“The role of DSOs in a Smart Grid environment”

Client: European Commission, DG ENER

Final report

Amsterdam/Rotterdam, 23 April 2014

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Foreword – Acknowledgement

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Preface

This document is the final report of a study on the role of distribution system operators in the smart grid environment commissioned by the European Commission, DG ENER. The work was performed in the context of the multiple framework contract for Economic Assistance in the field of energy (ref. SRD. MOVE/ENER/SRD.1/ 2012-409 lot 2). The project was carried out in the period September 2013 to December 2013 and included two sessions with Stakeholders (on September 27 and November 27 2013 respectively) in which intermediate project results were presented and discussed.

The authors have benefited from the comments of the experts.

Executive summary

Background

Smartening of the grid offers opportunities for changing the current energy markets into more efficient and flexible retail markets. This provides possibilities to develop new services and rearrange optimal network management – thereby introducing new actors to the energy system. New tasks and responsibilities will emerge for existing and new actors and existing ones will change. As a consequence, Distribution System Operators (DSOs) are facing several challenges. In this study, we analyse the role of DSOs in the smart grids environment.

The main research question to be answered by this study is: What are the roles and responsibilities of DSOs in the future energy retail market given the developments towards smart grids?

Smart grid services

The analysis to answer this question started off by identifying possible future market models and business opportunities for Smart Grids. Based on literature review and interviews with more than 30 stakeholders, the following five smart grids services were identified.

1. Flexibility services

Flexibility services are related to the ability to adapt and anticipate to uncertain and changing power system conditions, in a swift, secure and cost efficient manner. One can distinguish between the provision of and demand for flexibility services. Flexibility can be supplied by system users i.e. producers, consumers or prosumers (demand response, distributed generation, storage) or by intermediaries such as aggregators and suppliers on behalf of the former. On the demand side, network operators, both TSOs and DSOs, can use flexibility for congestion management as a substitute for infrastructure investments. With the increase of distributed generation, which is often not dispatchable due to its intermittent nature, network flows become more variable and cannot longer be efficiently resolved in the network planning phase by increasing network investments. Moreover, demand for flexibility also originates from aggregators, energy retailers and suppliers for portfolio optimization and from Balance Responsible Parties and TSOs for balancing purposes.

2. Infrastructure provision for electric vehicles

Expanding the use of electric vehicles requires a sufficient availability of charging points for electric vehicles to become attractive. Charging infrastructure also differs in the charging velocity, either normal or fast charging, and whether charging is performed in either a uncontrolled, dumb manner or a controlled, smart way. The latter has implications for the degree of flexibility which EV may be able to provide. In case of uncontrolled, dumb charging, opportunities for flexibility such as storage or discharging cannot easily be deployed, while in case of smart charging flexibility can be harnessed. Several actors may play a role in the provision of EV charging infrastructure, such as DSOs or suppliers who can use the charging points to sell electricity. Other commercial actors may also provide access to EV infrastructure, such as private investors and independent e-mobility providers who may provide electricity bundled with other services.

3. Energy efficiency services

Energy efficiency services encompass all services aimed at realising energy efficiency on the end-user level. Smart grids in combination with smart metering can provide detailed information on usage in order to (i) inform consumers; (ii) to help identify cost effective options for energy savings and may create new business opportunities for investments in energy savings. A number of different actors can provide energy efficiency services, such as DSOs, electricity suppliers, as well as independent firms, such as ESCOs.

4. Ownership & management of metering equipment

For the purpose of engaging consumers in Smart Grids at LV level, smart meters can act as an important enabler. Smart meters provide more accurate information for small customers on their energy consumption. Besides, they allow for easier supplier switching, cost savings in meter operation due to remote meter reading, and savings of call centre costs. Furthermore, smart meters facilitate the exploitation of demand response and potential generation flexibility behind the meter.

5. Data handling

New tasks and services in a smart grid environment depend on the availability of data provided by metering equipment, both in the grid itself and at customer premises. The data can be utilized for commercial actors, e.g. for realizing energy savings by demand response as well as grid operators for both short term system management as well as long-term grid planning.

Monopolistic versus competitive nature of services

The smart grid services have been consecutively assessed for their fit with a regulated or a competitive environment. The table below summarizes the scores of these services and allows for identification of similarities and differences between them. These characteristics are used to assess what role DSOs should play in the smart grid services domain.

Service	***Monopolistic characteristics***			***Competitive characteristics***		
	Public good characteristics	**Economies of scale and scope**	**Other externalities**	**Incentives for innovation**	**Customer orientation**	**Other**
Flexibility services	Network and system management are public goods	High economies of scale	Other characteristics of natural monopoly (non-storability of electricity, location rents, direct connections to customers)	Large potential for flexibility supply, ICT allows for aggregation of small flexible DER		Increasing number flexibility providers, limited number of flexibility categories, widely available price information
Infrastructure provision for electric vehicles	None	Limited economies of scale, some economies of scope	Chicken-and-egg problem, Higher penetration increases travelling distance of all electric vehicles	High number of technology providers	Experience with market segmentation and customer oriented retail processes by commercial actors	
Ownership & management of metering equipment	None	Some economies of scale and scope	Stimulates flexibility supply, positive externality ('enabler') for other system segments, potential possibility for better recovery of system with prosumers	High number of technology providers	Possibility to leave decision to install a smart meter to customers	

Service	*Monopolistic characteristics*			*Competitive characteristics*		
Energy efficiency services	None	Some economies of scale	Lack of awareness of benefits and costs of energy efficiency, negative externalities not included in energy prices, split incentives, high transaction costs EPC projects	Limited entry and exit barriers for technology providers		
Data handling	Non-rivalrous, (partly) non-excludable by legislation	Substantial economies of scale	Lack of adequate guarantees on privacy and use of smart meter data, data security	Many suppliers and users, market entry may promote product diversification		Low transaction costs

From this table the following conclusions are drawn.

The **procurement of flexibility services** for network purposes shows several monopolistic characteristics i.e. characteristics of a public good, economies of scale and other externalities which together constitute a natural monopoly. Therefore, in the future smart grids environment the role of the DSOs should be extended with the procurement of flexibility services for network management tasks, notably by involvement of DER in congestion management. In this way active network management is allowed while network investments that are likely to be inefficient can be postponed or avoided. This specific task fits in the current legal framework, since article 25 (7) of Directive 2009/72/EC allows for the involvement of DER 'that might supplant the need to upgrade or replace electricity capacity by the distribution system operator'. Opposite to procurement of flexibility services, provision of flexibility services is clearly a task for market actors due to its competitive characteristics.

Data handling is characterized by public good characteristics, economies of scale and other externalities, but also by higher innovation incentives in a competitive environment. Since data handling does not constitute a natural monopoly, in principle data handling is not necessarily to be performed by a DSO but could also be performed by other regulated or commercial stakeholders. At the same time there is a very clear need for public intervention.

Infrastructure provision for electric vehicles, **ownership and management of metering equipment**, and **energy efficiency services** show no public good characteristics and limited or uncertain economies of scale and scope, but at the same time also exhibit some important externalities. Therefore, public intervention maybe beneficial, depending on whether positive effects of public intervention do outweigh potential negative effects of public intervention on innovation and customer orientation.

For **infrastructure provision for electric vehicles** holds that the chicken-and-egg problem as well as the realization of the positive externality of EV charging points on the travelling distance of all EV users imply that public intervention is desirable, although only in the initial stages of EV uptake. In principle both DSOs and market actors can play a role in this stage. After the market uptake phase, there is no need any more for public intervention and the task should be left to market actors.

Concerning **ownership and management of metering equipment**, economies of scale and scope and positive externalities of installment of smart meters for making available the demand response potential point to a need for public intervention. On the other hand, high prospects for further technology development as well as efficient market segmentation point to a competitive approach.

The size of external effects should be assessed through a societal cost benefit analysis (SCBA) to determine under which circumstances and to which extent the benefits of public intervention would outweigh the benefits of competitive action. In case benefits of the former do outweigh the latter, DSOs can play a role, while in the opposite case a role for suppliers is deemed most logical.

Concerning **energy efficiency services**, its monopolistic characteristics indicate a number of clear reasons for public intervention including split incentives between building owners and tenants, negative externalities such as resource depletion that are not included in the energy market price, and spillover effects to other parties than the investors inducing too low investments in energy efficiency measures. However, the characteristics do not point to a natural monopoly and consequently an exclusive role for DSOs, implying that also other actors such as suppliers and ESCOs may qualify for the provision of energy efficiency services.

Given the different starting points of DSOs – both within and across member states – with respect to the penetration of DER, the amount of small-scale prosumers and the different network management philosophies, the extent to which DSOs have to fulfill new roles or have to expand existing roles differs widely. Broadly two categories of DSOs can be distinguished; (1) DSOs that are responsible for complex systems; and (2) DSOs responsible for less complex systems. DSOs in member states with a higher penetration of DER and a higher number of small-scale prosumers (i.e. more complex systems) are likely to perform already the initial steps of active network management, while DSOs in member states with a lower penetration of DER may still operate their network on the basis of passive network management. Therefore, for the DSOs that manage more complex systems the number of new roles may be lower and the extension of existing roles higher, than for the DSOs that manage more conventional type of distribution systems.

DSO tasks in the context of different market structures

For three selected Smart Grids services, the DSO tasks were analysed in the context of two different market structures; a DSO oriented market structure and a liberalized market structure where (part of the) tasks are assumed by market actors. Market structures of ownership and management of metering equipment as well as energy efficiency services are not discussed. For ownership and management of metering equipment holds that an advanced discussion on market structures has already taken place and Member States have already taken their positions. For energy efficiency services holds that only limited literature on different market structures is available, hence there is insufficient basis for a fruitful discussion. The table below summarizes the main barriers and risks for the remaining Smart Grids services for each market structure.

Service	Key risks and issues in DSO market structure	Key risks and issues in liberalized market structure
Flexibility services	• Inefficient allocation of flexibility between DSOs and market actors • Fragmented demand for flexibility lowers its value • Inefficient allocation of flexibility between DSOs and TSOs • Lack of information exchange between DSOs and TSOs	• Market based coordination not technological feasible and economic efficient in all types of distribution networks • Regulatory supervision required for coordination • More complex market structure lowers understandability for non-experts • Concerns on market liquidity in case of congestion
Infrastructure provision for electric vehicles	• Lack of well-thought exit strategy may create incumbent in commercial phase • Lack of innovation incentives discourages flexibility provision through smart charging and V2G • Lack of standardised data exchange between DSOs, both within and across countries due to lack of international or European standards	• First mover disadvantage effect in the absence of public intervention • Inflexible tender procedures or subsidy schemes that are not able to adapt to changes in need for charging points • Lack of roaming agreements between e-mobility service providers • Lack of standardised data exchange between e-mobility services providers

Service	Key risks and issues in DSO market structure	Key risks and issues in liberalized market structure
Data handling	• Competitive advantage for DSO by real-time insights in network operation data combined with ineffective unbundling • Lack of innovation incentives • Data security risk	• Non-discriminatory third party access to data not secured • Too high number of DAMs, preventing cost savings by realization of economies of scale • Lack of simplicity and clarity for consumers • Data security risk

Recommendations

Translating the results of the analysis into effective policies regarding the desired future developments in the European energy market is challenging, as the starting positions differ across Member States. Differences in economies of scale suggests that 'one size does not fit all'. Based on the analysis of monopolistic and competitive characteristics of smart grid services in the future Smart Grids environment and of barriers and risks for different market structures, the following recommendations can be derived.

Flexibility services

- We recommend that the full range of flexibility services is provided through a competitive market. This is based on the wide expected scope for innovation and the availability of pricing information, for which a competitive market model is beneficial;
- Flexibility procurement is an additional task for DSOs leading to more interaction with market parties. To the extent that DSOs who are not effectively unbundled engage in flexibility procurement, this may lead to possible conflicts of interest or the appearance of such a conflict. We recommend to only open the flexibility services market if a high degree of transparency and appropriate oversight by the regulator exists; and only for DSOs with effective unbundling;
- Flexibility services are required by TSOs, DSOs, suppliers and balancing responsible parties. With different objectives this may, at times, lead to conflicting interests. To safeguard the proper functioning of the energy system, a form of coordination will be required to address and resolve these conflicting interests. This coordination may be implemented through the market design and/or regulation. The report analysed different forms of coordination, including the promising option of procurement auctions. Further research in the possible forms of coordination between DSOs and market actors as well as DSOs and TSOs, and the limitations is needed;
- Sufficient incentives for investments in conventional network reinforcements are needed. Sometimes investments in smart grids are not feasible from a technical and/or economic perspective, implying that investments in conventional network reinforcements are the only option and/or most social welfare enhancing. Policy makers and regulators thus should allow for adequate incentives for this type of network investments. For securing that its market and societal benefits are adequately taken into account in investment decisions of DSOs, the network operator may be obliged through regulation to perform an integrated investment assessment, preferably a societal cost benefit analysis (SCBA). Such a SCBA should take into account the robustness of the network investment for different plausible generation and demand scenarios. For limiting administrative burdens, a SCBA might be limited to all investment proposals that meet a certain minimum monetary size;
- A level playing field for investments in conventional network reinforcements and smart grids is necessary. Network operators increasingly will have to consider a menu of options for accommodating network demand i.e. conventional network reinforcements as well as smart grids solutions. The higher risks of innovative smart grids solutions for DSOs compared to conventional network reinforcements should be properly accounted for in regulatory assessments for allowing smart grids solutions to be considered as a viable network planning option;
- To enable pricing signals for flexibility, we recommend that the energy retail prices are changed from fixed, regulatory prices (where this applies) to market driven, variable prices.

Infrastructure provision for electric vehicles

- Involvement of DSOs in the EV charging infrastructure market leads to market distortions. Therefore, in principle the role of DSOs in EV charging infrastructure should be limited. However, Member States may decide that DSOs should be involved in the initial stages of development of EV infrastructure. In this case, we recommend to formulate a clear exit strategy for when the market reaches the necessary level of maturity;
- Roaming of charging services is necessary when a customer wants to use a public charging station which is not operated by his own e-mobility provider. To prevent a slowing down of the development of the e-mobility market, we recommend to guarantee non-discriminatory third party access for using a charging station by all e-mobility customers by legislation for roaming agreements.

Energy efficiency services

- We recommend that the provision of energy efficiency services through the competitive market, as is the case today, is continued in the future;
- However, Member States might decide that DSOs, ESCOs and/or suppliers could play a role in promoting energy efficiency services. To prevent market distortion, we recommend that DSOs focus on non-discriminatory information provision and strive to hire market parties for the actual implementation of energy efficiency measures.

Metering equipment and data handling

Three data models have been discussed within the EG3 Smart Grids Task Force with central roles for the DSO (*DSO model*), an independent third party operating a central data hub (*CDH model*), and a data access-point manager (*DAM model*) respectively. In the first model the DSO operates a data hub and provides data to the market through this hub, while in the second model these tasks are performed by an independent entity. In both cases the central actors are regulated as a natural monopoly. In the third model no official data hub exists, but one or more data access-point managers (DAMs) guarantee data access at each meter point. These DAMs can be any certified commercial company.

In the context of the DSO model, we have developed the Appliances Management Support Unit (AMSU) concept. The AMSU is a means for the market to collect and/or present data, insofar the consumer desires this and data is not yet gathered by the DSO. Market actors may need this additional data for provision of innovative value adding services. We recommend to do further research to define where the border between the DSO Smart Meter domain (DSO) and the AMSU domain (market) should be.

We have analysed the main advantages and disadvantages of the three previously developed data models. Furthermore, we have indicated how the weight of different aspects of data handling can potentially influence the decision:

- Concerning the DSO model, we recommend to consider the AMSU-concept and the possibility of outsourcing of ICT operations (please see elaborations below) when assessing the main (dis)advantages. In that case, the DSO model contains the most efficient data handling of the three models. Furthermore, it provides some transparency in data handling (though less than the CDH-model) and allows for innovation (though less than DAM). If the emphasis is placed on the combination of these advantages the DSO model might be most suitable;
- Concerning the CDH model, we conclude that it contains the most guarantees for transparent, non-discriminatory and neutral data handling. The most apparent disadvantage is increased regulatory and administrative costs due to setting up a new regulated agent who should

cooperate with DSOs. Nonetheless, the CDH model might be suitable if emphasis is placed on transparent, non-discriminatory and neutral data handling;
- Concerning the DAM model, we conclude that it is expected to provide a high level of innovation. The main disadvantages are required regulation of the metering companies and risks of limited access of other market actors and DSOs to smart meter data. We conclude that the DAM model might be suitable if emphasis is placed on a high level of innovation.

Furthermore, we recommend to utilize efficiencies and innovation potential in data handling:
- Outsourcing data handling, jointly with several DSOs, to a platform owned by several DSOs (this is relevant only for the DSO model). This leads to economies of scale and decreases possibilities of discriminatory behaviour. In the CDH model such a platform is an explicit part of the model, while in the DAM model policy measures are necessary to limit the number of data access point managers to the social optimum;
- Utilize economies of scale in data collection (this is relevant for all models). All data models show potential in terms of economies of scale to have one actor collect data for all other actors to use. We recommend to regulate that the owner of the smart meter collects and shares data which is required on a sufficiently large scale, while market actors <u>might</u> collect additional data themselves (e.g. through the AMSU in the DSO model), should they require it for development of niche services.

