these analyses my colleagues and I proposed a new governance approach, the Common Information Platform (CIP)(Brandstaett *et al.* , 2017). The CIP constitutes a stakeholder-based decision making body that supervises the information management system and establishes a level playing field for services that require the data on energy consumption etc.. The basic idea of the CIP gets close to the concept of the Independent System Operator (ISO) (Balmert & Brunekreeft, 2010). The ISO delegates the responsibility for the operation of a specific infrastructure (e.g. network operation) to an independent body while the ownership of the infrastructure can remain with another party (e.g. an integrated utility). This concept therefore is primarily discussed in the context of monopolistic infrastructures to avoid discrimination, which shall be secured by the ISO. Different from the ISO concept the CIP does not separate the ownership and operation of the respective infrastructure (electricity and telecommunication), but integrates all eligible parties into the decision-making process to reduce risks of discrimination. Thereby, the CIP secures neutrality, non-discriminatory integration of third parties into the data exchange and reduces the requirement for regulatory oversight.

With this paper we want to take the discussions about stakeholder involvement in the governance of information management in smart grids (e.g. via the CIP concept) one step further: We discuss voting rules concerning two aspects: 1) securing non-discrimination and 2) promoting governance innovation.

To address these two issues we introduce the current state of the debate on stakeholder-based

[42] Actually, only one model, the Data Access Point Manager could be applied without regulation, the other models, namely the Central Data Hub and the DSO as Market Facilitator Model, require regulatory oversight to secure neutrality and non-discrimination (SGTF, 2013).

decision making in section 2. In this section we show that for the case of information management the stakeholder involvement into the decision-making process results in a collaborative governance approach. The collaborative governance approach applies the unanimity rule and requires that each stakeholder participates in the decision making. Based on the veto-player theory it is discussed in section 3, that unanimous decision-making based on individual votes (as it is proposed by the collaborative governance approach) can result in governance lock-in situations. Here we discuss how collective veto-voters can help to overcome these lock-in situations. Section 4 then applies the insights from the veto player theory to the question how the voting process within a collaborative governance approach for information management in smart grids can secure governance innovation. Within this section we show that the risk of lock-in situations, where no governance innovation is possible, is high for the case that each individual voter has veto power. Therefore, we propose to apply the concept collective veto players to overcome governance lock-in situations. We define six collective veto players who are based on the different roles involved in the information management system. Each collective veto player can decide to veto against a decision. To reduce the risk of discrimination of third parties or other minorities we propose to a apply a qualified majority vote for the decision within the collective veto player. Thereby, the potential for governance innovation increases, while the risk of discrimination of third parties decreases. section 5 concludes.

5.2 State of the Debate

The idea to apply stakeholder-based concepts in the electricity sector has been raised in other contexts before. In most cases the stakeholder concepts are proposed as an alternative to regulatory oversight. For example, Friedrichsen *et al.* (2014) investigated the potential role of stakeholders within the regulation of smart systems and point at the efficiency potentials, which might be derived from a stakeholder process. Pollitt (2008) promotes a similar concepts when he calls for a paradigm shift in the electricity regulation with a stronger emphasis on the process of regulation based on stakeholder involvement. Comparable ideas were picked up by Glachant (2012) with the open arena approach and Littlechild (2012) with the concept of negotiated settlements.

A stronger stakeholder involvement in regulation is motivated by two remedies of the traditional regulatory approach. First, traditional regulation suffers from information asymmetry: the regulator makes decisions for the consumers, without having the information about the consumers preferences. This is a typical example of information asymmetry that might cause inefficiencies (Glachant, 2012). Second, regulation tends to apply uniform approaches to regulate the industry (Littlechild (2008) illustrates this based on the regulation of Ofgem and Ofwat in the UK). However, uniformity might leave potential for innovation unexploited (Littlechild, 2008). Stakeholder involvement in regulation has already been applied to some extend in different contexts, for example in the US. Littlechild (2012) provides several examples from utility regulation where negotiated settlements in the US were successfully applied as alternatives to traditional regulation.[43]

Stakeholder involvement into regulatory processes can take different forms, from consulting by the stakeholders up to the delegation of decision power from the regulatory body to the stakeholders. We apply the concept of collaborative governance as it takes the stakeholder approach one step further by giving stakeholders not only an advisory role, but making the stakeholders the decision makers. This specific understanding of collaborative governance was defined by Ansell & Gash (2008):

> "[Collaborative governance is] a governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets."