Finally, we advise to encourage consumer acceptance and to stimulate security in data handling:
- Enforce simplicity and clarity for consumers. The DAM model requires more efforts from consumers as data owners need to deal with the higher number of interfaces and decisions to be taken. Regulatory measures are needed to limit these administrative interactions to the absolute minimum. This issue is less pronounced in the DSO and CDH market models due to the lower number of data handling entities, but equally important.
- Stimulate further research in data security in order to identify the size and frequency of data security risks as well as most appropriate mitigation measures.

Recommendations for the gas grid

The concept of smart gas grids is different from that of smart electricity grids. The key difference is the much larger possibility of storing energy in smart gas grids, notably through line-pack. Another important difference is that the potential for future development of decentralised gas production is relatively small. Nonetheless, the operation and management of gas grids could be enhanced by a smart gas grid and the smart end-use of gas. Furthermore, also the smart gas grid shows potential related to energy efficiency services and the development of new types of services

The most relevant recommendations in relation to the gas grid include:
- The limited potential of flexibility services in the gas grid stresses the necessity of analysing whether the benefits of a procurement model outweigh the resulting administrative burdens. We recommend that member states explore this, using a cost benefit analysis;
- Explore the potential of flexibility services provided by the gas grid to the electricity grid and vice versa;
- Some efficiencies may be achieved by combining the electricity and gas field: a combined roll-out of smart meters and collaboration in data handling. We recommend to explore those synergies.

1 Introduction

Smart Grids are seen as an important and effective way to transform the traditional energy grids. The use of ICT hardware/software and communication-infrastructure allows for (near) real-time monitoring and steering opportunities of network components such that the transportation and distribution capacity of the grid can be increased in a more flexible manner and against lower costs (compared to investments in more distribution and transmission capacity only). Thanks to these increased monitoring and steering capabilities, the flexibility potential of producers and consumers can be utilised to improve the operational management of electricity and gas networks, and to lower the (price)volatility in electricity markets. Smart Metering systems are an important step towards Smart Grids and they facilitate consumers to evolve into active participants in the energy market by responding to Time-of-Use (ToU) tariffs.

Changing the current energy markets into more efficient and flexible markets not only implies improving the capacity and flexibility of the grids, it also implies a change of the traditional top-down approach in the energy system. Integration of more decentralised generation (mostly connected to distribution networks) and of consumers which are developing into consumer-producers requires modernising of the role of the Distribution Systems Operators (DSOs). Operation and maintenance (the traditional role of DSOs) of the distribution system is not sufficient anymore; more (pro-)active grid development, management and operation are required as these changes place new requirements on the networks in terms of operational security, while they offer at the same time more options for the DSOs to manage their grids more flexible and more efficient.

The changing energy environment will introduce new service opportunities and thereby new actors to the energy system. New tasks and responsibilities will emerge for existing and new actors, moreover existing ones will change. DSOs have the opportunity to cooperate with the new suppliers and new market actors to enable a more flexible and efficient demand response.

As a consequence, the Distribution System Operators are facing several challenges. First of all they have to modernize their grids and at the same time they have to become more ‘active’ operators. Given the monopolistic character of the DSOs, they should perform those activities that in the public interest can be best performed by a regulated natural monopoly, while other activities should be performed by market actors in a competitive market environment.

In this study, we analyse the role of Distribution System Operators in the smart metering and smart grids environment, in order to provide a set of recommendations regarding the roles and responsibilities of the DSOs in the future energy retail market. In this analysis the diversity of the energy market structures across the Member States is taken into account and the regulatory framework set under the Third Energy Package is fully acknowledged. As new tasks and responsibilities will emerge for existing and new actors, these tasks should be performed and responsibilities allocated such that efficient outcomes are being realized. The analysis is aimed at the identification of those tasks that are most efficiently performed in competitive markets and have a low risk of leading to a market failure. Those tasks that are of predominantly monopolistic character and should be allocated to a regulated entity are also identified. Next to this task analysis, synergies with other actors (specifically the ICT sector) and the need for regulatory intervention are explored.

A key question that is being addressed in the analysis is how the market structure will change when the Smart Grids have been implemented. Different stakeholders will be subject to different drivers in this changing market and will push for different market models. This study will describe the DSOs, including the drivers and the relationships to other stakeholders. Furthermore, we will elaborate on the future energy market models and business opportunities as well as the tasks and services of each individual actor in this future market.

This study provides a follow-up on the Internal Energy Market (IEM) Communication (EC, 2012b) and can serve as a basis for possible recommendations to the Member States. The Member States will have to ensure that the new tasks are appropriately assigned, and DSOs, as regulated businesses, will be in a position to deal with the new challenges and not be overloaded with new tasks for which it is not necessary or efficient to be performed by DSOs. The European Commission has requested the Member States to produce Action Plans on how to modernise the energy grids and to determine the rules and obligations for DSOs. These plans should be in accordance with the Energy Efficiency Directive (EC, 2012a). The analysis provided in this study and its recommendations are considered important inputs to the formation of these plans.

Chapter 2 discusses the methodology of the report. Chapter 3 presents the analysis of energy market models and business opportunities, focussing on the literature review and on the results from the stakeholders questionnaire. In chapter 4, the selected smart grids services are introduced as well as the actors that provide or procure these services. Subsequently, in chapter 5 these smart grids services are evaluated on their monopolistic and competitive characteristics and especially the presence of public interests that may require an additional role for DSOs as regulated entities. Chapter 6 continues with an evaluation of the roles for DSOs under two different energy market structures, and highlights the most important market and regulatory barriers and risks to the roles for DSOs. Next, Chapter 7 analyses lessons learnt from the international experience of smart grid roll-out in different countries. Finally, Chapter 8 discusses the roles for gas DSOs and the key features that differ between gas and electricity systems. Chapter 9 wraps up by providing recommendations on the roles of DSOs in both gas and electricity systems in the future retail market.

2 Methodology

The main research question to be answered by this study is: What are the roles and responsibilities of Distribution System Operators in the future energy retail market given the developments towards smart metering and smart grids?

Smart Grids are defined as electricity networks that can efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both (so called prosumers) – in order to ensure an economically efficient, sustainable power system with low losses, high quality, security of supply and safety. Therefore energy grids are complemented with ICT infrastructure, sensors and actuators such that remote monitoring and control of network components as well as Distributed Energy Resources (DER) are enabled. The main DER technologies which will have to be accommodated in a smart grid environment are Distributed Generation (DG), Distributed Storage (DS), Electric Vehicles (EV) and Demand Response (DR).[1] Smart metering relates to ICT enabled meters that can provide (near) real time and remote reading of metering information. In the case of electricity, DER are connected to the low, medium or high voltage distribution networks[2] and thereby directly impacting the operations of the Distribution System Operators (DSOs). Although the potential for smart metering in the case of gas is similar, differences in technology give rise to somewhat different issues. Compared with electricity, gas can be stored more cost-efficient - for example in networks - and the scope for local production is limited to the feed-in of alternative gases such as biogas.

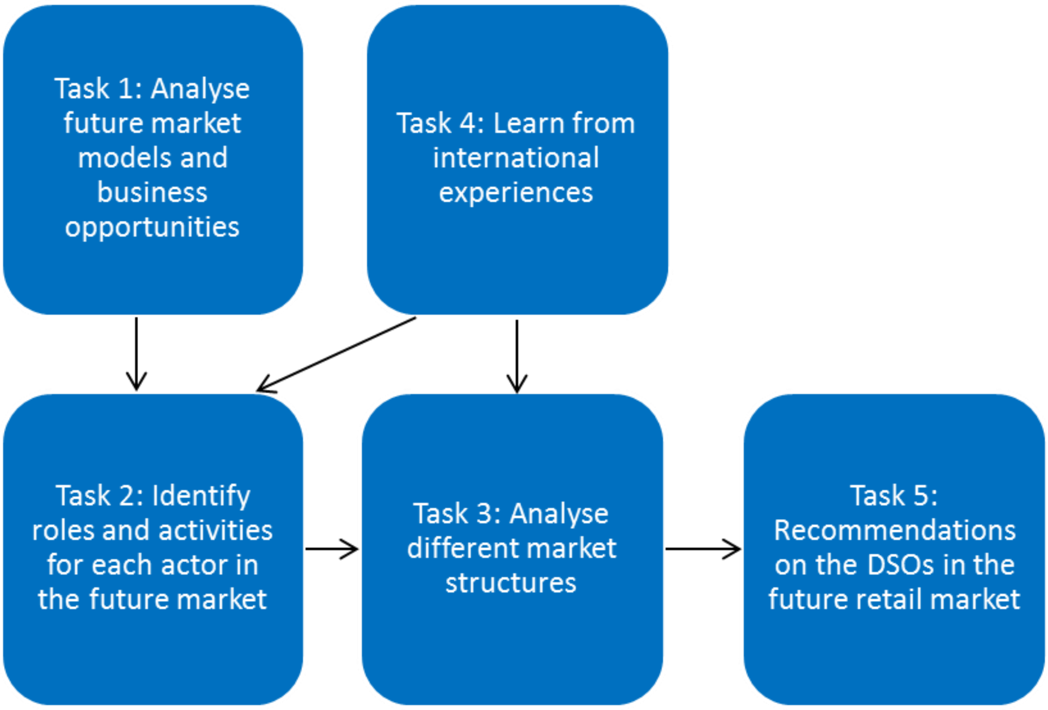
ICT enabled-grids provide for improved efficiency of operations of the grid and for assuring the reliability of the grid. Compared to the traditional grid operations, new tasks or services can be distinguished in support of the DSOs or being provided by the DSOs to other parties. This includes the coordinated use of DER as part of the grid operations. At the same time the new information becoming available, in particular through the smart meters, allows new services to be provided to the energy consumers. These services could in principle be provided by the DSOs or by third parties.

An analytical approach, which consists of five steps, has been applied to answer the main research question. Figure 2.1 reflects these five steps or tasks, which are described in detail in the text below including their interrelationships.

1 See Ruester et al. (2013).

2 Following CENELEC standard EN 50160 (2010), we use the following classification: LV < 1 kV, MV 1 kV – 36 kV, HV 36 - 150 kV.

Figure 2.1 Research tasks and relationships

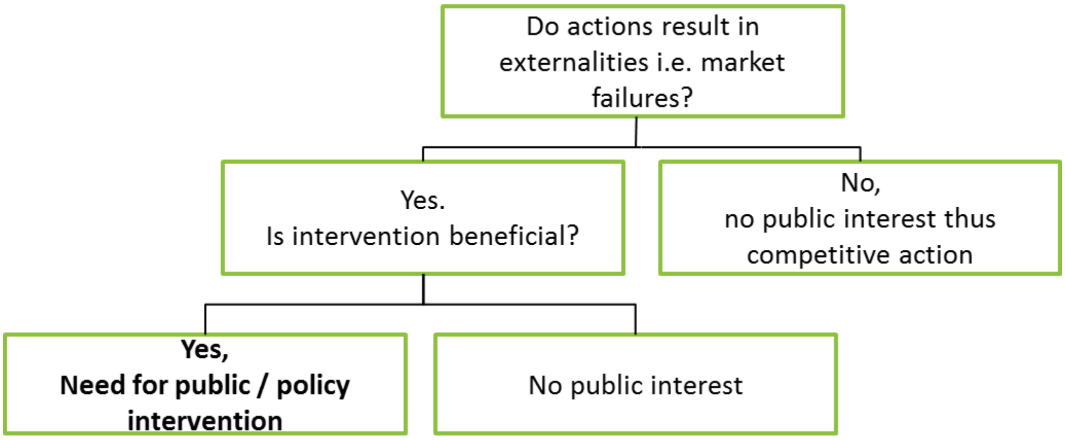


The different tasks reflected in Figure 2.1 can be summarized as follows:

In Task 1 possible future market models and business opportunities for smart grids and smart metering are identified through interviews and a literature study. The findings are summarized in a number of important trends. The technological trends include the development of distributed generation technologies, network technologies and the increasing importance of ICT. The societal trends reflect the prosumers as well as the policy objectives (sustainability targets for 2020 and beyond) which drive the need for the provision of new smart grids services.

Based on the business opportunities identified in Task 1, in combination with the international experiences identified under Task 4, Task 2 assesses the potential roles of the DSOs in the provision of new smart grids and smart metering services using a two-step multi-criteria analysis.

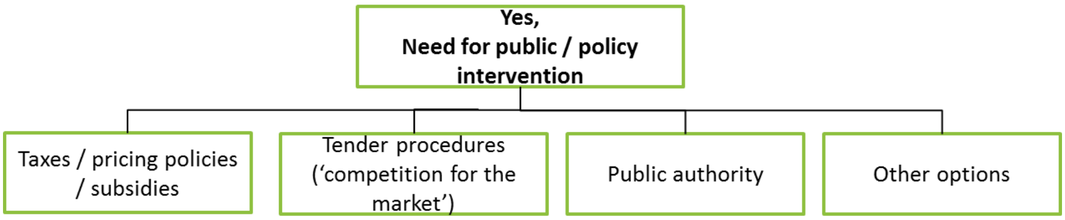
Figure 2.2 Multi-criteria analysis of potential roles of DSOs in the Smart Grids environment – first step



First, the theory of public sector economics is applied for the identification and assessment of public interests, while accounting for electricity system specificities. We evaluate five smart grid services against five criteria to identify to which extent market or government failures may play a role in the provision and procurement of each of the services (i.e. determining its score on monopolistic characteristics) as well as the potential for favourable efficiency properties of using the market structure (i.e. determining its score on competitive characteristics).[3] The existence of public good characteristics, economies of scale and other externalities imply a risk of market failure in the provision and procurement of the service. Whether or not intervention is beneficial depends on government failures which may be due to public intervention. E.g. sometimes the government lacks information for adequate intervention or intervention brings along substantial costs that do not outweigh the benefits of intervention. Furthermore, the need for incentives for innovation and customer orientation points to the advantages of provision and/or procurement of the new services through a competitive market. If intervention is considered to be beneficial, a public interest emerges which needs to be safeguarded by public intervention.

Second, in case there is a need for public intervention, a range of policy and regulatory measures exist that may be applied to guarantee that public interests are taken into account. These range from new regulations, including taxes, pricing policies and subsidies, via tender procedures for public services, all the way to service provisioning by a public authority (see Figure 2.3). Whether simple or more intrusive policy measures are required depends on the importance of the public interest identified. So-called 'free riding' of market parties will drive the need for policy measures that improve coordination in the electricity system. Market failure may result from the abuse of market power and hence require policy measures to ensure a level playing field between electricity system stakeholders. Of particular interest is the non-discriminatory access to information, essential for the operation of the grids on the one hand, and the development of new services on the other hand. The degree to which policy measures are required determines whether the service can be provided through a competitive market or is best delivered by a regulated entity and as such can be assigned as new role for the DSOs to be performed.

Figure 2.3 Multi-criteria analysis of potential roles of DSOs in the Smart Grids environment – second step



The heterogeneity in the designs of the energy market across the Member States influences the most appropriate assignment of the tasks and services identified in Task 2. Therefore Task 3 aims to assess the barriers and risks for each smart grid service under two different future energy market designs.

In Task 4 relevant international experiences are investigated, which provides input for the five smart grid services (as identified in Task 2) as well as the selection of future market structures (as part of Task 3).

[3] Ruester et al. (2013) use similar criteria in their analysis of tasks of DSOs for ownership and management of metering equipment, electric vehicle charging infrastructure, and data handling services. In contrast in this study we structure the application of criteria by distinguishing two steps; first, criteria are applied for identification of the need for public intervention, second, given the need for public intervention, criteria are applied that determine the roles of DSOs as well as the boundaries to those roles.

Finally, in Task 5 of the study the recommendations on the roles and responsibilities of DSOs in the future retail market are formulated, given the anticipated smart grids and smart metering environment, based on the outcome of all preceding tasks, in particular Task 3.

3 Task 1: Future energy market models and business opportunities in the Smart Grids environment

In this chapter we will discuss input from authors and from the stakeholders to identify (business) opportunities in the Smart Grids environment. Additionally, we specifically discuss the position of the authors and stakeholders with respect to the role of DSOs related to several of these opportunities.

3.1 Trends in the smart grid environment

In this section, we capture information from literature sources to identify the technological and societal trends and policy objectives. This will be used as input to identify market models en business opportunities in the smart grid environment.

3.1.1 Technological trends

Technological development in the smart grid environment is going at a rapid pace. Especially relevant for the smart grid context are developments in electricity generation and demand, smart grid technology and information technology (ICT).