Importantly, collaborative governance is not the same as self-regulation. Self-regulation is often understood as soft law, i.e. non-binding rules that are followed by actors due to informal practice (Marsden, 2008). In the context of such soft-law multi-stakeholder governance serves as a term to summarize the application of advisory committees, hearings, on-line consultations to integrate stakeholders into the regulatory process (Marsden, 2008). This definition of Marsden (2008) limits the influence stakeholders on the final decision. Advising is not the same as making a decision. Therefore, we stick to the concept of collaborative governance.

Following the basic concept of collaborative governance leads to the idea that the public agencies do not only integrate stakeholders into the decision-making process, but that the agencies delegate the power to make decisions to the stakeholders. Within the decision-making process the

[43] further examples from Canada and UK from energy and airport regulation can be found in Littlechild (2008) and Decout & Littlechild (2009)

public agencies then only need to moderate in case of disputes. Still, the public agencies have the responsibility to define the framework of the decision-making process. For the case of information management this would mean that a public agency (e.g. the regulator) defines the institutional background, e.g. with respect to technology and provider neutrality, data security and privacy rules etc. As soon as the institutional environment of information management is defined properly (by public agencies), the stakeholders can govern the information management themselves. The stakeholder body would then be responsible to define and delegate the necessary tasks for the operation of the information management system to different parties (e.g. for data storage, information infrastructure etc.). There will be different instruments to assign these tasks, most prominently tendering. Under the assumption that the institutional setup is defined properly the information management itself does not need to be regulated (for details see Buchmann (2016)).

Ansell & Gash (2008) conducted an analysis of 137 projects where stakeholder-based decision making was evaluated and derived two key issues that need to be defined properly to secure that a collaborative governance approach operates in a neutral and non-discriminatory manner: First, it should be inclusive, i.e. all stakeholders should participate the decision making, and second, membership rules as well as the decision-making process should be defined properly. Within this paper we want to focus on the decision-making process given a collaborative governance approach for information management. The definition of collaborative governance by Ansell & Gash (2008) points out that the decision making within this concept is consensus-oriented. This does not necessarily mean that consensus is the only possible option (Ansell & Gash, 2008). Rather, it needs to be specified how a voting scheme in a stakeholder-based governance approach for information management can be designed to secure neutrality and non-discrimination. These voting rules are especially relevant given a situation with different stakeholders who have different resources and power.

5.3 Voting, Collaborative Governance and the Veto Player Theory

The collaborative governance approach defines unanimity as the preferred decision making rule (Ansell & Gash, 2008). Traditionally, unanimity is the favored concept to reach pareto preferred solutions, i.e. unanimity secures that a decision is only made if all participants are better off or at least none is worse off than before the decision (Wicksell, 1869) (or more recently (Buchanan

& Tullock, 1962)). Although unanimity secures pareto preferred outcomes, this voting system has several drawbacks. Most criticism addresses the potentially high transaction costs related to define a decision that is approved by all participates in a larger community (Mueller, 1978).[44]

Majority voting is the common alternative to the unanimity rule. The primary advantage of the majority rule is that it can reduce transaction costs compared to the unanimity rule: Negotiations only need to proceed till the majority supports a proposal, not till a consensus between all parties is reached. Though majority rules can reduce transaction costs they induce new costs, the so called "external costs of the decision rule". These external costs are defined as the potential losses members of a minority might face in case of a majority voting against their properties. How high these external costs are depends on the difference between the utility that could have been achieved given a unanimity decision and the utility achieved under the majority voting rule (Mueller, 2009). Wicksell (1869) described this situation as the coercion of the minority. It follows from the above that the decision about a voting mechanism faces a tradeoff: high transaction costs of the unanimity rule (that might increase due to strategic behavior), and external costs resulting from a majority voting against the minorities preferences.

The collaborative governance approach applies the unanimity rule to strive for a balance between all parties, independent from the fact how powerful these parties might be. Especially in the context of collaborative governance approaches it is important to secure that less powerful institutions can defend their interests and preferences against more powerful institutions. Therefore, the unanimity rule grants every voter with a right to veto against a decision, which shall secure pareto preferred outcomes (Mueller, 1978).[45] Thereby, each voter becomes what Tsebelis (2002) calls a veto player. Veto players are defined as persons or institutions whose support is

[44]These high transaction costs still exist if other then the pareto criterion are applied to reach unanimity, e.g. the Kaldor-Hicks criterion (also known as the potential Pareto criterion) (Kaldor, 1939)(Hicks, 1939)). The Kaldor-Hicks criterion is based on the assumption that an unanimous decision can result in a loss of utility by some involved parties, as long as 1) the overall gains are higher then the overall losses and 2) the winners reimburse the losers for their losses (side payments), so that in the end the losers have not a reduces utility and the total utility increases. Still, the resulting side payments result in high transaction costs as well. Similar effects with respect to transaction costs can be expected from the Scitovszky criterion as well (Scitovszky, 1941).