In electricity generation, a prominent trend is the emergence of distributed generation (Coster et al., 2011), for example solar Photovoltaics (PV), wind power and micro combined heat and power (micro-CHP). The market share of solar PV electricity had an early growth rate of 33% per year between 1997 and 2006 (Hoffman, 2006), and is expected to increasingly become an economically advantageous source of energy (Branker et al., 2011) within this decade (Fthenakis et al., 2009). Wind power is developing rapidly, experiencing an early annual growth of 25% between 1992 and 2007 (EWEA, 2009). Furthermore, on-going developments in turbine efficiency and increased fuel prices further stimulate their competitiveness in the future (EWEA, 2009). Micro-CHP is a promising, though less mature technology, which is "*on the verge of becoming mass marketed as a next generation domestic heating system*" (Houwing et al., 2011). These trends are expected to continue, leading to a higher market share of distributed generation in the future (Cossent et al., 2009). The higher share of renewable energy on the supply side will result in an increase in variability in supply.

On the demand side, electricity demand is likely to increase significantly and become more variable as well. This is caused by the expected increased market share of electric vehicles in transport (Gómez et al., 2011).

Smart grid technology is one of the enabling technology to cope with variability and developing, which allows more data to be collected and processes to be automated. Distribution automation is an example of improved efficiency in grid operation, reducing operation costs and increasing grid reliability by introducing a higher degree of automation and autonomy in the operating system (ABB, 2013). In parallel with the development of smart grid technology, the costs for metering and data collection can be expected to decrease. Mott macDonald (2007) estimated a cost reduction rate of approximately 7% per year.

Progress in the ICT sector will greatly affect the development of smart grids and resulting business opportunities (Erlinghagen and Markard, 2012). In a Smart Grid, a significant increase in information collection, data storage and exchange is expected. Business potential and innovation is therefore strongly affected by (the efficiency of) this information management (Erlinghagen and Markard, 2012).

3.1.2 Societal trends

Societal trends relate to consumer preferences which show structural changes over the years. In the context of smart grids, the most relevant societal changes are environmental awareness, self-sufficiency in energy supply and valuation of privacy.

Increasing environmental awareness is a trend which has been on-going for several decades. The last decade attention has focussed on climate change and the use of fossil fuels. End-users of energy are confronted with global challenges to increase energy efficiency, reduce fossil energy use and increase the share of renewable energy sources. This has led to increased demand for products which address these challenges. The willingness to pay for these products can transcend the direct financial return on investment for many new technologies. This is line with Purchula et al. (2007)), who state that "*environmental policies are probably the major driving force for the demand for distributed generation*". In that sense, a reduction in environmental impact becomes an objective in itself.

An example of a direct influence of this trend on the smart grid environment is the increasing demand for distributed generation, like solar PV. In many Member States the use of PV in households is more profitable than keeping savings in a bank account. This large market drives down the cost price of PV systems. This makes PV also cost effective in Member States with lower end user prices. Some researchers expect PV to become competitive with thermal power plants by 2020 (Fthenakis et al., 2009). To improve energy efficiency, smart meters can be utilized to identify potential energy savings. Furthermore, smart meters can make end-users aware of their, perhaps previously unknown, day to day energy consumption. This can potentially lead to a reduction in energy usage (Darby, 2006; Owen and Ward, 2006), as the better informed end-users may internalize the energy costs as well as the environmental impact in their consumption behaviour.

The self-sufficiency in energy supply refers to the trend of increasing consumers preferences to become independent energy producers, as opposed to depending on large (anonymous) utilities. In many local projects consumers show a willingness to pay that exceeds the pure financial returns. The wish to feel independent therefore becomes an objective in itself. Longo et al. (2008) used choice experiments to illustrate this phenomenon, showing that consumers state that they are willing to pay a higher electricity price when energy security, climate change and air pollution impacts are internalized. In practice, energy independence can be internalized through the installation of e.g. solar PV on an individual house, as well as the joint development of (renewable) energy supply and other utilities in small communities (Walker, 2006). Opportunities to put this in practice, e.g. through ICT solutions to organise this, stimulate this trend. Local communities with a wish to be as independent as possible from the large energy suppliers also want to store electricity to reduce the problem of the erratic supply of solar and wind energy. The use of electric vehicle fits in this strategy, as well as the installation of electric boilers and heat pumps. This trend leads to small, local smart grids with a high complexity.

On a smaller scale, consumers are interested in home energy management systems. Smart meters and more variability in tariffs can boost this development. Smart meters are in these cases connected to other smart devices that interact with appliances in the house. For many consumers cost reduction is the main reason for installing this type of technology. But it is also possible to optimise the consumption for minimising environmental effects or maximising local power production.

Increasing 'registration' of information on communications and behaviour of consumers has led to growing concerns related to privacy (Rust et al. 2008). The implementation of smart meters is in some Member States strongly affected by this trend, as smart meters are collecting and providing information about the users behaviour and consumption. Even with limited smart meter data and crude algorithms, extensive personal information can be derived by analysing the data (Lisovich and Wicker, 2008). Therefore, this concern may stimulate opposition against smart meters, posing a challenge for a (partial) roll-out.

3.2 Literature positions on the role of DSOs in business opportunities

Smart Grids are developing very dynamically and the amount of literature is growing fast. To the extent possible within the timeframe of this study, we cover the most relevant literature. We have explored the position of a wide range of authors with respect to the role of DSOs in the utilization of resulting business opportunities.

The transition towards more distributed energy resources which have a higher production volatility require TSOs and DSOs to react (Cossent et al., 2009). Historically, capacity is designed to manage maximum demand (the fit and forget approach). The literature shows trends towards increased utilization of flexibility services, with the purpose of reducing investment costs (Eurelectric, 2013a). Smart grids provide opportunities for efficient implementation of flexibility services. Implementing flexibility services is an opportunity, but also a challenge for grid operators. Batlle and Rivier (2012) identify practical constrains which need to be addressed. One of these constraints is that TSO and DSO grid management decisions affect each other, as well as market players. Furthermore, it should be prevented that consumers or retailers are selling the same flexibility multiple times, which turns out to be difficult in practice. This requires TSOs and DSOs to come up with clear definitions of hierarchical procedures and grid management plans adapted to one another and to the market (Batlle and Rivier, 2012).

Procuring flexibility services therefore requires a specific market model. As the role of DSOs in flexibility services will likely become bigger in the future (Van der Welle and Dijkstra, 2012), authors stress that it should be ensured that during this transition DSOs should remain neutral (EDSO, 2012; Eurelectric, 2013a). This calls for a clear distinction between regulated and competitive market segments, in which flexibility and ancillary services can be arranged in a competitive market (Eurelectric, 2011, 2012 and 2013a). For example by using an auction model supervised by the regulator (Ruester et al., 2013). This view is shared by various other authors (EDSO, 2012; Batlle and Rivier, 2012;).

Concerning the market model design on flexibility services, Batlle and Rivier (2012) sketch two principles: (1) demand should be lowered where this is most efficient and (2) demand adjustments of different spatial scales should be addressed in an integral manner. An elaboration on available models for procuring flexibility services is provided by D-Cision and Brattle (2009), who compared several models for congestion management. These models were assessed based on technical, economical, policy and regulatory criteria. The criteria for which the models scores showed the strongest differentiation were costs and long term economic efficiency.

Importantly, several authors stress that one-size-does-not-fit-all with respect to grid management. For example, EDSO (2012) and Eurelectric (2013a) state that in the European context, the implementation of a model for procuring flexibility services should contain sufficient flexibility for DSOs and TSOs to develop the most appropriate solution.

Several critical observations are provided with respect to flexibility services. These regard whether demand-side response to Time of Use (ToU) tariffs can deliver sufficient predictability and reliability to underpin decisions not to reinforce networks. Furthermore, practical issues arise concerning how the signals should be given to consumers, given the fact that DSOs are not organized for frequent contact with large numbers of consumers (E&Y, 2012).

Storage capacity electric vehicles

Electric vehicles (EVs) currently only hold a very small market share in the automobile sector. Public accessible infrastructure for recharging EVs is limited. In combination with smart grids, EVs provide potential for 'valley filling', which refers to energy consumption during off-peak hours. Furthermore, if EVs are connected to the grid and do not require immediate charging, the energy stored in the batteries can be used during peak hours. Therefore, EVs provide a potential storage for variable renewable energy production and can potentially lower grid management costs through decreasing the investments required for handling peak capacity.

Zabala et al. (2012) discuss practical aspects of the role of DSOs within EV infrastructure. From the perspective of DSOs, EV Service Providers (e.g. charging stations) are similar to other retailers and power consumers. However, EV Service Providers have different consumption patterns requiring tailored algorithms. Consequently, Zabala et al. (2012) consider it the role for DSOs to encourage beneficial recharging patterns. Without smart grids, this can be done by means of varying tariffs, based on patterns in electricity demand. With smart grids, dynamic pricing can be used to further match supply and demand. Communications between DSOs and EV service providers regarding the pricing, which should enable consumers to adjust their behaviour, should also be taken up by DSOs (Zabala et al, 2012).

Eurelectric (2010) presents several market models for a rollout of EV charging infrastructure. The role of the DSO varies between an ownership role, a leading role or a facilitating role. Khoo and Gallagher (2012) discuss these business models, focusing on the economics and business potential underlying the market models. An important factor for the business potential of the electric vehicles are consumer preferences, for which a public charging network is crucial (Deloitte, 2010). However, exploitation of public charging stations is currently not commercially feasible (Khoo and Gallagher, 2012). This is supported by Ito et al. (2013), who state that infrastructural development for EVs are socially efficient when the percentage of EVs purchased of total new vehicles purchased exceeds 6%, which is far beyond the current penetration rate.

Eurelectric (2010) considered it premature to recommend one model over the other. EDSO (2012) prefers a DSO-model in which DSOs are provided with an extension of their regulated role, realising the installation and running the operations. They consider this to be beneficial, because it would "*enable cost-efficient local load management, helping the deployment of charging spots, guarantee open access and support standardisation*" (EDSO, 2012). Other authors consider that member states should individually decide upon the type of market roll-out (Ruester et al., 2013; Eurelectric, 2013a). Khoo and Gallagher (2012) conclude that, if a swift development of EV on a significant scale is desired, a DSO driven market model is most suitable.

Ruester et al. (2013) consider that when the EV market and EV infrastructure are in a more mature phase, other market models are preferred over the DSO model. They also recommend tailored solutions developed by member states, in which specific characteristics of DSOs and distribution systems should be taken into account. Furthermore, because of evolving technologies, they argue that the integration of EVs should be gradual, to prevent (publicly financed) technological lock-in.

Reducing energy consumption

Smart meters provide the potential to realise energy savings. Consumption data can be used to provide direct feedback on consumption, which can lead to reduction in energy consumption (Darby, 2006; Owen and Ward, 2006). Furthermore, when analysed by comparing consumption data across consumers, data can be used to identify potential energy efficiency services.

This potential can be utilized by numerous actors (consumers, the energy efficiency services market, grid operators, etc.). The majority of the literature considers energy efficiency services to be a role of the market or consumers. DSOs should be expected to play a facilitating role, limited to supplying means of collecting the required information for identifying effective energy efficiency potential, ensuring a level playing field for competition (Eurelectric, 2013a; EDSO, 2012; Ruester et al., 2013; GEODE, 2010).

Efficiency in smart meter roll-out

KEMA (2012) discusses efficiencies regarding smart meter roll-out. They argue that the timeframe in which smart meters are expected to be introduced affects the optimal (in terms of costs and benefits) strategy for allocation of responsibilities in smart meter introduction. Furthermore, they state that the costs for smart meter introduction generally decrease as more time is available. For different approaches of smart meter roll-out, KEMA (2012) discusses meter ownership and management responsibilities:

- Under a fast track metering roll-out approach, KEMA (2012) considers a model with the DSO responsible for smart metering to be beneficial. However, Ruester et al. (2013) argue that a mandatory roll-out could lead to installation of meters for consumer groups where costs exceed the potential benefits;
- KEMA (2012) states that for a multi-utility approach, combining the introduction of smart meters for electricity with other utilities, a model with an independent service provider is preferred. This would "*reduce unbundling and coordination problems*" (KEMA, 2012). Furthermore, Ruester et al. (2013) mention "*a situation in which a single regulated market actor attempts to choose a 'winning' technology early in its innovation chain and thereby reducing innovation is prevented*";
- In the voluntary roll-out approach consumers own the equipment.

KEMA (2012) does not prefer models in which the supplier or metering asset provider is responsible for the deployment of smart meters, because this may lead to high coordination costs and stranded investments. This is line with EDSO (2012), who consider that DSOs are able to set up meter-management cost-efficiently.

Efficiency and challenges in data collection and management

The Expert Group for Regulatory Recommendations (EG3) of the Smart Grids Task Force (SGTF) proposed three market reference models on options of handling smart meter data exploiting potential synergies and efficiencies.In *the DSO model*, control and operate the (de)central data hub. DSOs act as a regulated neutral market facilitator and serve as an information conduit. In the other two models DSOs are not providing the data to the market, but a third party does. In *model 2* this is a *(regulated) independent central communication platform*. This party ensures that only authorized parties receive and send data. *Model 3 is a DAM model* where commercial parties (certified companies) act as a data access manager, providing access to data and functionalities of devices. The companies do not hold and handle energy data centrally. Furthermore, DSOs receive the metering data based on regulation.

Several literature sources argue for having a DSO responsible for the data management. The first argument is based on the need for some of the smart grid data to support regulated DSO operations. According to EDSO (2012) it is crucial that the responsibility for the services and the data of the DSO network operations reside with the DSOs. Eurelectric (2011) reinforces the first point by stating that "*DSOs must in any case have access to technical and power quality data to ensure that they can efficiently perform their tasks".* The second argument involves the exchange of data between market players. EDSO (2012) and Eurelectric (2012) mention that a DSO, being a regulated player with a confidentiality obligation, is a likely party to handle data confidential and neutrality. For this reason EDSO (2012) claims that a DSO could provide the data hub or data exchange, while the data is owned by the consumer. Eurelectric (2011) and Ruester et al. (2013) agree with a DSO as data handler as long as information is shared with the market in an efficient and non-discriminatory manner so that customers are able to seek products or services that suit their needs, while suppliers can invoice their customers and develop new products and services.

Literature shows that model 2 is rejected by most DSOs as being inefficient. Since a DSO is a regulated and independent actor, adding another institution for data handling would only make the situation unnecessarily complicated. GEODE (2013) argues that DSOs have the best knowledge on which ICT and Telco solutions can fulfil their requirements best. This is in line with the JRC report Update on smart metering (2012), which states that DSOs are the forerunners in terms of innovation in smart metering. Eurelectric (2012) and EDSO agree with GEODE (2013) that Model 2 is the least preferred model, however they do acknowledge some successful examples of data hubs owned and controlled by national industry associations in Sweden, by combined Grid Operators in the Netherlands and by the national TSO in Denmark.

Model 3 aims at reducing the data security issues of model two**.** This model is considered preferable over Model 2 by many DSOs, because ICT decisions should remain in the DSO domain in order to guarantee security of supply and to fulfil their role of market facilitator. Commercial players are considered less likely to make data available in a non-discriminatory, secure and regulated way (Nielsen, 2002b). Furthermore, limiting the number of different roles and actors in the market contributes to transparency (CEDEC 2013). Consequently, a cooperation model between DSO & ICT providers is possible in which the responsibility for data collection, handling and communication remains with the regulated DSOs, but where technology, innovation & operational strengths of the ICT companies are used (CEDEC 2013). Kok (2012) suggests using a multi-agent system, which would result in a mechanism that would allow for coordination of a large number of smaller consuming and producing devices without the autonomy and privacy of the owners of these devices becoming compromised.

Ruester et al. (2013) summarize that each of the three models has pros and cons. They recommend setting a minimum European standard with respect to data collection, storage, availability and privacy. Member States would, under these requirements, be able to chose the data model they consider most appropriate. EDSO (2012), CEDEC (2013) and Eurelectric (2012) prefer model one, mainly because some metering data is crucial in managing the grid and secondly because third parties may not be completely reliable when it comes to privacy and security issues. A role as facilitator where DSOs share information is in an efficient and non-discriminatory manner for other parties while ensuring privacy of consumers is considered desirable by Eurelectric (2012) and Reuster et al. (2013).

Increasing 'registration' of information on communications and behaviour of consumers has led to growing concerns related to privacy (Rust et al. 2008). The implementation of smart meters is in some Member States strongly affected by this trend, as smart meters are collecting and providing information about the users behaviour and consumption. Even with limited smart meter data and crude algorithms, extensive personal information can be derived by analysing the data (Lisovich and Wicker, 2008). Therefore, this concern may stimulate opposition against smart meters, posing a challenge for a (partial) roll-out.

3.3 Questionnaire and interviews

3.3.1 Goal

Developments in smart grid and smart metering are on-going and accelerating. Consequently, the most recent insights and information isn't necessarily available in the literature. Furthermore, the role of DSOs in smart metering is still debated, which calls for active stakeholder participation in our research. For these reasons, a questionnaire and several interviews have been conducted among stakeholders with respect to smart metering and smart grids for both electricity and gas.

3.3.2 Coverage of stakeholders

In order to acquire sufficient results in a short time, it was decided to conduct an online survey. The survey questions and the invited respondents are shown in Annex I and Annex II respectively. Despite the extensive efforts applied, this online questionnaire had a limited response. As an alternative approach to collect the information, we decided to interview a number of selected stakeholders on an individual basis.

We have interviewed a total of 31 stakeholders, including DSOs, suppliers, ICT providers and regulatory authorities (see Annex B). The DSOs are represented the strongest. To overcome time and language barriers we also explicitly opened the possibility to answer the questions in writing (in English or German). All interviews resulted in a written summary that was sent to the interviewee for review. The interviews took typically between 1 and 2 hours. The findings with respect to the gas sector are reported in chapter 8.

3.3.3 Summary of findings

We summarize the findings of the interviews by describing the position of interviewees with respect to the roles of DSOs in a smart grid environment. Furthermore, we elaborate on the potential business opportunities.

Role of DSOs in Smart Grids

From the point of view of DSOs, smart grids are not a final goal, but a tool for efficient system management, which can also be replaced by other technologies (e.g. increasing grid capacity). For grid operation DSOs do not need the large amount of data that can be provided by smart meters. Nevertheless, positive effects of smart meters are recognized, such as enabling better network planning and control. It was also suggested by some DSOs that metering data could be used by public entities to better target subsidies and policies to maximize energy efficiency.

In some Member States regulators clearly want to reduce the role of DSOs to a minimum. In others, DSOs are expected to execute the same range of tasks as nowadays. The role of the DSO as data provider is currently intensively discussed. Not many DSOs look forward to have completely new roles in a smart grid environment, although they foresee the market structure as well as their existing tasks to become more complex. They see their role being gradually adapted to the new situation. Only a few DSOs see a possibility of providing new services and activities, such as advance network supervision and promoting energy efficiency awareness. Local balancing is seen by many DSOs as becoming more relevant, though provided in close cooperation with the TSOs. Although, some DSOs consider all balancing activities as tasks of the TSO. From the point of view of DSOs, it is their task to maintain the grid operation, secure the supply, connect and give access to the network, and collect and provide (metering) data to third parties. DSOs insist that there is no need for another monopoly actor as DSOs represent an already regulated and neutral party.

For national regulators the provision of a non-discriminatory market access and of a level playing field constitute the most important factors when deciding on whether or not an activity or task should be executed by DSOs. And most of the interviewed DSOs, regulators, suppliers and ICT providers support the statement that DSOs should ensure the optimal use of the infrastructure and should facilitate market operation. An association of suppliers and a German regulator pointed out that if DSOs are responsible for managing the smart meter data, the level playing field for other market parties could be threatened if the DSO is not subject to ownership unbundling. These stakeholders suggest that the owner of the DSO could have a better access to data than other stakeholders. The DSOs we interviewed that are only legally unbundled were suggesting that they are able to assure the non-discriminatory access to the data.

In many countries DSOs are now responsible for smart meter installation, metering and reading. Even in Germany, where metering is liberalised, not many consumers choose a metering operator other than the one that belongs to their current DSO. All DSOs see themselves as market facilitators and they support the view that small consumers should have one main point of contact, the retailer or an ESCO.

Business opportunities

Ownership and management of smart meters

In most countries, the roll-out of electricity smart meters is either already running or planned for implementation in the coming years. However, not every country has a clear roll-out timetable yet.

The roll-out of smart meters is conducted mostly by DSOs, which includes purchase, installation, operation and maintenance. So, smart meters are in most cases owned by DSOs. However, in Scotland, smart meters are installed and owned by the meter suppliers. In France, due to concession arrangements smart meters are owned by the municipalities. In Germany the metering companies are owning the smart meters, although the ownership of smart meters is still under discussion. According to the national German regulator metering is not seen as being a lucrative business.

Sometimes consumers also have an option to own or rent the meter. However, if consumers own the meter they also have to maintain and update it, which could lead to inefficiencies due to a lack of knowledge or coordination. When DSOs own smart meters the cost of purchasing and operation (e.g. read-out infrastructure) are expected to be lower by avoiding a proliferation of different meter types and versions in the network. Furthermore, when DSOs own the meter difficulties are avoided when the customer is switching energy supplier. Some DSOs have built alliances to procure smart meters and encourage competition between suppliers of meters.

There is a discussion on who should bear the costs of large-scale roll-outs. Some DSOs state that costs should be socialized, while others do not have preferences on this issue since the installation costs are considered to be small. On the other hand, costs of maintenance, upgrading and collecting of metering data are expected to be a heavier burden on DSOs and several DSOs foresee these costs being passed on to the consumers. Moreover, several DSOs claimed that the business case for smart metering will never be positive for DSOs. Therefore the costs as well as the benefits should be part of a distribution tariff. When the meter is owned by the DSO, this is automatically achieved since the investment cost (depreciation) and the operational cost (lowered by efficiency gains) are already components of the distribution tariff. In the case of Spain, replacing meters is regulated to avoid any extra-cost for the consumer, hence the DSOs had to modify the amortization procedures to reduce the value of the fixed assets to zero by the time of the replacement. In Belgium, the costs of pilot projects were incorporated into the grid fees. In Germany the metering is done by a separate market entity, the Metering Service Operator (MSO). The cost are billed to the customers separately or through the retailer. In Italy and Sweden the DSOs report the profitable exploitation of smart meters. The rollout in both Member States are completed and the DSOs estimate that the DSOs return on investment will be higher due to the higher efficiency in the metering operation.

A DSOs and a regulator noted that an investment in smart meters enables technical innovation, new products and services by other market parties, e.g. ESCO's. Since these market parties derive a commercial benefit from the available infrastructure, one could envisage a financial compensation for its use. These benefits are seen as to be taken into account for the calculation of the distribution tariff (similar to, for example, a road tax for transport companies). In France revenues from providing information on consumption to third parties (registered and allowed by consumers) are used to lower the grid tariff.

Data management

Many DSOs believe the DSOs should play a market facilitator role under the following two conditions: strict rules on data use to ensure end user privacy and an non-discriminatory access to meter data for all parties approved by the end user. All DSOs interviewed insist on collecting and managing metering data because they need this data in any case for safeguarding, controlling and managing their network. However some regulators do not see DSOs as a natural data provider. Also, the opinion was expressed that whoever owns the smart meters, should also provide the data to third parties. As in Germany, where the metering operators are expected to cooperate with "gateway" operators to provide data. ICT providers pointed out that small DSOs may not have enough data to handle to profit from it and that management unbundling is enough in case DSOs are to manage the data.

In several countries, DSOs possess their own database and platform already or are in the process of realizing this. However, a centralized national data platform is preferred by a number of DSOs and regulators. An example is the existing Energy Data Services Netherlands, a central data platform owned by network operators. Another example is Belgium, where a central metering clear house to be operated by all DSOs is expected to become operational in 2016.

Most of the DSOs interviewed are not convinced by synergies of partnerships with ICT and TelCo companies to the extent of sharing responsibilities. They prefer ICT and TelCo companies to be pure service providers for DSOs. ICT providers also support this view. Regulators also recognize that ICT companies with their present know-how may not be able to manage data platform more efficiently than the DSOs due to lack of network knowledge and TelCo providers may not have sufficient knowledge to manage a system designed for energy utilities. In the advanced CDMA-450 project of Alliander in the Netherlands we also see this role division between DSO and the ICT provider (KPN). While KPN operates the network and platform, the full responsibility remains with the DSO.

Among the three models of data management proposed by the EG3, most DSOs, TSO, Regulators and other stakeholders interviewed choose the first option (model 1, the DSO model), where the DSOs act as market facilitator, having a neutral position and not being involved in commercial activities. This choice is explained by the fact that DSOs are already regulated, so there is no need for another regulated party. Moreover, an independent company is not recognized as being able to provide this service more efficiently than a DSO. The second model proposed by the EG3 is considered possible only if all DSOs are obliged to use the same database. This second model is planned to be introduced in the UK. The DSO in Scotland has the view that data provided on a common data platform will be detailed enough to allow efficient network operation and management. The third EG3 model is mostly rejected for data confidentiality reasons, with the exception of Germany. In Germany, the Data Access point Manager (DAM) model in the form of a "Gateway" is seen as the most probable outcome.

In Sweden and Italy the DSOs see smart meter roll-out as a profitable business case and have started the roll-out ahead of the regulative directives. Mostly, hourly resolution is used, but also the 15-minutes resolution is either already implemented (e.g. in Spain) or currently discussed by some DSOs (e.g. in Belgium). Some DSOs stated that a higher resolution might benefit some specialized services, but will unnecessary complicate the settlement process. Also, more frequent information does not necessarily lower consumption. Home devices with the ability to analyse consumption patterns will be needed.

The functionalities of smart meters differ per country: smart meters exist with only one-way communication, with various resolutions, with or without ToU tariffs, with or without possibility of a remote update or remote disconnection. The importance of regulating the minimum level of functionality of meters was often mentioned.

Improve energy efficiency

Energy efficiency promotion is not seen by most DSOs, Regulators and supplier associations to be a task of the DSOs, but rather a task of energy suppliers. However, in some Member States (Belgium, Denmark and Italy) creating energy efficiency awareness is already an obligation of DSOs. Nonetheless, other national regulators mentioned that data provided by smart meters can enhance energy efficiency awareness and if DSOs possess this data, they can also promote energy efficiency.

It was also often stated by a French DSO that customers are not ready to participate in this new market and that little response is coming from their side. Although, for example in Germany, the prosumers are quite active, the demand side management activities by some suppliers were not very successful. Also in Germany, the E-energy project showed decreasing interest of household consumers to data provision. Some interviewees stated that more frequent information makes end consumers more aware about the switching process and their energy usage, but consumption levels do not drop significantly.

Load shedding and better load profiling are quite uniformly considered a task for retailers, aggregators or ESCOs. For local balancing, DERs are seen as being able to deliver reliable capacity and congestion management to DSOs. Only in emergency situations (the so called yellow and red traffic light situations) the DSOs see advantages of the ability to remotely shut off and reconnect consumers and producers in smart grids.

Reducing required grid investment

Offering flexible electricity prices is seen by most of the DSOs as a task of aggregators. It is considered to be an energy market service, not a network necessity. Regulators also prefer the market to fulfil this role of involving and incentivising consumers by means of flexible tariffs. Also, a few DSOs stated that DSOs have little experience in the field of customer relationship management.

Electrical vehicle charging infrastructure

The point of view on who should provide the charging infrastructure for EVs did not lead to a single answer. Some DSOs consider it to be their task as they are to provide connections to the grid. They are able to solve the chicken or egg problem by socializing the upfront costs of the charging infrastructure. Facilitating the roll-out of EV charging infrastructure primarily means the connection to the grid to the charging infrastructure and ensuring adequate grid capacity. In order to have a cost-effective roll-out, DSOs are expected to also have an impact on the determination of the number, type, location and technology of the charging infrastructure. Most DSOs and regulators expect market parties to invest in EV charging stations. They see the role of DSOs in connecting these stations and installing smart meters.

3.4 Resulting (business) opportunities

Based on the identified technological and societal trends, interviews with stakeholders and literature review, we have identified a broad range of (business) opportunities in the Smart Grid environment. These opportunities aren't necessarily commercial, they also encompass potential benefits for the non-market actors. Furthermore, they may partially overlap each other. We conclude this section with rearranging these opportunities into five concrete future services.

Reducing required grid investment

Distributed Generation (DG) causes the grid to become more complex. This increases the required grid capacity and simultaneously offers the potential for more complex system management. Congestion management using flexibility services can save costs compared to applying the 'fit-and-forget' approach. Furthermore, DG increases the capacity of DSOs to respond to emergency situation and realise damage control.

Spatial and temporal matching of supply and demand

Congestion can be mitigated by better matching local supply (e.g. solar and wind power) with local demand. This provides the potential to save on grid capacity investment and/or congestion management. These delayed or avoided investments can be achieved by managing supply (DG) as well as demand (e.g. through the electric vehicles charging infrastructure).

Utilize electricity storage capacity of electric vehicles

Batteries of electric vehicles can be used for technical balancing of the grid. This is a specific example of potential for congestion management. Through peak-charging, electric vehicles can also negatively affect demand volatility, posing an additional opportunity to efficiently handle the development of electric vehicles charging infrastructure.

Reduce energy consumption

Real-time information on consumption volumes can potentially help reduce energy consumption. These savings can be shared with the private sector who can help identify and realise savings potential.

Environmental awareness: visualising environmental impacts

Consumers sometimes value environmental benefits of a product (beyond financial returns). So in addition to actual financial savings, smart meter data shows the potential to more easily allow end-users experience environmental impacts, supplying the ‘being involved with the environment’ product. These environmental benefits represent a value for end users and can be combined with financial savings to increase the value of applications that help identify and realise the savings potential.

Change consumption patterns

Real-time information on prices will allow consumers to respond to dynamic prices by changing their consumption patterns. To help utilize this potential, the private sector can develop automated solutions to optimize consumption patterns (domotics). This allows balancing between energy savings and value attached to consumption in specific patterns (for example, shifting domestic appliance energy usage but not shifting energy usage for cooking). Furthermore, domotics can create new value in niche markets beyond the scope of energy savings, responding for example to the societal trend of becoming more independent in your energy needs.

Changing consumption patterns can be beneficial for small scale consumption as well as large scale consumption. A few examples of large scale consumption which can be delayed relatively easily are heat pumps and charging electric vehicles.

Utilize economies of scope in smart meter roll-out

Combining the roll-out of smart grids with the realisation of other (utility) infrastructure offers significant cost savings. For example, in remote areas, the roll-out of smart grids can potentially be combined with realising broad band internet.

Utilize economies of scale in smart meter roll-out

A large scale roll-out of smart meters shows significant opportunities for economies of scale. Savings can be achieved with large orders and when installing smart meters neighbourhood by neighbourhood, instead of house by house.

Utilize economies of scale in data collection and management

The potential of smart meter data opens up commercial business opportunities. This may lead to multiple data platforms (public and private), which is inefficient because data consumption is non-rivalrous. This provides opportunities to jointly organise data collection and management.

Cooperation with ICT/Telco sector

An increase in data management as a result of smart meters represents a business challenge as well as an opportunity. Cooperation with the ICT/Telco sector offers potential for utilizing their available expertise.

Standardisation of smart meters

Deploying one type of smart meter on a standerased of smart meters (e.g. with less or more ICT functionality) offers opportunities for economies of scale in both roll-out as well as management of smart meters. However, this also encompasses a threat of a technological lock-in.

Conclusion

These (business) opportunities may partially overlap. Therefore, to enable the subsequent analysis, we have categorized the opportunities in five activities / tasks. The opportunities can be roughly divided in those services that 1) use the increased information flow to affect the volatility of supply and demand to increase the efficiency in grid management and save energy; and 2) the opportunities involved with how relevant information can be collected and handled efficiently.

Increased efficiency of the grids capacity can be reached through the matching of demand and supply and congestion management. All services which can potentially provide flexibility are discussed under the primary service 1: flexibility services.. A special case for potential congestion and flexibility services is presented in the form of the growing number of electric vehicles and the accompanying electric infrastructure. This results into unique opportunities (e.g. batteries for storage), but also challenges (e.g. capacity requirements for peak-charging), therefore deserving an individual analysis (2: infrastructure provision for electric vehicles). Applying detailed in-time information to increase energy consumption efficiency, either driven by cost reduction or environmental awareness, can result in a net energy reduction. This net reduction differs in nature from 'just' changing volatility. Furthermore, the market for flexibility service is in a less mature stage than the energy efficiency services market. Therefore, these opportunities will be grouped as 3: energy efficiency services.

The utilisation of opportunities involved with the roll-out and management of the metering equipment is closely interlinked with the ownership of the equipment, because most of these opportunities economies of scope and scale. Ownership and management services have therefore been bundled to one service (4: ownership and management of metering equipment). The opportunities involved with the data handling are linked to, but contain separate opportunities compared with ownership and management of metering equipment. A few examples are efficiencies in data handling (number of platforms), privacy issues and non-discriminatory access to data. Consequently, 5: data handling is a separately discussed service.

The five service categories are summarized in table 3.1 below. We specifically focus on opportunities which are influenced by a smart grid environment. We would like to stress that this is one possible categorisation and isn't necessarily 'set in stone'. Other categorisations are possible, though we feel that this observation does not endanger the analysis. This is primarily because we consider these functions to fully encompass the range of future functions resulting from smart grids. A further elaboration on the five services is provided in chapter 4.