[45]The veto power can be interpreted as a system of checks and balances and is applied in this manner in different contexts, e.g. the presidential veto right in the US.

needed to change the political status quo. In his veto player theory Tsebelis (2002) differentiates between institutional and partisan veto players. While institutional veto players are established via constitutions or laws, partisan veto players result from the political game, e.g. via majorities in councils, parliament etc. Furthermore, the theory addresses individual veto players (i.e. a single person or an institution) and collective veto players (e.g. parliaments, senates). Though collective veto players have veto power, this does not imply that the members of the collective veto player have a veto right. Rather, most existing collective veto players (e.g. decisions to override presidential vetoes by the U.S. Congress (2/3), or verdicts by the Council of Ministers in the EU (approximately 5/7)) apply majority voting (simple or qualified majorities) to decide internally whether or not the veto power of the collective veto player is used to stop a policy change (Tsebelis, 2002).

The veto player theory strives to analyze the effect of veto players on political stability. Political stability here refers to a situation where political change of the status quo is unlikely or even impossible (Tsebelis, 2002). The concept of political stability is of high interest for our analysis, as it can be defined as opposite of the potential for policy innovation. I.e. political stability describes how reluctant the political status quo is to adapt to changing circumstances. The higher the political stability, the lower the chances for policy innovations.[46] Within the following we rather speak of inertia in the decision-making process to stress that innovation is hampered due to the inflexibility in the decision-making process in a collaborative governance approach. Furthermore, we speak of governance innovation rather then policy innovation, as our analysis focuses on the governance design, and not policies. An important implication of this theoretical approach is that inertia in the decision-making process increases with the idealogical distance between the different veto players involved in a decision. The more the veto players differ with respect to their individual preferences, the more likely it is that the policy will not change. Vice versa, introducing new policies requires that the veto players together support these changes. Obviously, veto players will only support policies that at least do not decrease their current utility. More likely, veto players support decisions that make them better off.[47] If a decision is made only by veto players, then a policy change will result in a pareto preferred outcome, i.e. every party is at least not worse of by the new policy. Various empirical studies support the veto

[46] Tsebelis (2000) here refers to the term "responsiveness of the political system".

[47] Either directly via an increase in utility (pareto criterion) or via a side payment (Kaldor-Hicks criterion) by other winners of the new policy, which increases or at least keeps their utility stable.

player theory for different contexts, e.g. labour legislation, taxes etc. (Bawn (1999)), Hallerberg & Basinger (1998), Tsebelis & Chang (2004)).

The relation between inertia in the decision-making process and innovation increases with the number of veto players who are involved in the same decision (Justesen, 2015). On the one hand, inertia of the existing policies or rules increases with the number of veto players. On the other hand, the flexibility of the system to apply new rules (i.e. the potential for governance innovation) decreases the larger the number of veto players is. This observation is supported by the before mentioned studies of Hallerberg & Basinger (1998) and Franzese (2002). These studies revealed (e.g. based on data from decision processes in the OECD countries) that with an increasing number of veto players the potential for lock-in effects (no political change is possible as there is always a majority against a proposal) increases.

Tsebelis (2002) points out that the risk of a lock-in at the governance status quo is lower in the case of collective veto players. Collective veto players might even be able to overcome situations where a lock-in would occur for a decision-making process based on individual veto players. Whether collective veto players are able to overcome such a lock-in effect depends on the preferences of the individual members of them and the voting rule applied to the decision. Both aspects will be analyzed in the next paragraph. Therefore, collective veto players do not guarantee a governance change, but offer the potential for such a change. However, this potential for governance change is based on the lower potential of inertia in the decision-making process associated with collective veto players. These are two sides of the same coin.

Tsebelis (2002) illustrates in his analysis that collective veto players offer the possibility of incremental governance innovation. This potential for governance change is based on the different preferences within the single collective veto players. Each collective veto player consists of several members with individual preferences. These preferences of the members will differ from each other to a certain extent. Tsebelis (2002) here uses the term "m-cohesion" to describe how close the individual preferences of the members of a collective veto player are to the median preference of the collective veto player. The higher the m-cohesion, the more homogenous are the preferences of the members of the collective veto player. On the one hand, a high m-cohesion implies that there exists a chance for small and incremental changes to the governance approach, as many members of the collective veto player have very close preferences. On the other hand, a high m-cohesion results in smaller number of options for a governance change that deviate strongly from the current status quo, as fewer members of the collective veto player have preferences that deviate from the median preference of the collective veto player. However, these deviations from the median of the collective veto player are required to find enough support for a significant governance change. Therefore, if m-cohesion is not to high, then collective veto players offer the chance of at least incremental governance changes (or even significant changes, if m-cohesion is lower, but not to low to find a majority).