Table 3-1 Smart Grid actors

Future services	Underlying (business) opportunities
Flexibility services	Congestion management, temporal and spatial matching of supply and demand, change consumption pattern
Infrastructure provision for electric vehicles	Demand management, utilize electricity storage capacity of electric vehicles, congestion management
Energy efficiency services	Reduce energy consumption, environmental awareness through visualising environmental impacts
Ownership & management of metering equipment	Utilize economies of scope and economies of scale in smart meter roll-out, standardisation smart meters
Data Handling	Utilize economies of scale in data collection and management, cooperation with ICT/Telco sector

4 Task 2: Identification of tasks and services for DSOs in the future power system

4.1 Introduction

The main function of this chapter is to provide an introduction of the six smart grids services identified in Table 3.1 as well as an introduction of the roles of DSOs and other stakeholders with regard to tasks and services related to smart grids.

In Section 4.2, we provide a brief overview of the major services related to smart grids. Subsequently, we discuss the actors who might possibly provide and procure these services.

4.2 Possible future functions of Smart Grids: future services

Following Figure 4.1 we distinguish the following concrete services in the future Smart Grids environment:

1. Flexibility services;
2. Infrastructure provision for electric vehicles;
3. Energy efficiency services;
4. Ownership & management of metering equipment;
5. Data handling.

Each of these tasks is described in more detail below.

Ad 1) Flexibility services

Among the major tasks of DSOs is network planning and network operation. Nowadays, they provide voltage control, load curtailment in case of local congestion and, in the longer run, through investment in infrastructure. With the increase of distributed generation, which is often not dispatchable due to its intermittent nature, network flows become more variable and cannot longer be efficiently resolved in the network planning phase by increasing network investments. Instead, network operation becomes more important for DSOs. New technologies and smart grids constitute new options for network operation and system management by providing flexibility in (local) generation, demand and storage. Flexibility is here defined as the ability to adapt and anticipate to uncertain and changing power system conditions, in a swift, secure and cost efficient manner. One can distinguish between the provision of and demand for flexibility services. Flexibility can be supplied by system users i.e. producers, consumers or prosumers (demand response, distributed generation, storage) or by intermediaries such as aggregators and suppliers on behalf of the former. On the demand side, network operators, both TSOs and DSOs, can use flexibility for congestion management as a substitute for infrastructure investments. Moreover, demand for flexibility also originates from aggregators, energy retailers and suppliers for portfolio optimization and from Balance Responsible Parties for imbalance settlement.

Ad 2) Infrastructure provision for electric vehicles

Expanding the use of electric vehicles requires a sufficient availability of charging points for electric vehicles to become attractive. A distinction can be made between two types of charging: (i) recharging points that are accessible to the public, and (ii) recharging points that are not accessible to the public (EC, 2013b). The first category is defined as recharging points that offer non-discriminatory access to users. Those can be located either in public or private areas. The second category concerns recharging points with restricted access to the public, one might think of recharging points in private areas with private access. Charging infrastructure also differs in the charging velocity, either normal or fast charging, and whether charging is performed in either a uncontrolled, dumb manner or a controlled, smart way. The latter has implications for the degree of flexibility which EV may be able to provide. In case of uncontrolled, dumb charging, opportunities for flexibility such as storage or discharging cannot (easily) be deployed, while in case of smart charging flexibility can be harnessed.

Several actors may play a role in the provision of EV charging infrastructure, such as DSOs or suppliers who can use the charging points to sell electricity. Other commercial actors may also provide access to EV infrastructure, such as private investors and independent e-mobility providers who may provide electricity bundled with other services.

Ad 3) Energy efficiency services

Smart grids in combination with smart metering can provide detailed information on usage and tariffs in order to (i) inform consumers; (ii) to help identify cost effective options for energy savings and may create new business opportunities for investments in energy savings. As an example of the latter, a company may invest in energy savings measures together with households or firms in exchange for a part of the savings being realised. A number of different actors can provide energy efficiency services, such as DSOs, and electricity suppliers, as well as independent firms, such as ESCOs, electrical installation companies or construction companies involved in providing insulation.

It should be noted that the Energy Efficiency Directive (EC, 2012a) requires from Member States that they decide who should be the responsible party for reaching energy efficiency targets, which may include the DSOs and suppliers.

Ad 4) Ownership & management of metering equipment

For the purpose of engaging consumers in Smart Grids at LV level, smart meters can act as an important enabler. These meters have to be manufactured and installed, they will need to be owned and operated, but not necessarily by the same party. Manufacturing and installing meters are tasks currently performed in a competitive market. For ownership and operation, there are two main options: a regulated model or a liberalised model. In the first option, metering equipment is owned and operated by a regulated party, typically the DSO. In the other option market parties own and operate the meters. Suppliers or an independent meter provider could fulfil both roles, while aggregators or ICT service providers could assume the operation of the meters while they are owned by the customers.

As regards the roll-out of smart meters, in most Member States the DSO is in charge of the roll-out of smart meters and they are supervised by regulators to guarantee efficient solutions.

Ad 5) Data handling

The new tasks and services which will be part of the smart grid environment depend on the availability of data provided by the metering equipment. This data is used by both commercial operations (such as, for example, the provision of flexibility services and operation of electrical vehicle charging infrastructure), as well as grid operators (for both short term system management as well as long-term grid planning).

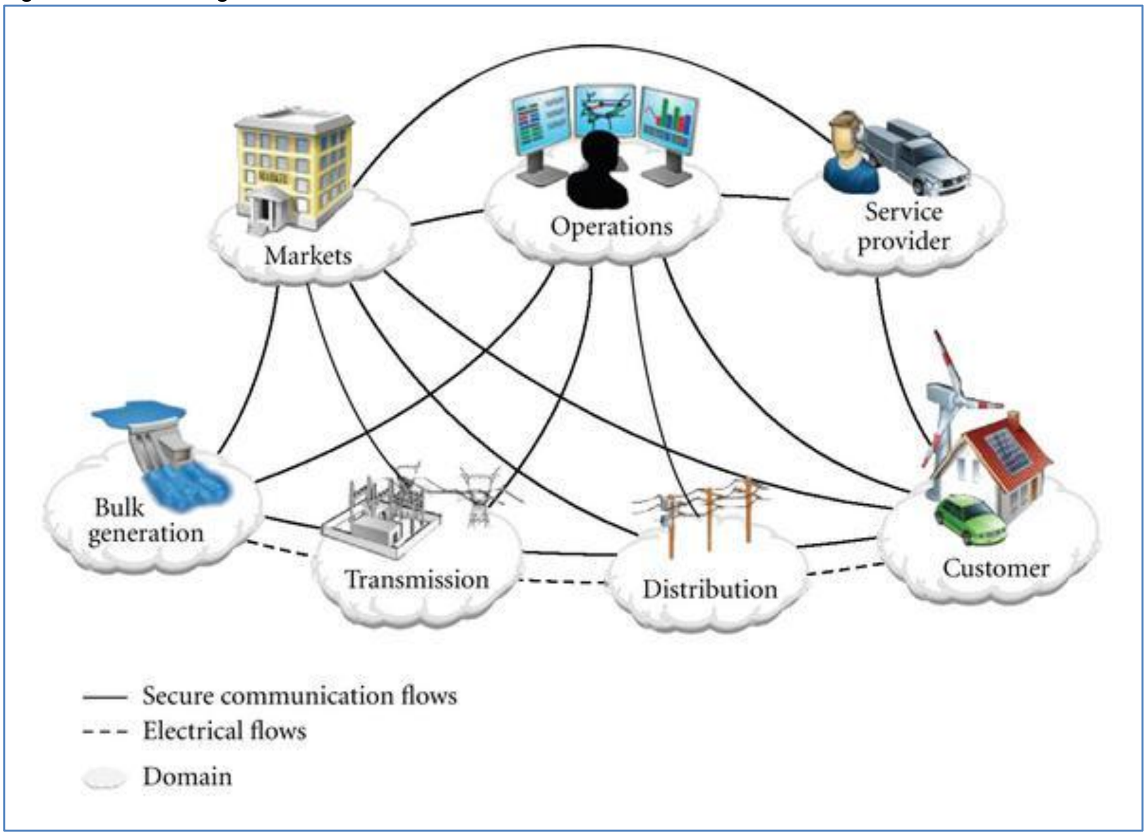
As explained in paragraph 3.2, for the data handling itself, the Smart Grid Taskforce EG3 distinguishes three different operational models. In one model the DSO ensures the data handling.

In a second model data is handled by another regulated party, while in the third model a commercial party provides the data handling services.

4.3 Actors in the smart grid environment

Numerous studies in recent years have described the different actors involved in smart grid environments and the tasks and services they may provide. In this section, we will provide an overview of the main actors and services involved and make a selection of those services which will be analysed in the next section.

Figure 4.1 The smart grid environment



Source: NIST

There are large numbers of different actors involved in the smart grid environment.

Figure 4.1 provides a simplified image of the smart grid environment within the broader electricity system. Within this system, we can distinguish a number of different groups and actors according to their functions and responsibilities(based upon the EU Task Force on Smart Grids (EG3, 2011), see Table 4-1. The transmission operators and distribution operators together constitute the category of grid operators. All parties physically connected to the grid form the category of grid users, both at the supply and at the demand side. The energy market place is formed by the actors that are involved in the trading of electricity i.e. traders, suppliers and aggregators as well as the parties that are responsible for imbalance settlement. The technology providers include the grid equipment providers (hardware and software, services) as well as the providers of equipment connected to the grid at the consumer premises. The influencers are the indirect actors, impacting the operations within and on the smart grid, they include governments and regulators (both national and at the EU level), standardization bodies and the financial sector, as provider of investment funds. Note that actors may have roles within multiple categories.

Table 4-1 Smart Grid actors

Categories	Actors
Grid operators	• Transmission System Operator (TSO); • Distribution System operator (DSO).
Grid users	• Generator; • Customer; • Electrical installer; • Supplier; • Retailer.
Energy market place	• Balance Responsible Party; • Clearing & Settlement agent; • Trader; • Supplier; • Aggregator.
Technology providers	• Electric Power Grid Equipment vendor; • Ancillary Services provider; • Metering operator; • Information & Communication Technology (ICT) service provider; • Grid communications network provider; • Home Appliances vendor; • Building Energy Management Systems (BEMS) provider; • Electric Transportation / Vehicle Solutions provider.
Influencers	• Regulator; • Standardization bodies; • EU and national legislation authorities; • Financial Sector entities.

Source: Own depiction of EC (2011a)

Appendix C provides an extensive description of the different actors. For the purpose of our analysis, we will especially focus on those actors which may use or supply services in a market place in addition to DSOs and TSOs. These will include actors such as consumers, producers, suppliers, retailers, aggregators, metering companies, installers and technology providers.

5 Task 2: Evaluation monopolistic versus competitive nature of services

5.1 Introduction

In the previous chapter, the smart grid environment has been described and a number of major activities and services have been introduced which can or have to be provided within the smart grid environment. In this section, we will evaluate to what extent a service is best provided by a regulated entity (such as, for example, a DSO) or whether it should be left to parties operating in a competitive market. This analysis will test the monopolistic and competitive characteristics of the different tasks and services. We consider the following five general criteria to test the services as discussed in Chapter 4:

1. Public good characteristics;
2. Economies of scale and scope;
3. Other externalities;
4. Incentives for innovation;
5. Customer orientation.

The first three criteria test the monopolistic characteristics, while the last two criteria test the competitive characteristics.

Ad 1) Public good characteristics

In general, a distinction can be made between on the one hand private goods and on the other hand public goods. Private goods are the standard goods which can be bought and sold on markets, such as, for example, mobile phones, apples and oranges. This is different for public goods. One of the characteristics of public goods is that one cannot exclude others from the use of the good (non-excludability), as is the case of normal goods. An example is national defence, which benefits everyone within a country. In the context of energy, security of supply is an example. Security of supply policies also benefits everyone, one cannot limit it to specific groups. Another characteristic is that the use of a good or service by one person does not diminish the use by someone else (non-rivalrous). This characteristic also applies to national defence or security of supply.

Public goods are often subject to the ‘free rider’ problem whereby there is no direct payment made for the use of the good. As a result a public good may be under-produced, overused or become degraded. Given these characteristics, there will be no competitive market for these goods and they will have to be supplied by governments or regulated entities. We will therefore investigate the different tasks and services in order to determine whether they have the characteristics of a private good or a public good.

In this context, it is also important to note that DSOs have the responsibility for system stability and security of supply, which is largely a public good. Therefore, a new allocation of roles and responsibilities should not jeopardize security of supply and system integrity. In the analysis this aspect will be taken into account under the heading public good characteristics.

Ad 2) Economies of scale and scope

Some goods can be supplied at lower costs when they are supplied by one or a few firms rather than by a large number of competing firms. This is referred to as economies of scale. Electricity networks are an example of such goods. The reason is the high fixed costs related to the provision of these goods. Economies of scope can be realized if a number of related goods are supplied by one firm instead of different firms for each individual good. Synergies in the production of the different but related goods within one firm reduce the overall costs. When there are large economies of scale or scope, it is more efficient to have only one or a few firms instead of a large number of firms. This raises the issue of market power and the possibility of inappropriate use of market power, which is typically mitigated through regulation.

Ad 3) Other externalities

An external effect, or externality, occurs if someone's production or consumption activities hurt or help others outside a market. A manufacturing plant may produce harmful fumes as a by-product of its production process. These fumes create an externality that harms people in the surroundings. Since the firm does not have to pay for the harm they cause, they will not take into account the social costs in their decisions. A negative externality may also result from consumption, e.g. air pollution of a car. Also positive externalities exist. Imagine a new industrial factory, it may buy raw materials, needs employees and purchases bookkeeping services from other firms. Also in the energy sector several externalities occur. An example are split incentives in the building sector; in rental properties there is little incentive for the building owner to invest in energy efficiency measures if the tenant pays the energy bill. Or potential privacy and data security issues around smart meters; individual producers cannot guarantee privacy and data security, a coordinated approach is key.

Ad 4) Incentives for innovation

Innovation is an important issue within the smart grid environment. One of the benefits of smart grids is expected to be found in the development of new goods and services, which will depend on whether there are sufficient incentives for innovation. Whether innovation is stimulated by competition or monopolistic nature of tasks will depend on the position of the technology on the technology learning curve. In case the technology is nearby commercialization, innovation may be more stimulated by competition as market actors do have a higher appetite for making profits than regulated (natural) monopolies. A famous example is the telephone industry, where innovation increased dramatically after market liberalisation. However, when a technology is still in the demonstration phase, a regulated (as a rule a monopoly) or subsidized party might be better placed to stimulate innovation because profits will be limited or altogether absent. Nuclear fission is a prime example of a technology which is still in a long way from the market and therefore will not be developed by a market party without government intervention. It also applies to technologies which require the development of a sufficient large market in order to become competitive. We will come back to this in the discussion of infrastructure provision for electric vehicles.

Another important characteristic to consider related to innovation is the potential for innovation. For some technologies or services, the room for further development is limited. In contrast, goods such as mobile phones have a large potential for innovation. Limiting production to one regulated firm would considerably hamper innovation.

Innovation can also relate to business transformation. In the case of the energy transition were new business models will emerge and existing business models will fade out, this can be regarded as a business transformation. The question is whether such a transformation will take place without adequate regulatory intervention.

Ad 5) Customer orientation

Since market parties have to compete for customers they are generally considered to be more customer oriented and to provide better service than regulated parties who do not have to compete for their business in the absence of regulation of quality of service, notably commercial quality. Benefits of market parties are more dependent on the level of sales and product margins, while the benefits of network operators often depend on a derived demand and on regulated network tariffs. Tasks for which the commercial quality is important should therefore preferably be supplied in competition since this prevents the need for additional regulation of commercial quality.

In the following section, we will evaluate the major services identified in Chapter 4 (see Table 5.1 for the overview). For each of the services, we will assess and indicate whether they are best provided by the market or by a regulated entity and conclude with recommendations on the role of DSOs in the provision or procurement of each service. Section 5.7 concludes with an overview on the possible future roles of DSOs in providing services in the smart grid environment.

Table 5.1 Major smart grids services

Flexibility services
Infrastructure provision for electric vehicles
Energy efficiency services
Ownership & management of metering equipment
Data handling

5.2 Provision and procurement of flexibility services

5.2.1 Introduction

With the advent of intermittent generation, whereby production varies with weather conditions such as wind power and solar irradiation, there is an increasing need for flexibility in the power system value chain to maintain competitiveness and security of supply. Energy markets are characterized by higher price variability due to more frequent excess of electricity, increasing the need for flexibility to reduce the difference between supply and demand through imbalance settlement. Larger variability of network flows increases peak demand for network capacity and lowers average network utilization, making network investments less profitable and requiring flexibility to keep network operation in control. For the same reason, network congestion occurs more frequently at a wider variety of locations and at different times. Lower predictability of power supply increases demand for system balancing (Holttinen, 2004) as well as demand for ancillary services, such as voltage control. The latter applies in particular to the uptake of distributed generation in rural networks, which contributes to voltage rise issues (Ramsey *et al.* 2007; Zvingilaite *et al.* 2008).

Therefore, unlike the practice was before, DSOs may deploy flexibility services for congestion management in day-to-day network operation in order to save on network reinforcements that would be used only occasionally or to a very limited extent. Moreover, DSOs may need flexibility services to fulfil some system operation tasks at the distribution network level such as balancing, which are currently only performed at the transmission level without the active participation of demand and generation facilities connected at the distribution level.