Obviously, the majority rule applied within the collective veto player has a strong effect on the occurrence of inertia, too. Basically, the higher the required majority, the higher the potential of inertia, and consequently, the lower the chance of a governance change. Importantly, due to the application of majority voting within the collective veto players this process is open to other than the one-man-one-vote approach of individual veto-players. For example, weighted voting processes could be applied within the decision process of the collective veto players as well.

Based on the insights from the veto player theory two questions for the application of the collaborative governance approach on the topic of information management evolve: Can we expect that a lock-in evolves with respect to decisions to be made for the governance of information management and if so, how can we avoid such a lock-in to make innovation possible?

5.4 Voting in a Collaborative Governance Approach for Information Management

For the case of the governance of information management we identify a potential for a lock-in in the decision-making process, if individual veto players are involved. To avoid the lock-in in the decision making we propose to apply collective veto-players.

5.4.1 The involved roles within the decision making process in the context of information management

To identify the potential of a lock-in effect (with individual veto-players) in the given context of information management we first need to define who the participants within the collaborative decision-making process are. As the collaborative governance approach proposes an unanimous decision making, all decision makers then can be defined as veto players. The overall purpose of the governance approach is to secure neutral and non-discriminatory operation of the information management system in smart grids. Incumbents and third parties should equally participate in the governance of the information management system. If this purpose should be addressed via a collaborative governance approach, then it is necessary that all relevant parties that are (or might be) affected by the information management system should become part of the decision-making process.

Basically, all active parties in a smart grid are relevant stakeholders for the information management system, as all of them are more or less integrated into the exchange of data. We propose to define roles to cluster the relevant parties according to their preferences with respect to information management. On a very general level we can define two groups of actors in information management: First, the data sources and second the data sinks. We will describe these in more detail below. Data sources are all parties that provide data to the information management system. For example, households providing data on their energy consumption, generators providing data on electricity production etc. Here, we define three different roles to group the data providing actors:

1. Generators: This includes conventional as well as renewable generators
2. Consumers: residential, industrial and commercial consumers providing data on energy consumption and potential flexibilities e.g. for demand side management, charging of electric vehicles etc.
3. Storage providers: small and medium scale storages that send data on storage capacity, flexibility etc.

Together, these three roles incorporate all those actors in the future energy system that are anticipated to provide flexibility to the market. According to EUTFSG (2015) flexibility can be defined as

> ”... the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation)...”

One of the key task of information management is to secure that the flexibility potential (especially on the distributed level) can be exploited. Here, information management shall secure data availability for the market. Therefore, it is important that these roles are part of the governance approach.

Data sinks are the data receiving/using parties. These are all those eligible actors that make use of the data. Here, we define three relevant roles as well:

1. Network operators: These are both, the TSOs and the DSOs. They need network relevant data to secure operation. With new intelligent network management approaches (e.g. flexible curtailment of renewable generators) the data requirement of the network operators increases.

2. Retailer: Retailers use the data for billing, flexible pricing etc.

3. Service providers: new service providers evolve in the context of smart girds. Though they are currently only in the introduction phase, different ancillary services can be anticipated. Currently, the discussion focuses on different aggregation services in smart grids, for example to establish a virtual power plant.[48]

Obviously, the above differentiation in data sources and data sinks is too rigid for the real world of smart grids. It might happen that one party is both, data source and sink. Furthermore, the concept of smart grids is still in its introduction phase. Therefore, new roles might evolve in the development process of smart grids. The governance system of information management should be capable to adapt to these changing requirements. To address this challenge we propose that a threshold should be defined that specifies how many stakeholders are required to be part of a new role before the new role is established within the governance approach. Thereby, it shall be avoided that a minority of new parties organize in a role and veto against certain issues. Otherwise, a fragmented governance structure might evolve where no decisions can be made. The threshold should define that a new role should only emerge, if the role consists of a number of members that represents a relevant percentage of the total members. The level of the threshold can either be defined within the decision process of the governance approach or, if that results in market entry barriers, by public agents (e.g. the regulator).

Still, for now the six identified groups above serve as a good approximation of the relevant

[48] Aggregator: offers services to aggregate energy production from different sources (generators) and acts towards the grid as one entity, including local aggregation of demand (Demand Response management) and supply (generation management). In cases where the aggregator is not a supplier, it maintains a contract with the supplier.

actors of information management in smart grids and are an excerpt from the roles defined by the 3rd working group of the European Task Force Smart Grid (EUTFSG, 2011).[49] This differentiation of the participants within the governance of information management is only required for the analysis of collective veto players, which will follow later. For now, we define that each participant that would fit into one of the defined roles is an individual veto player.

Having defined the relevant veto players we need to analyze their preferences to identify the potential for a policy change or a lock-in in the existing status quo.

5.4.2 The potential lock-in effect within a voting process on information management based on individual veto-players

Following Tsebelis (2002) the risk of a lock-in in the decision-making process increases with heterogeneous preferences. The more the preferences of the decision makers differ, the lower is the chance that they will unanimously agree on a policy change. Taking a look at the involved roles identified above reveals a high potential for diverging preferences between them (we illustrate this with an example in the next paragraph). This is due to the fact that not only a fraction of the society or the industry needs to be involved in the collaborative governance of information management. Rather, a broad part of the society and a large number of parties are affected by the information management and therefore should be part of the collaborative governance approach. One example which illustrates the potential difference in preference between the involved roles is smart metering, the related data exchange and privacy concerns. If we take a look at the different roles, we can identify the different preferences concerning data exchange in smart grids. This issues has already been analyzed by different scholars, especially against the background of smart metering (Horne *et al.* , 2015). Smart metering allows to collect data on the consumers energy demand nearly in real time, which on the one hand offers some potential for new services. On the other hand, the usage of this data drives privacy concerns. Starting with the first role of generators we can expect these parties to have an interest in a detailed data exchange on their electricity production, as this data allows them to sell their electricity to the market or to request governmental subsidies for the produces electricity, at least in the case of renewables. As long as their business is dependent on the data exchange, generators can be expected to be

[49]In some countries it might be necessary to define further roles for relevant parties. In Germany, metering entities could be defined as an additional role. However, as the most metering providers are incumbent network operators, they are already covered with the other roles.

less restrictive with their data then, for example, private households. As soon as generators start providing flexibility to a market (e.g. to regional markets as it is proposed by Batlle & Rivier (2012)) their interest in data exchange and availability will increase further.

Importantly, many distributed generators are owned by private households, e.g. small scale photovoltaic power plants installed on roof tops. However, electricity generation is not a primary characteristic of private households, therefore we include these so called "prosumers" into the category of consumers and not generators. Several studies have revealed that private households have strong privacy concerns related to smart metering, especially if the data from smart metering is exchanged within an information management system (Horne *et al.* , 2015). This might be different in the case of commercial and industrial consumers, as long as the data on energy consumption is concerned. For larger energy consumers, like companies from the metal industry, energy consumption is an important part of production costs. These costs can be reduced via data exchange and the products based on this data, e.g. demand side management (for details see dena (2012)). In the case of Germany larger industrial and commercial users (energy consumption above 100 MWh p.a.) are already familiar with a more detailed data exchange with electricity providers, as they already apply a more detailed metering system, called recording metering system. Furthermore, some industrial and commercial users already participate today in (pilot) virtual power plant projects, where detailed data sets are already exchanged today. Therefore, the industrial consumers differ to some extent from the private consumers with respect to their preferences concerning data exchange and privacy issues.

Storage providers and their business case ((short-term) flexibility) depend to a large extent on the availability of data about electricity production and consumption. To identify the demand for flexibility, detailed data is required, especially if flexibility is going to be provided on a (regional) market. Therefore, storage operators (at least commercial ones, this might not apply to private households owning a small-scale electricity storage to store locally generated electricity from RES) might have a strong preference for a very detailed data exchange and less restrictive privacy rules. Similarly, network operators have a priority on data availability and might have lower expectations concerning privacy of data. So far, the network operators are the traditional data collectors and distributers for most consumers. The role of the DSO will become more interactive with an increasing share of RES in the low-voltage grids.[50] Especially, if the DSO shall apply new ICT technologies to reduce the costs of network integration of RES (E-Bridge *et al.* , 2014). With the increasing role of ICT the demand of DSOs for detailed and real-time data to operate the grids in an efficient manner might increase as well. Therefore, DSO probably will have an increasing interest in data availability. This might be the case for retailers and other service providers as well. Both group of actors will have an interest to gain a very detailed data set to develop and provide new services based on this data.

While privacy is just one issue that will be relevant for the governance of information management in smart grids, it serves as a good example to stress that the preferences of the actors involved in the decision making might differ significantly from each other. Importantly, the example of data privacy does illustrate, that preferences might not only differ between roles, but within roles as well (e.g. private vs. commercial/industrial consumers). Therefore, if all parties from the above roles participate in a collaborative governance approach where the decision making is based on unanimity, then the veto player theory projects that lock-in effects will occur for specific topics like data exchange. These governance lock-in situations will result in an political environment that does not easily adapt to innovations, e.g. on the technological level. The following figure illustrates this lock-in situation for the simplified case, that a decision is made by individual veto players that belong to different roles. The winset of the status quo, the number of policy options that would be supported by all veto players, is very small or even empty. Therefore, ones a decision is made, this political status quo is unlikely to change given unanimous decision making based on the individual veto players. I.e. the chance of political innovation is small.