The procurement of flexibility services by DSOs for network and system operation differs according to system states. As is the common practice in transmission networks, for distribution networks three different system states can be defined in a “traffic light scheme”, i.e. normal operating state (green), alert state (yellow) and emergency state given unsecure operation (red) (Eurelectric, 2013a). In the normal operating state the network is secure and power can flow both from producers to consumers as well as back to the system when generation exceeds demand. In the alert state, the "DSO has an emerging congestion. DSO actively engages with the market (DG or load) to procure flexibility to relieve grid constraints", (Eurelectric, 2013a, p. 21-22). In the emergency state, the secure operation of the distribution system is hampered by voltage increase and congestion. The DSO has to take emergency actions; including the management of distributed renewable generation and network management to control the isolation and subsequent restoration of outages.

Note that DSOs are not the only party which are in need of flexibility services; TSOs need flexibility for congestion management and system balancing, while suppliers and balancing responsible parties (BRPs) need flexibility services for portfolio optimization (including imbalance settlement) purposes.

Flexibility can be provided by DER which can easily ramp up and down such as CHP with heat buffer,[4] storage facilities and customers with flexible loads (using demand response). Small and medium-sized, flexible DER can provide flexibility either to DSOs and TSOs or to different electricity market participants such as aggregators, suppliers, and ESCOs for different time frames (ranging from multiyear-ahead forward markets until near real-time balancing markets).

Definition of flexibility services

At least five types offlexibility services can be distinguished;[5]

1. **Portfolio optimization** 'is used by market players to meet their load obligations at minimum costs by arbitrating between generation and demand response on different time horizons' (He *et al.* 2013). The responsibility of portfolio optimization is sometimes assigned to BRPs by TSOs in the framework of imbalance settlement;
2. **Preventive congestion management** relates to congestion management that takes place before gate closure of wholesale markets ('preventive'). Following the system states definitions above, it is assumed that flexibility services can be procured through the market if the system state, i.e. the traffic light is yellow;
3. **Curative congestion management** is near real-time resolving of local network overload through network operation after gate closure of wholesale markets ('curative'). Given the need for fast actions, the system state will be more often characterized by the red traffic light, and hence fast, emergency type of actions are required. The need for curative congestion management decreases if there are more possibilities for preventive congestion management;[6]
4. **System balancing** refers to "procurement of balancing reserves (capacity) and balancing energy by the TSO to perform balancing, meaning all actions and processes, on all timescales, through which TSOs ensure, in a continuous way, to maintain the system frequency within a predefined stability range" (ENTSO-E, 2013a);
5. **Ancillary services** relate to "a range of functions to guarantee system security. These include black start capability, frequency response, fast reserve, the provision of reactive power and

[4] Also wind and solar PV do have excellent ramping capabilities but at the same time they have very low marginal costs making their deployment for provision of flexibility services relatively more expensive since the revenues they obtain from electricity provision are higher than the revenues obtained by other flexibility services providers with higher marginal costs. Consequently, currently flexibility of DG is mainly provided by CHPs with heat buffer which show higher marginal costs than wind and solar PV.

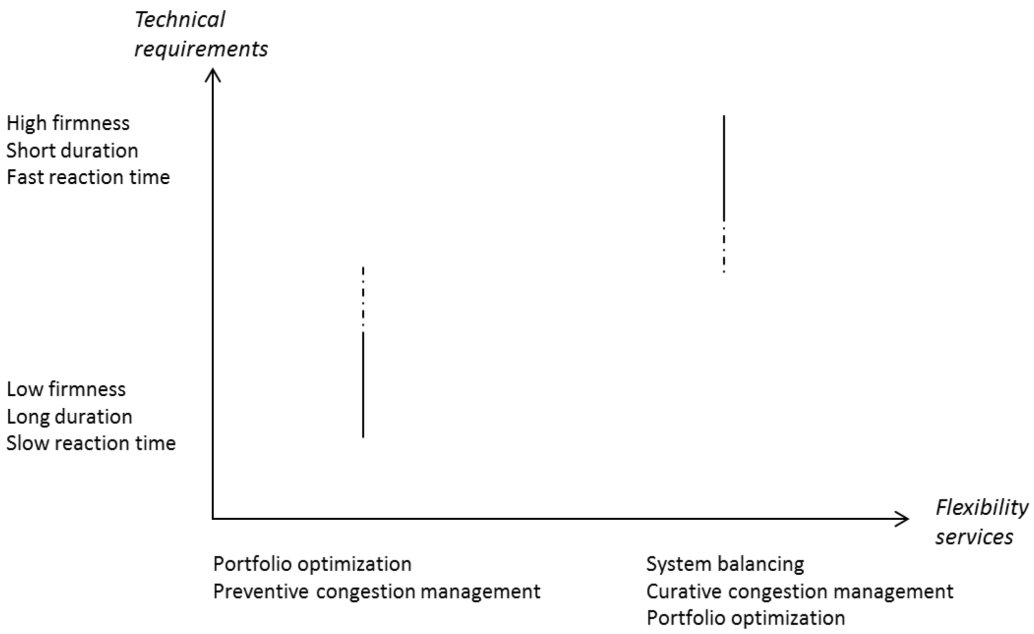
[5] This set of services is similar to He *et al.* (2013) who discern five types of demand response services. Apart from flexible loads, flexibility services can also be provided by flexible (distributed) generation and (electricity or heat) storage facilities. Heat storage facilities allow for flexible, electricity driven CHP operation that is (largely) independent from actual heat demand.

[6] The importance of curative congestion management is expected to diminish, given the increasing role of intraday markets and associated preventive congestion management near to real-time. Furthermore, preventive congestion management allows for better alignment of economic mechanisms with technical characteristics of the power system than curative congestion management.

various other services" (ENTSO-E, 2012). Some ancillary services can be provided by resources across different distribution systems and procured on a system wide basis (e.g. black start, islanded operation, compensation for system losses), while others are by definition local as they require local provision and procurement (including reactive power and voltage control). In the remainder of this study ancillary services are (largely) left aside, since the provision of these ancillary services does have limited added value, and the turnover is small and therefore the business case for DSOs.[7]

Portfolio optimization, congestion management, and balancing services are procured through markets, mainly as energy (as opposed to capacity) products. The provision of energy products is subject to technical requirements, which range from a relatively limited nature (for portfolio optimization and preventive congestion management) to a relatively extensive nature (for curative congestion management and balancing). Those requirements relate to reaction time, duration and firmness of response (He *et al.* 2013). The faster the reaction time of response, the shorter the duration of response, and the higher the required firmness, the higher the technical requirements for flexibility provision. The technical requirements for different flexibility services are depicted in Figure 5.1. It is shown that technical requirements for curative congestion management and balancing are higher than those for preventive congestion management, as the former are often needed at or close to real-time and are crucial for system security, while the latter usually are arranged on the day preceding physical delivery, known as D-1 (i.e. before gate closure of the day-ahead market). Portfolio optimization is shown both at the left and right side of the figure since it is mainly done at D-1, but at the same time is also possible after D-1 up to gate closure of the intraday market (H-1) in order to make corrections to submitted schedules (KU Leuven & Tractabel, 2009). Hence, market players sometimes require also flexibility services on a short notice i.e. with a fast reaction time and for a short duration, but without high firmness. At the right side of the figure portfolio optimization is thus situated in the dotted part of the vertical line.

Figure 5.1 Technical requirements of different flexibility services



Source: ECN, graphical and simplified representation of He *et al.* (2013).

7 Note that system balancing services such as frequency control and secondary and tertiary reserves are sometimes denoted as ancillary services, but here are discussed separately. For an indication of the limited costs of ancillary services such as reactive power and black start in the total wholesale costs we refer to PJM (2010).

5.2.2 *Assessment of competitive and monopolistic characteristics*

In assessing the nature of flexibility services, we distinguish between *flexibility provision* and *flexibility procurement*.

Flexibility provision

For flexibility provision the market entry barriers will be higher when a faster reaction time is required, if a longer duration of response is required, and when the required firmness is higher. These market entry barriers are also reflected in the technical requirements that have been defined before the uptake of renewable energy and distributed generation took place, i.e. in a period with lower demand for flexibility. Actual requirements of national network codes did often not foresee the adverse effects of for instance minimum size requirements for market participation of DER and rules regarding asymmetric upward and downward bids in balancing markets on the provision of flexibility in the future. Although these requirements may increase the market entry barriers for provision, other features emphasize the competitive nature of the provision of flexibility services: there are many active sellers, products can be categorized in a limited number of categories[8], and price information is widely available due to transparent electricity wholesale markets.

Furthermore, the fast development of ICT and renewable energy technologies (e.g. wind, PV, biomass), combined with demand response and storage technologies, provides ample scope for innovation and further development of the flexibility potential. Moreover, new devices, intermediaries and ICT applications (smart metering, aggregators, energy management systems etc.) help to open up this potential by lowering transaction costs. Competition rather than regulation can be considered as most conducive to accelerate the development and utilization of the flexibility potential. As a conclusion, both product characteristics and scope for innovation indicate that the provision of flexibility services can be best performed as a competitive task.

Flexibility procurement

On the other hand, the consumption of flexibility services is limited to a few buyers; DSOs and TSOs for congestion management as well as system balancing, and suppliers and balancing responsible parties for portfolio optimization and imbalance settlement. Imbalance settlement also takes place on the day of physical delivery up to the gate closure of the intra-day market which is in the majority of cases one hour before real-time. This implies that both types of flexibility products as distinguished in Figure 5.1 are required by regulated network operators as well as commercial market actors.

Given the public good and economies of scale characteristics of network management, electricity networks are considered as natural monopolies that are each served by one network operator. Consequently, network management in distribution networks is necessarily performed by DSOs. Provided that the procurement of flexibility services allows for postponement or avoidance of network investments that are likely to be inefficient and hence is an alternative manner of network management, it will automatically be a new or extended task to be performed by the regulated DSOs. See text box 5.1 below for a more detailed discussion of the character of already *existing* network and system management functions for DSOs (and TSOs) that are likely to be extended to some extent when DSOs obtain a role in flexibility procurement.

8 Based on He *et al.* (2013), Table 2, three types of products can be distinguished; (1) Preventive congestion management and portfolio optimization with relatively slow reaction time, long duration of response, and low firmness; (2) Balancing services and curative congestion management with fast reaction time, short duration of response and high firmness of response; (3) Ancillary services with very fast reaction time, short duration of response and very high firmness of response.

Given the additional task for DSOs in flexibility procurement, different market structures are possible. An important issue in elaborating potential market structures is that the suppliers and BRPs operate in a competitive market and compete with the DSOs and TSOs in the market for flexibility services. Securing the public interests in this mixed market presents a new challenge. We address these issues in Section 6.3.

Box 5.1 Natural monopoly characteristics of networks

Network management

For network management holds that networks provide a clear example of natural monopolies (Ajodhia, 2006). Natural monopolies imply that services are cheaper if the market is served by one or a few firms rather than by a large number of competing firms. Natural monopolies are characterized by high economies of scale relative to market demand. Economies of scale originate from high fixed costs, which are independent of the level of output.

Other important characteristics of natural monopolies are high capital-intensity, non-storability with fluctuating demand, locational specificity generating location rents, producing necessities which are essential for the community, involving direct connections to consumers (Ajodhia, 2006; Newbery, 1999). Newbery (1999): “The network is an obvious case where duplication raises the total cost of supplying market and hence meets the modern definition of natural monopoly. If demand fluctuates, and the product or service cannot be stored, then capacity will need to be sized to peak demand, or demand rationed. Locational advantage suggests that one firm will obtain at least a local monopoly, and different firms may enter to exploit different locations. Finally, the combination of necessity and direct connection implies large market power and the risk of market power abuse by the firm, so that regulation and/or public ownership is politically inevitable.” Furthermore, physical characteristics of AC power flows imply that flows can be controlled to a limited extent only and depend on all other flows in the network that result from other transactions. Hence there are externalities of private transaction, stressing the need for supervision by a network operator to guarantee network reliability and stability. All in all, these reasons imply that managing several small networks by separate DSOs requires much interaction and coordination with neighbouring networks, and therefore duplication, which make it more expensive than managing one larger network by one DSO.

System management

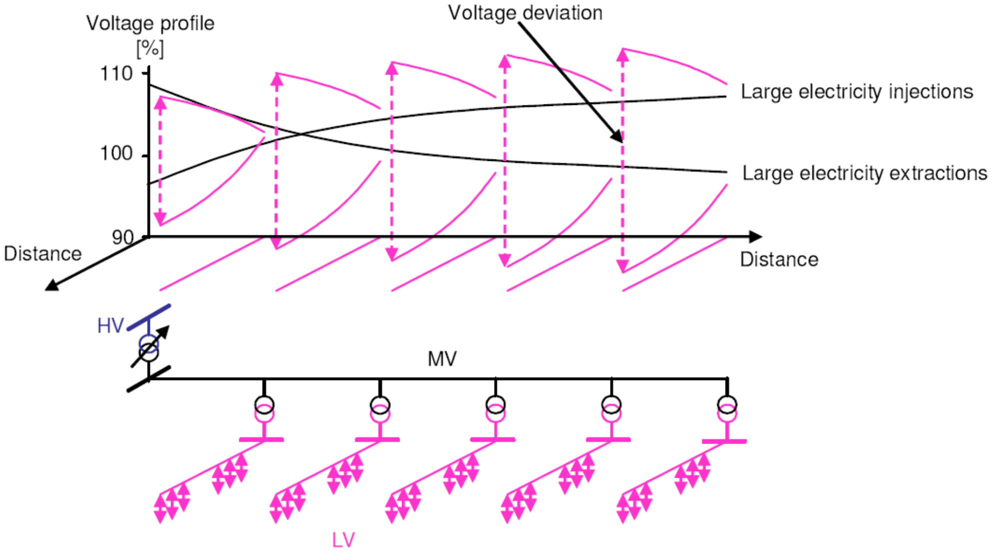
For system management holds that the system operator (SO) in general is responsible for three supply security services in the short-term to ensure reliability and quality of supply; keeping the system in balance and hence provide frequency stability, keep the voltage at the right level, and restart the system when it suffers a complete collapse (Stoft, 2004). Like for network operation, public good characteristics of these services require a system operator. These characteristics are related to the special character of electricity.

System balancing

Concerning system balancing, very limited possibilities for electricity to be stored requires that supply and demand have to be matched on a second-by-second basis. Generators do not have an incentive to invest in enough production capacity that accounts for many uncertainties about supply and demand since they do not face the full costs of a disruption. They only face the costs of electricity not sold, not the resulting costs for society (i.e. the value of lost load). Furthermore, a lack of information exists due to demand inelasticity related to the absence of real-time metering and billing for small consumers, as a result of which a large group of consumers does not pay the time- (and location-)dependent spot-price, but rather a price averaged over a certain period (e.g. a year) and based on a ‘copper-plate region’. Consequently, electricity consumers such as households do usually not instantaneously face high prices during periods with high price levels, nor do they experience price variability. Household electricity demand thus typically does not react at all (or at best with a large time lag) to changing market conditions. Moreover, for technical and economic reasons it is not possible to curtail all customers individually from using capacity, even when some of them are not paying for the cost of keeping that reserve capacity available for them when they need it. This follows from the non-excludability nature of reserve capacity, which allows for free-riding of electricity consumers on reserve capacity. Furthermore, reserve capacity is largely “non-rivalrous” i.e. more reserves can be consumed through higher energy use without compromising others’ security. Only in emergency conditions individual consumers run the risk that increasing demand will trigger an interruption of his or her own supply (NERA, 2002; ECN/SEO, 2004; CPB, 2005).

Voltage control

Another important task of the system operator, both TSOs and DSOs, is maintaining voltage within narrow bands in order to supply customers within the required voltages. In case a consumer is served with power that is not locally produced, the voltage decreases over the distance that power has to be transported from producer to consumer. Also injection of active power modifies such voltage profile. When the production of DG is high at the end of a circuit and at some points in time there is insufficient local load to absorb the whole production, power flows occur in reverse direction (from distribution to transmission). As a result, voltage may rise to too high levels and exceed voltage limits (Zvingilaite et al. 2007). The following figures show the change in voltage profiles when electricity flows in both directions.



Source: Meeuwsen (2007).

Voltage control is needed and for that purpose reactive power must be injected locally, either passively by capacitor banks or actively by generators. Reactive power is a less pure public good than system balancing since its use diminishes the use of a good or services by someone else and the use by the grid and its users can also be measured, although it is expensive (Stoft, 2004).

In a smart grids environment, DSOs may face increasing difficulties in maintaining the voltage profile at the customer connection point, particular on LV level, as active voltage control is often not in place. Besides, most distributed generation is not equipped to participate in system management (Eurelectric, 2013a).