[50]The distribution grids or low-voltage grids are those electricity networks that connect the end consumer to the overall network.

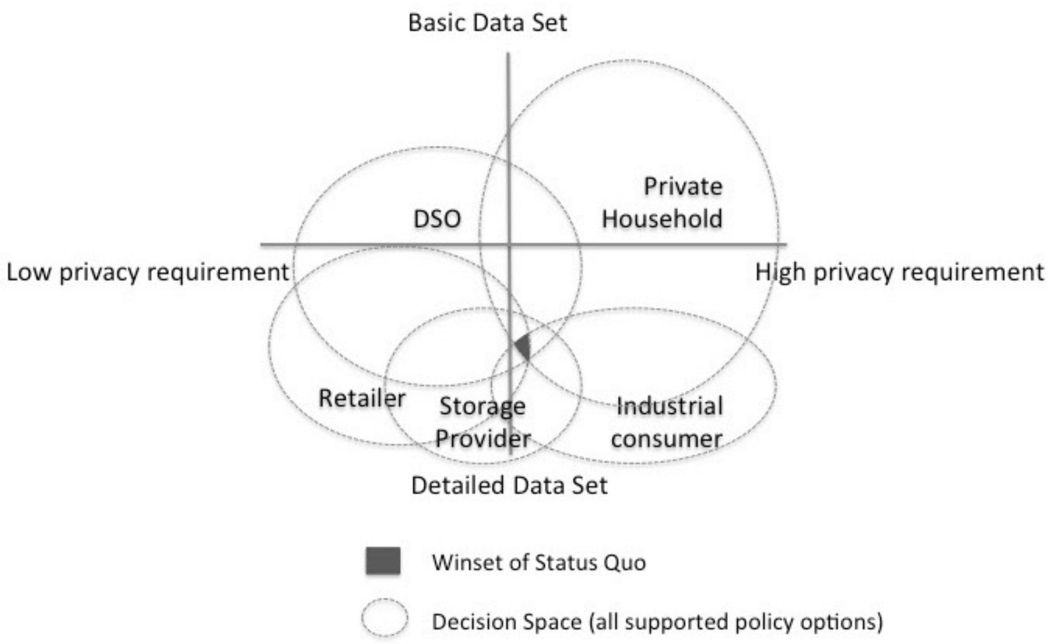

Figure 5.1: Illustration of the potential governance lock-in effect for decisions made on data exchange from smart metering given individual veto players

However, innovations are especially relevant in the context of the governance of information management. This is due to the fact that the task of information management is not yet established, but currently evolves. In this early development phase new tasks and new market opportunities emerge. Here, the governance of information management needs to be able to adapt to these changing requirements, e.g. to secure that innovative products can occur. The governance system itself needs to be flexible, which implicates that governance innovation is possible. E.g. with the emergence of new third parties it might be possible to extend or alter the definition of roles as they were defined above. Here, the governance approach for information management needs to be flexible enough to adapt to those new requirements, as has been discussed in the first part of this section.[51]

[51]It might happen that, due to strategic behavior, the existing participants within the collaborative governance approach try to avoid to change the role definition, e.g. to protect their own interest. In those cases the regulator would act as a mediator and require the adaption of roles to integrate new third parties.

5.4.3 Voting in the context of information management based on collective veto players

One way to increase governance innovation is the application "collective veto players". Tsebelis (2002) proposes to establish collective veto players to overcome lock-in situations in the decision making based on individual veto players. In the given case of information management the collective veto players could be established based on the roles involved, i.e. each role could become a collective veto player. Given a scenario with collective veto players, Tsebelis (2002) defined two aspects that define the potential for governance innovation (low inertia in the decision-making process): the majority rule applied within the collective veto players to decide on a veto, and the number of participants within the collective veto player. With respect to the majority rule two main concepts are applied in most cases: simple and qualified majorities. Basically, the lower the threshold of a majority decision, the lower is the potential for inertia in the decision-making process, vice versa the higher is the chance of governance innovation. Therefore, simple majorities offer a higher potential for governance innovation in the context of collective veto players. Tsebelis (2000) delivers empirical support for this statement based on the decisions made in the American political system, where incremental changes did occur due to the application of the simple majority rule. Furthermore, Tsebelis (2000) argues that these political changes would not have been possible if the political decision were not made by collective but individual veto players.

Whereas simple majorities increase governance innovation, they result in high external costs. Because the minority in a simple majority vote can reach 49.9%. These 49.9% might face a decrease in utility based on the majorities voting, which increases the external costs of the decision making. These high external costs of the simple majority rule are one of the main reasons why it is not applied in many political contexts (e.g. decisions to override presidential vetoes by the U.S. Congress (2/3), or verdicts by the Council of Ministers in the EU (approximately 5/7), for further examples see Tsebelis (2002)). Furthermore, the low political stability associated with the majority rule is another reason why it is not applied often. However, in the given context of information management this low political stability is an advantage of the simple majority.

The external costs of the decision making can be reduced by increasing the threshold of the majority voting, e.g. change it from simple to qualified majority. However, though the external costs of the qualified majority voting will be lower, it reduces the chances of policy changes, i.e.

qualified majorities increase political inertia and preserve the status quo.[52] Therefore, whether a simple or qualified majority is applied depends on the resulting external costs and are therefore context specific.

Based on the previous analysis concerning the decision making within a collaborative governance approach for information management in smart grids it seems reasonable to apply a system of collective veto players rather then individual ones to avoid governance lock-in effects. An important question then is whether a simple or qualified majority voting system should be applied within the collective veto players. There is no uniform answer to this question, as it depends on several factors which voting system should be applied. The fact that the governance of information management should secure innovation and therefore require a certain level of flexibility in policy supports the application of a simple majority voting system. A qualified majority voting system can reach policy changes as well, as long as the winset of the status quo is not empty. This depends on the very specific context of each decision making. Therefore, it is not possible to anticipate whether or not the winset of the status quo for all the relevant decisions to be made concerning the governance of information management will be empty or not.

One important aspect in the context of information management in smart grids are new emerging and existing third parties. These third parties need to take part in the governance of information management to secure neutrality and non-discrimination, which is why we introduced the concept of a collaborative governance approach. However, third parties represent a minority in most areas of the electricity supply chain (generation, retail). Therefore, a simple majority voting incorporates the risk of discriminating third parties as the incumbents have (at least in the status quo of the energy sector) the majority in most roles. Though this might change over time, the risk associated with an underrepresentation of third parties in the decision making on the governance of information management is the potential loss of innovation capacity, which is supposed to be

[52]Tsebelis (2000) illustrates another important difference between simple and qualified decision making within collective veto players. For a simple majority the majority winset of the status quo is very unlikely to be empty, i.e. there are always policy alternatives to the status quo which have the support of a simple majority. This can but must not be different in the case of qualified majorities. Here it depends on the difference in preferences between the parties involved in the decision making. It is at least not unlikely that only the status quo has the support of a qualified majority. In this specific case, political inertia will be high and governance innovation wont be possible.

very high among third parties (and here especially startups).

This problem is not a theoretical one, but already occurs in existing stakeholder approaches in the energy sector. Take PJM, Pennsylvania-New Jersey-Maryland (PJM) interconnection, which is a regional transmission organization[53], as an example. PJM operates the largest competitive wholesale market worldwide (located in the US) and successfully applies a stakeholder approach to govern this market. Similar to our proposal above PJM separates its 900 members into five different roles. Among these roles there is the role of "generators". In 2015 about 80 full members (with voting power) of PJM belong to the role "generators". This role consists of conventional power plant operators (primary natural gas) as well as companies that solely produce electricity based on renewables. The new market parties that produce electricity from RES account for roughly 40% of all voting members within the role "generators". Let us assume that PJM would apply a majority rule to decide on a veto from a role (i.e. the role becomes a collective veto player), e.g. the role "generators". In this case the incumbents within the role "generators" could always veto against an issue, even if all new market parties (40%) that belong to the same role are in favor of the issue the decision is made about (at least given the current membership structure). This would be possible against the interest of the new market parties form the RES sector, because the incumbents always have a majority of 60%.The example from PJM illustrates that the threshold within the decision making of a collective veto player not only has an influence on the stability of the status quo, but can have significant effects with respect to discrimination of certain parties as well. Therefore, it seems reasonable to apply a qualified majority as the required threshold for decisions on the governance of information management in smart grids to reduce the risk of third party discrimination, especially of the new market parties among them.This is actually what PJM does as well to avoid discrimination.