Black start

Restarting the system after a breakdown of the system is another task of the system operator. These so-called black start services are needed since ‘most generators need to take electric power from the grid in order to start themselves’, Stoft (2004). Consequently, after a breakdown they are not able to facilitate a restart. Considering that black start services are a pure public good it is clear that a regulated actor, the system operator, has been given this task. In principle, both TSOs and DSOs qualify for the provision of these services.

5.2.3 Roles of the DSOs

Table 5-2 shows the results of the assessment of monopolistic and competitive characteristics of procurement and provision of flexibility services.

Table 5-2 Monopolistic and competitive characteristics of flexibility services

Monopolistic characteristics	Public good characteristics	Network and system management are public goods
	Economies of scale and scope	High economies of scale
	Other externalities	Other characteristics of natural monopoly (non-storability of electricity, location rents, direct connections to customers)
Competitive characteristics	Incentives for innovation	Large potential for flexibility supply, ICT allows for aggregation of small flexible DER
	Customer orientation	
	Other	Increasing number flexibility providers, limited number of flexibility categories, widely available price information

Given the monopolistic characteristics of flexibility procurement for network and system management purposes, in the future smart grids environment the role of the DSOs is extended with an additional task related to flexibility: the procurement of flexibility services for network management tasks, notably by involvement of DER in congestion management. This specific task fits in the current legal framework, since article 25 (7) of Directive 2009/72/EC allows for the involvement of DER ‘that might supplant the need to upgrade or replace electricity capacity by the distribution system operator’.

Furthermore, DSOs should -in line with their current market facilitation task- collect and provide processed of information on network constraints to market participants. Market participants need this information on a more frequent basis, given the consequences of (increased) deployment of congestion management at distribution level for portfolio optimization and imbalance settlement, which have to take into account spatial constraints. This role follows naturally from article 25 (3) of Directive 2009/72/EC which obliges DSOs ‘to provide system users with the information they need for efficient access to, including use of, the system’.

Both tasks clearly depend on the distribution network at hand; distribution networks are heterogeneous and constructed given different generation and demand characteristics such as different penetration levels of DER and differences in geographic distribution of resources.[9] Especially in member states which face a substantial penetration of DER and many small-scale prosumers, DSOs may have to resolve network congestion increasingly in the operational phase and sometimes emergency generation curtailment may have to take place to maintain network reliability and system stability. In those distribution networks, DSOs have to operate more complex systems requiring additional market facilitation services as well as procurement of flexibility services

[9] Indeed also different network characteristics such as operation at different voltage levels and different network topologies may result in different types of roles for DSOs. However, these network characteristics result in less clear cut distinctions between DSOs than the generation and demand characteristics outlined above.

for network management tasks. In other member states, the uptake of DER proceeds less fast and therefore additional tasks related to congestion management and curtailment issues will be rather an exception for DSOs, at least for the time being.

5.3 Infrastructure provision for electric vehicles

5.3.1 Introduction

As indicated in Section 4.3, several actors may play a role in the provision of electric vehicle (EV) charging infrastructure. Below we discuss first the market for this infrastructure, followed by a discussion of the advantages and disadvantages of providing a role in infrastructure provision to either regulated DSOs or commercial market actors, such as charging infrastructure operators.

From a consumer point of view, there are broadly two types of infrastructure services, which are dependent on the charging velocity and are related to different technologies: normal and fast power recharging points respectively. EC (2013b) defines a normal power recharging point as “a recharging point that allows for a transfer of electricity to an electric vehicle with a power of equal or less than 22 kW excluding devices with a power of less or equal to 3,7 kW, which are installed in private households or whose primary purpose is not recharging electric vehicles, and which are not accessible to the public”. Likewise, a fast recharging point “means a recharging point that allows for a transfer of electricity to an electric vehicle with a power of more than 22 kW”.[10] Additionally, vehicle to grid (V2G) infrastructure services could be provided as it is foreseen that electric vehicles “could contribute to the stability of the electricity system by recharging their batteries from the grid at times of low general electricity demand and feeding power from the batteries back into the grid at times of high general electricity demand” (EC, 2013b, recital 13). Given the EU mandate to standardise infrastructure to ensure its interoperability for electric vehicles (EC, 2010) and the additional EU requirements for enhanced interoperability of recharging points (recital 26 of EC, 2013b) it is assumed that the number of infrastructure service categories remains limited in the future.

5.3.2 Assessment of competitive and monopolistic characteristics

Concerning the nature of EV charging infrastructure, Ruester *et al.* (2013) note that “EV charging infrastructure does not inherit cost structures that would lead to a natural monopoly (that is, sub-additivity of costs is not given), nor can under-provision due to a notion of public goods be expected, given that there is a sufficient amount of EV users and demand for charging stations.” If subadditivity of costs is not given, this implies that economies of scale and scope are limited since those are the main sources of cost subadditivity. Hence, installation of EV charging points by several firms is not more expensive than installation by one firm. Indeed, under assumption that a presumed public good characteristic is not likely for EV charging, since the consumption of charging services by one person may diminish the consumption by someone else (‘rivalry’) and one can easily exclude people from using a charging point if they do not pay (‘excludability’). Hence, EV charging points do have characteristics of a private good implying that free-riding by third parties on investments in EV charging points is limited, given the condition stated above.

Furthermore the infrastructure market for EV charging points is characterized by a high number of technology providers at the supply side, as well as many (potential) installers and/or operators of charging points at the demand side, including DSOs, commercial actors such as suppliers, charging infrastructure operators, aggregators, e-mobility providers, and public entities, amongst others local

10 See Article 2 of the proposed Directive (EC, 2013b).

governments and public lighting companies. Entry and exit barriers to EV charging infrastructure provision appear to be limited and transaction costs for finding a trading partner appear to be relatively low. Commercial actors usually have also wide experience with developing customer oriented retail processes as well as with market segmentation (prioritizing customers with highest charging demands).

All in all, the market for EV infrastructure provision has many competitive features. However, in practice public intervention should not be ruled out for two reasons (Ruester *et al.* 2013). First, a "chicken-and-egg" problem exists; there will be no incentives to invest in charging stations if the penetration of EVs is limited, and the other way around, there will be no demand for EVs if charging stations are absent. Second, investments in charging stations do have positive external effects (Ito *et al.* 2013). Charging stations do not only have direct gains but also create indirect benefits as they increase the travelling distance for all vehicles. Both arguments apply only at the initial uptake of the EV charging infrastructure. These problems will diminish after passing a certain threshold of charging stations at several suitable locations.

Finally, it is argued that the provision of charging infrastructure in public areas involves higher risks and therefore should be regulated (Gomez *et al.* 2011; Ruester *et al.* 2013). Given that in practice private entities are active in sectors that carry much higher business risks than the energy sector, such as telecom and aviation, we consider this argument not a strong reason for regulation. Of course, business risks are lower in a regulated environment as the default risk of regulated actors is lower than that of private actors, implying that the required rate of return is lower and consequently the business case for EV charging infrastructure is (more) economically viable. However, in the extreme this would mean that all tasks which are currently in the private domain should instead be regulated as this would diminish the business risks of firms and therefore increases their economic viability. Consequently, we are not convinced that this constitutes an additional reason for regulation of charging infrastructure for EVs.

Taken together, there is a reasonable argument for public intervention in the initial phase of market uptake for mitigating the "chicken-and-egg" problem as well as for internalizing the positive externalities of investment decisions in EV charging infrastructure. This is already acknowledged by a proposal for new EU legislation requiring the build-up of a minimum infrastructure of charging points for electric vehicles with sufficient coverage, at least twice the number of vehicles, and 10% of them publicly accessible, especially in urban agglomerations before the end of 2030 (EC, 2013b). After a minimum infrastructure of charging stations has been built-up, public intervention is no longer required. Hence, interventions should not last for a long or unspecified time period; it is advised either to limit the intervention period beforehand or to plan already a future evaluation moment before the intervention starts.

5.3.3 Roles for the DSOs

Table 5-3 shows the results of the assessment of monopolistic and competitive characteristics of infrastructure provision for electric vehicles.

Table 5-3 Monopolistic and competitive characteristics of infrastructure provision for electric vehicles

Monopolistic characteristics	Public good characteristics	None
	Economies of scale and scope	Limited economies of scale, some economies of scope
	Other externalities	Chicken-and-egg problem, positive externality on travelling distance of all EV
Competitive characteristics	Incentives for innovation	High number of technology providers
	Customer orientation	
	Other	

Given the identified market failures and externalities, public intervention is necessary in the market uptake phase. However, because EV charging infrastructure does not have the characteristics of a natural monopoly, public intervention regarding this service does not have to be the exclusive remit of DSOs but in principle can be assigned to a range of stakeholders. In this context Ruester *et al.* (2013) rightfully note that public intervention "must not necessarily result in public or DSO ownership of charging stations. Alternatively, also competitive tenders for infrastructure roll-out or subsidizing pre-qualified private entities can kick-start EV adoption". Section 6.4 provides an assessment of possible DSO and competitive market structures, including its barriers and risks. Given that market failures and externalities are envisaged to be present in the market uptake phase only, it has to be noted that only in this phase public intervention is deemed necessary.

Independent of the choice for DSOs or market actors in charge of EV charging infra, DSOs do have the following (additional) roles; (1) supervise the consequences of additional charging points for grid reliability and the need for additional network capacity like for regular grid connections; and (2) provide proactively information on potential network constraints for EV charging points to multiple market players. The other way around DSOs should be informed in advance of proposals for new charging points in the grid. In that way they are allowed to prepare themselves adequately for adjustments in network planning and/or operation.

5.4 Ownership & management of metering equipment

5.4.1 Introduction

Many customers at Low Voltage (LV) and Medium Voltage (MV) levels do not yet dispose of smart meters. Smart meters can offer important benefits to network operators, suppliers and aggregators, which will be partly passed on to customers. Benefits of smart metering include the reduction of energy consumption due to behavioural changes as a result of more accurate information for small customers on their energy consumption, easier supplier switching, cost savings in meter operation due to remote meter reading, and savings of call centre costs. Furthermore, smart meters partly enable the exploitation of demand response and potential generation flexibility behind the meter.

Ownership and management of metering equipment will influence the roll-out of smart meters, and hence the realization of benefits by both commercial market actors as well as regulated network operators. This stresses the importance of an appropriate system structure that allows for realization of maximum benefits for society with functionalities of smart meters i.e. the surplus ('the size of the cake') as well as for a fair distribution of benefits and costs within the value chain ('the slice of the cake').

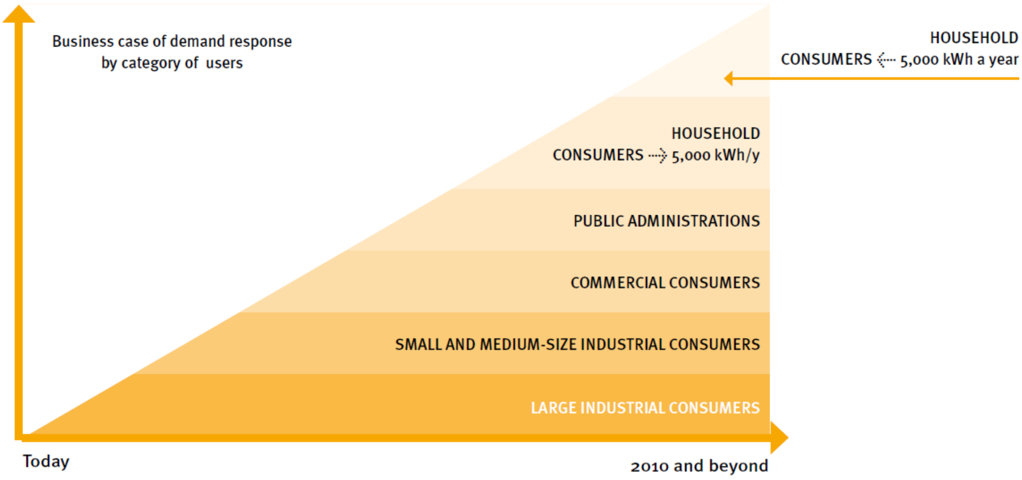
5.4.2 *Assessment of competitive and monopolistic characteristics*

Concerning the nature of the services related to the ownership and management of metering equipment, as said before there are basically two options: a regulated model or a liberalized model. Based on Ruester *et al.* (2013) these models can be defined as follows. The regulated model (applied in most EU countries) treats metering services as part of the regulated tasks of the DSOs. The regulator sets the rules according to which smart meters can or have to be installed, together with the methodology to remunerate the parties that incur the costs. Usually costs are socialized through network charges. In the liberalized model (e.g. applied in Germany and the UK) some or all metering services are open to competition and installation of smart meters is left to the initiative of market agents. Although the costs of these meters are initially financed by market agents, they are transferred to the ultimate beneficiary (i.e. the customer) through top-ups on electricity prices or as a non-recurrent expense. For example, in the UK smart meters will be funded by suppliers.

Irrespective the definition of the two models, we will first evaluate the competitive and monopolistic characteristics of ownership and management of metering equipment using the evaluation criteria defined above. Subsequently, we will link those characteristics to the choice between both models. Competition may be preferred for the following reasons. First, there are potentially many sellers (technology providers) and buyers (supplier, DSO or third party) of smart meters. Hence, there is competitive pressure to provide a good meter at a reasonable price. Second, provided a sufficient level of standardization of smart meters is realized through EC mandate M/441 for utility meters, competition is more conducive for innovation as it allows for selection by the market of best suited technological solutions instead of choosing a 'winning' technology early in the innovation chain. Competition may also support the development of a broader range of metering solutions. Third, competition leaves the decision to install a smart meter to the customer. When customers are not convinced of the benefits, they are not obliged to have a smart meter installed and hence they do not have to pay for such a meter.[11] Market actors probably also will perform market segmentation for roll-out of smart meters, i.e. given fixed costs of a smart meter selecting first the category of network users with flexibility potential against lowest marginal costs, followed by a category of network users with flexibility potential at somewhat higher marginal costs, etcetera (see Figure 5.2). Hence they may be able to make the same flexibility potential available against lower costs.

[11] For the countries with a liberalized model, Germany and the UK, holds that despite competition there are some legal obligations at system level for roll-out of smart metering. In Germany certain obligations are already in place by law, although it is not yet clear how the roll-out will be financed. In the UK, there is an obligation on all gas and electricity suppliers to take reasonable steps to complete the roll-out of smart metering by the end of 2020. However, there rest no legal obligation on individual consumers to have a smart meter. Smart meters are funded by suppliers and hence by individual customers as beneficiaries. Furthermore, also countries that apply the regulated model sometimes apply a (partially) voluntary deployment strategy. This includes Malta, Sweden, Italy (partially), Denmark (partially), and the Netherlands (possibility to opt-out). In contrast with the UK situation, in the latter group of countries customers that do not want a smart meter have to pay for the smart meters as metering costs are socialized.

Figure 5.2 Business case of demand response by category of users



Source: Eurelectric, 2011.

However, there are also a number of reasons that would support public intervention:

1. For the realization of economies of scale and scope a coordinated large-scale roll-out is preferred as it will limit the costs; meters will be installed street-by-street rather than on-demand by a supplier or aggregator. Moreover, a large scale roll-out allows for the realization of synergies with other DSO tasks such as network operation;
2. A mass roll-out will be very favourable for making available demand response potential in support of flexibility services earlier than under a competitive approach;
3. Without regulatory intervention there is a high risk that the roll-out of smart meters depends on the perspective taken by the market actor or network operator; the market operator may ignore the wider system benefits of the utilization of smart meters, while the network operator may ignore the potential commercial benefits in the absence of adequate regulation. Such a partial investment evaluation may induce too low investments in smart meters;
4. In case of a black-out in a grid with a high penetration of local generation the restoring of the system will be more complicated than in a traditional grid. The DSO will need to coordinate the reconnection of DER and of end-users. If a large proportion of generation is located behind the smart meters the DSO will need to operate the break facility in these meters to facilitate a secure restart (a possibility of which the DSO should inform relevant actors in advance);
5. In case of critical or emergency conditions load shedding might be required. In such an emergency situation, being a threat to the security of supply, the DSO would need the possibility to respond at the level of end-users by remotely disconnecting (parts) of the load, i.e. (partly) shutting-down customers.

5.4.3 Roles for the DSOs

Table 5-4 shows the results of the assessment of monopolistic and competitive characteristics of ownership and management of metering equipment. First of all, there is no evidence of a natural monopoly. At the same time there are different externalities, although the size of the externalities did not become clear during this research.