As mentioned in section 3 the application a majority voting rule to the decision process of the collective veto player can either be based on a one-man-one-vote process or on a weighted voting system. The one-man-one-vote process should secure that third parties and less powerful stakeholders are not discriminated in the decision process. This is why, for example, PJM applies the one-man-one-vote process as well. However, besides discrimination, there are other criteria which shall be addressed by the voting process, e.g. the utility represented by, or the expertise on a specific topic of a stakeholder. To address these issues a weighted voting process allows to

[53]based on the concept of an independent system operator, for details see Balmert & Brunekreeft (2010)

differentiate the voting power between the participants within the voting process. For example, in the context of information management it might be required that for some issues related to the stability of the electricity networks the network operators have a higher weight in the decision process, as they have more information about the implications of the decisions on the electricity grids and the resulting costs. Similar, if privacy issues related to the data of private consumers are affected by a decision process, then consumers (or their representatives) might have a higher weight in the voting process. Clearly, there are many open questions in this context which need further specification and research. However, it is outside the scope of this paper to address these issues in detail.

5.5 Conclusions

A stakeholder-based governance approach for information management is motivated by two aspects: First, third parties gain market shares (especially in generation) with the development of smart grids and the diffusion of renewable energies. Thereby, they become important actors in smart grids, in addition to the incumbents. This more important role needs to be acknowledged and reflected in the decision-making process. Second, the governance of information management needs to secure non-discrimination and neutrality. Both aspects can be addressed via a collaborative governance approach.

Within this paper we build upon the concept of the Common Information Platform (CIP), which is a stakeholder-based decision body that should govern information management systems in smart grids (Brandstaett *et al.* , 2017). This concept applies the collaborative governance approach, which delegates decision-making power from public institutions (in our case the regulator) to stakeholders of the governed system (in our case information management in smart grids). This paper focuses on the decision-making process within a collaborative (i.e. stakeholder-based) governance approach for information management in smart grids.

To specify the decision-making process for the governance of information management we first defined the involved parties in the decision process based on six roles (generators, consumers, storage providers, network operators, retailers and service providers). These six roles consist of many different participants, who should be involved in the decision making to secure neutrality and non-discrimination.

Different from the collaborative-governance theory we do not propose to apply unanimity as the basic decision rule. The collaborative-governance theory applies the unanimity rule to secure pareto preferred results: no party will support a decision if this decision would reduce its own utility. Basically, unanimity allows each deciding party to veto against a proposal. Therefore, the veto power of each participant is key of the unanimity decision process. However, unanimity comes with high transaction costs to find a proposal that is supported by all voting parties (similar effects can be expected with side-payments, if other than the pareto criterion, e.g. Klador-Hicks criterion, are applied). For the case of information management we analyze the veto process in greater detail. Based on the veto-player theory we show that if each individual party involved in the governance of information management has an individual veto right, then the chance of governance lock-in situations is quite high. This is due to the potentially heterogeneous preferences among the relevant parties that should be involved in the decision making (e.g. within the roles and especially between the involved roles). We illustrate this using the example of data exchange from smart metering and privacy concerns.

Based on these insights we propose to apply the *collective veto player approach*. The main difference to the individual veto player approach is that the collective veto player delegates the veto power to a group of actors, and not each individual actor. This group then needs to decide whether or not a veto is voted by the whole group, i.e. by the collective veto player. In the given context a collective veto player is a role within the energy system that consists of many actors. We define six roles for the given energy system (generators, consumers, storage providers, network operators, retailers and service providers). Each of these roles consists of many different individual stakeholders. We note that these roles can change over time and new roles can emerge as well. By a majority vote the stakeholders from the role can decide whether or not the role (i.e. the collective veto player) vetoes against an issue. Thereby, the threat for governance lock-in situations can be reduced (under certain circumstances). The roles defined for the governance of information management would then become the collective veto players. Within each role a majority voting decides about whether or not a proposal is supported by the role. To avoid discrimination of third parties and other minorities (within a role)[54] we apply a qualified majority

[54]For the case of new roles emerging in the context of information management it will be required, that the governance approach includes this new role into the decision making process. I.e. new roles should become collective veto players as well.

vote for the decision within the collective veto players. Based on the example of PJM in the US we show that the simple majority rule increases the probability of discrimination of third parties.

Summing up, based on our analysis in this paper we propose the following voting process for a collaborative governance approach in smart grids based on the example of the CIP:

1. Membership within the CIP should be open to all stakeholders that either provide (data sources) or use data (data sinks) in smart grid via the information management system.
2. The members are structured according to six roles (generators, consumers, storage providers, network operators, suppliers, service providers)
3. Each role is a collective veto player.
4. Decisions within the collective veto players are based on qualified majorities.
5. Each member of a role has one vote for the decision process within the collective veto player.
6. Final decisions are made by the collective veto players (i.e. roles).
7. Each collective veto player has one veto-vote in the final decision.

Though these recommendations are not exhaustive, they should build the basis for the first design of a collaborative governance approach for information management in smart grids.

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