Table 5-4 Monopolistic and competitive characteristics of ownership & management of metering equipment

Monopolistic characteristics	Public good characteristics	None
	Economies of scale and scope	Some economies of scale and scope
	Other externalities	Positive externality on flexibility supply, positive externality ('enabler') for other system segments, potential possibility for better recovery of system with prosumers
Competitive characteristics	Incentives for innovation	High number of technology providers
	Customer orientation	Possibility to leave decision to install a smart meter to customers
	Other	

Therefore, it is important to determine under which circumstances and to which extent public intervention would outweigh the benefits of competitive action and possible government failure . A standard policy instrument to gain insights in the size of external effects is a societal cost benefit analysis (SCBA). Such an analysis is also prescribed by Annex I of Directive 2009/72/EC in order to secure that overall system-wide benefits of smart meters are taken into account. A SCBA can indicate that the social benefits of the deployment of a certain number of smart meters exceeds significantly the private benefits and therefore a regulated model may be preferred. A large scale roll-out prevents too low investments in smart meters and maximizes the surplus for society ('social welfare'), allowing for the realization of the overall benefits of smart meters for both commercial market actors and regulated network operators. Generally, DSOs may then be best placed as existing regulated actors to perform the required investments in smart meters. Alternatively, the SCBA may indicate that the social net benefits of deploying a certain number of smart meters exceeds the benefits to be realized by investors only to a minor extent. In this case, the size of external effects is limited and a liberalized model can be applied wherein investments in smart meters are left to market actors.

SCBAs show quite different results per country, which amongst others relates to differences in the penetration of less or non-controllable DER and the heterogeneity of DSOs in power systems. Power systems with a substantial penetration of less or non-controllable DER do have a higher demand for flexibility and hence demand response, which is partly enabled by smart meters. In these power systems, there is a stronger need for a timely rollout of smart meters which maybe better fulfilled by the regulated model when there are not too many DSOs and therefore economies of scale during roll-out can be realized.[12] Instead, countries with a relatively low penetration of DER and/or many small DSOs can realize less significant economies of scale and scope (i.e. synergies) of a large scale meter roll-out and hence may opt for the liberalized model.

[12] Please note that Germany fulfills the first condition i.e. high demand for flexibility, but probably not the second condition i.e. the high number of DSOs does not allow for economies of scale in smart meter roll-out.

5.5 Energy efficiency services

5.5.1 Introduction

Energy efficiency 'means the ratio of output of performance, service, goods or energy, to input of energy', see Directive 2009/28/EC, article 2. Here we explicitly restrict energy efficiency services to services that reduce the energy consumption over time and hence result in energy savings. This means that demand response services that shift consumption from one moment to another moment but do not result in energy savings over time are not included in the energy efficiency services definition here.[13] The reason is that demand response services are already discussed under flexibility services in Section 5.2.

Energy efficiency is increasingly seen as important for meeting GHG emission reduction targets as well as to reduce energy poverty of low-income energy users. Following the RES-E Directive, member states strive for an improvement in energy efficiency of 20% by 2020. Energy efficiency is generally considered as the first step to realize energy savings in the built environment, before utilization of renewable energy and finally most efficient use of fossil fuels (Trias Energetica concept). Last years, this concept/strategy has been linked to the 20/20/20 goals for the whole energy sector; if less energy is consumed a given amount of energy produced results in a higher percentage of renewable energy as fraction of consumption.

As indicated before, Smart Grids enable the provision and utilization of detailed information which can help to (i) inform consumers and (ii) to identify cost-effective options for energy savings and create new business opportunities for investments in energy savings. Different actors can provide energy efficiency services, including DSOs, suppliers and ESCOs. 'An Energy Service Company (ESCO) may engage in energy supply contracting (ESC) and/or in energy performance contracting (EPC). In the case of ESC, the ESCO "supplies useful energy, such as electricity, hot water or steam to a building owner (as opposed to final energy such as pellets or natural gas in a standard utility contract)" (Wuertenberger et al. 2012). In this way it provides comfort to building users by supplying different services (electricity, DHW, space heating). In the case of EPC, the ESCO delivers turnkey services, providing all the services required to design and implement a comprehensive project at the customer facility, from the initial energy audit through long-term Monitoring and Verification (M&V) of project savings. The ESCO tailors a comprehensive set of measures to fit the needs of a particular facility, and can include energy efficiency, renewables, distributed generation, water conservation and sustainable materials and operations. The ESCO arranges for long-term project financing that is provided by a third-party financing company, typically in the form of a bank loan. The ESCO provides a guarantee that the savings produced by the project will be sufficient to cover the cost of project financing for the life of the project (Seven, 2013).

The main energy efficiency services thus include the supply of comfort, (renewable) energy, and installation of (renewable) energy installations and energy savings measures.

5.5.2 Assessment of competitive and monopolistic characteristics

The nature of energy efficiency services can be characterized as follows. On the one hand, these services do have several competitive features. First, energy efficiency services do have the characteristics of a private good that can be bought and sold in competitive markets (one for each service). Second, entry and exit barriers to the supply of energy efficiency services are limited.

[13] In He et al. (2013), Annex IV (conclusions of public consultation), p. 59 the same distinction between energy efficiency and demand response services is made.

Many small-scale electricians (for installation and maintenance of domestic hot water (DHW) and space heating) and construction companies (for insulation) are already active on the market. Relatively low entry and exit barriers also increase the scope for innovation that often results from the involvement of new actors.

On the other hand, the services do have several monopolistic features. First, economies of scale may be realized by following a street-to-street or district-by-district approach. Besides, some economies of scope might be realized with either provision of metering services by DSOs (given DSOs are often the point of contact for consumers for metering) or provision of renewable energy by suppliers. Second, lack of awareness of consumers of the benefits of energy efficiency measures may lower demand for energy efficiency services to a suboptimal low level, impeding market-based procurement of energy efficiency services. Third, from a societal perspective energy is too cheap, as externalities such as the costs of natural resource depletion, health impacts from pollution, and climate change are not included in the market price for energy. This implies that consumers and project developers do not receive accurate price signals reflecting the true marginal cost of energy use, and demand for energy efficiency services is lower than societal optimal. Fourth, energy efficiency services can imply some positive external effects to other parties than the investors, inducing too low investments in energy efficiency measures since part of the benefits does not accrue to the investor. This cost allocation issue is caused by split incentives. Split incentives occur when the investor who pays for the upfront costs for energy efficiency measures is not the same person who reaps the benefits of lower energy costs. For example in rental properties when there is little incentive for the building owner to invest if the tenant pays the energy bill. Conversely, the tenant may not be interested in an investment into energy efficiency measures either, as he may move out before the end of the payback period. There may also be comparable split incentives, e.g. between project developer and building owner/user in new buildings, where there may be no or little benefit for the developer to incorporate energy efficiency measures, if he does not expect to fully recover the higher initial cost from the building owner/user. Hence, if provision of energy efficiency services is left to market actors without supplementary regulatory measures the positive impact on lowering the demand for network services is ignored in investment decisions. Similarly, in case provision of energy efficiency services is performed by DSOs, the positive impact on diminishing demand for energy by consumers is ignored. Fifth, transaction, measurement & verification costs of EPC projects are high (Wuertenberger et al. 2011). Savings are measured through a comparison between a baseline and post-retrofit energy costs. This comparison is complicated by the baseline which may be difficult to determine with enough accuracy due to a lack of availability of historic data and dependency of the baseline of changes in climate conditions and energy prices. Furthermore, the utilization of the building may change. All in all, there are some clear reasons for public intervention.

5.5.3 *Roles for the DSOs*

Table 5-5 shows the results of the assessment of monopolistic and competitive characteristics of energy efficiency services. Given the monopolistic characteristics of energy efficiency services, there are a number of clear reasons for public intervention. However, the characteristics do not point to a natural monopoly and therefore an exclusive role for DSOs. This implies that several actors may qualify for the provision of energy efficiency services.

Table 5-5 Monopolistic and competitive characteristics of energy efficiency services

Monopolistic characteristics	Public good characteristics	None
	Economies of scale and scope	Some economies of scale
	Other externalities	Lack of awareness of benefits and costs of energy efficiency, negative externalities not included in energy prices, split incentives, high transaction costs EPC projects
Competitive characteristics	Incentives for innovation	Limited entry and exit barriers for technology providers
	Customer orientation	
	Other	

Designating provision of these services to either suppliers, network operators (DSOs) or ESCOs has some advantages or disadvantages depending on the actor chosen. Suppliers may be preferred as this fits into the supplier centric market models with suppliers as the main point of contact for retail market customers. Member states are increasingly implementing this type of market models; CEER (2012a) mentions that in 11 of 22 respondent countries suppliers are already the main point of contact, and recommends remaining member states to implement a supplier centric model since such a model is best reference for ensuring the rights of the consumer. At the same time, it is acknowledged that different, more sophisticated approaches might be needed for accommodating demand response and smart grids developments e.g. leading to a new actor such as prosumers, although processes still should be supplier centric. The UK and France already implemented supplier centric energy efficiency obligation schemes. Furthermore, the provision of energy efficiency services is a possibility for suppliers to diversify their services away from low margin commodities towards services with a higher margin. On the other hand, suppliers may have no intrinsic interest in energy savings by their customers as rigorous energy saving measures will limit their energy supply directly and thus may be in conflict with their core business.[14] Hence, they may limit themselves to provide energy efficiency services to the category of customers that is likely to deliver them net supplier benefits (i.e. the sum of income from energy saving measures and energy supply is positive), rather than providing these services to the category of customers that can realize the highest energy savings.

DSOs can also be selected for provision of energy efficiency services. An advantage is that investments made for these services can be easily recovered by network charges and as such offer a stable basis for financing of energy efficiency obligations. However, at the same time the regulatory support for DSOs is also a disadvantage as the guaranteed margins by regulation provide DSOs a competitive advantage over third parties offering the same services, potentially distorting the level playing field between DSOs and other energy services providers such as ESCOs or suppliers.[15] Hence, policy measures are needed to secure the level playing field between DSOs and other energy services providers. In Denmark, Flanders and Italy energy efficiency obligations lie already with grid companies (Boot, 2009; Wuertenberger et al. 2011; Eurelectric, 2013c). In practice, however, these tasks are largely carried out by commercial companies in Denmark and Italy. In the case of Denmark obliged network operators are not allowed to implement energy saving projects themselves which are therefore carried out by commercial daughter companies (Boot, 2009; Wuertenberger et al. 2011, based upon JRC info), while in Italy DSOs outsource a large part of the obligation to ESCOs or buy Tradeable White Certificates from

[14] Cf. He *et al.* (2013), p. 24, who see the same conflict between the provision of demand response and energy by the supplier.
[15] This argument is also put forward in Annex IV (conclusions of public consultation) of He *et al.* (2013), p. 59.

ESCOs. Besides, without an appropriate regulatory framework DSOs may limit their focus on those consumers that are located in areas where the network utilization is near its maximum in order to realize savings on network investment costs and energy losses by reducing peak demand. Hence, they may ignore those consumers that can most effectively gain large energy savings, but are not critical for network planning and operation. Because of the availability of more effective measures for DSOs, it is questionable whether energy efficiency measures at customer premises are most effective and economical for network operators and hence do outweigh alternative measures like flexibility procurement (including demand response), reduction of technical network losses or conventional network reinforcement.[16] At the same time, in a number of cases (e.g. a residential district with outdated energy inefficient houses which are planned to be renovated as well as a need for replacement of network assets) interests of consumers and network operators may overlap to a major extent.

Finally, ESCOs can provide energy efficiency services as well. An advantage is their independent position since they are usually not involved in network operation tasks such as DSOs and often have more limited market tasks than suppliers, and therefore are likely to have less conflicting interests. Consequently, less policy measures are required to safeguard the public interests. As a result, ESCOs could be preferred to incumbent network operators (DSOs) and suppliers in the provision of energy efficiency services. However, following EC (2012a) it is up to the Member States to decide whether they prefer to designate ESCOs, suppliers or DSOs as obligated parties within energy efficiency obligations schemes.[17]

5.6 Data handling

5.6.1 Introduction

In a smart grid environment several tasks and services will depend on the availability of data provided by the metering equipment installed in the grid as well as at connection points of network users. Data volumes and value of data will increase substantially. Data handling is important for three groups of services; for facilitating "(i) commercial operations, but also for (ii) ensuring a stable system functioning and quality of supply, and (iii) efficient grid planning", Ruester et al. (2013).

Three data models have been discussed within the EG3 Smart Grids Task Force with central roles for the DSO, an independent third party operating a central data hub, and a data access-point manager respectively. In the first model the DSO operates a data hub and provides data to the market through this hub, while in the second model these tasks are performed by an independent entity. In both cases the central actors are regulated as a natural monopoly. In the third model no official data hub exists, but one or more data access-point managers (DAMs) guarantee data access at each meter point. These DAMs can be any certified commercial company. For further background information on the three data models, we refer to EC (2013a).

5.6.2 Assessment of competitive and monopolistic characteristics

The choice for each of the data models depends –amongst others- on the characteristics of the data; are externalities involved in data handling which require public intervention or does e.g. innovation require a more competitive setting? In the following we discuss the different competitive and monopolistic characteristics of data handling.

[16] Such an integrated type of assessment is foreseen by Article 2 (29) of Directive 2009/72/EC.

[17] Although the Energy Efficiency Directive (EC, 2012a) in Article 7(4) establishes that DSOs or retailers might be designated as obliged parties within energy efficiency obligation schemes, this does not exclude the allocation of roles to other actors, see Article 7(9).

First, data handling is non-rivalrous i.e. its use by one entity does not diminish the use by someone else (Ruester et al. 2013). Besides, information goods such as data are to a certain extent non-excludable, depending on technology or law (Varian, 1998). From a technological point of view, data can be consumed at the same time by different actors, such as suppliers and consumers (Ruester et al. 2013). From a legal point of view, following the Smart Grids Task Force Expert Group (EG) 2 it is important to distinguish between personal and non-personal data; "personal data is considered as specific data and can be traced back to the individual consumer whereas non-personal data could be aggregated data and does not contain references to natural persons". Following EC (2012c) "processing of personal data by or within a smart metering system should be legitimate". For privacy reasons consumers own their personal data, and prior to utilization by third parties have to give explicit consent for each value added service, and can withdraw their consent free of charge. Since personal data is the basis for aggregated data which is deployed for the provision and procurement of smart grids services, the legal point of view suggests that data handling is to a certain extent excludable.

Based on these observations, we can distinguish –at least in theory – two different situations. If data is considered as partially non-excludable, data handling should preferably be performed by one regulated entity. Otherwise the benefits of investments in data handling will necessarily be distributed over several actors. This would imply that the investor recovers only part of its investment costs in data handling and investments would take place at a suboptimal level when considered from a societal point of view.[18] If instead, data consumption is considered as fully excludable, market actors can bundle data handling with either network management or energy trading on an exclusive basis. Then, data aggregation or generation can be subsidized and offered as part of a bigger product package (Ruester et al. 2013). However, without regulation this maybe at odds with non-discriminatory third party access to data (see section 6.5 for further discussion).

Second, the data market is a market with potentially many data suppliers and users and low transaction costs, but with limited number of data handlers due to the substantial fixed costs of operating a data platform. Data handling requires investments in data aggregation and data trade. These fixed costs give rise to substantial economies of scale. Realization of economies of scale is determined by the legal possibilities for market entry. If market entry is allowed, two opposing external effects should be accounted for. On the one hand, market entry may have a positive external effect due to a higher valuation by inframarginal consumers of an increased variety in data handling providers. On the other hand, market entry may have a negative external effect on other data providers; they will lose part of their customers, and will experience a revenue loss since the decrease of profit margins is higher than the decrease of production costs. Hence, a trade-off exists between promoting product diversification and competition on the one hand, and exploitation of economies of scale on the other hand (Teulings et al. 2003). In the case of the electricity system, the balance seems to tilt towards the negative external effect since data is primarily an input for the provision of smart grids services and hence its heterogeneous character is limited.[19] This implies that the profit margin resulting from additional data heterogeneity due to market entry may not be sufficient to compensate for the fixed costs of operating a data platform.

The economies of scale and data heterogeneity depend on the proposed data model. In the data model where the data is retained by the DSO, both economies of scale and scope can be achieved. The latter result from synergies of data handling and network operation tasks because for both

[18] The other way around, similar to charging points for electric vehicles, data handling has a positive external effect since the value of a data handling platform increases with the number of consumers and providers of data.

[19] It is primarily the aggregation level of the data that differs: the network operator may need more granular data for network monitoring than the supplier for balancing responsibility. At the same time, data may originate from the same metering points.

tasks data is required. In the data model where an independent and regulated third party operates the central data hub substantial economies of scale can be achieved as well. However, in the model with a central role for one or more data access point managers the economies of scale are lower, since several DAMs may use the same data to compete for delivering their services to grid users.

Third, depending on the data model innovation incentives will vary; in case of a monopolistic regulated entity, as in data models where a regulated actor – either a DSO or third party – is in charge, the innovation incentives are lower than in the model with commercial data access point managers operating in competition.

Fourth, smart grids and smart meters also produce data (with a frequency) not directly necessary for the management or planning of the grid. This extra information is potentially useful for the customer or the supplier. It could also be anticipated that the amount of additional information will grow as market forces are trying to satisfy yet unknown needs of customers. This data offers value for the development of (new) services which can be offered to customers. Because of their innovative nature, a competitive market is highly suitable to explore and utilize this potential value. Similar to the point above, innovation incentives in data utilization are lower when a regulated actors handles data as opposed to competition.

Fifth, in the current situation government failures are limited since current regulation around data handling is limited. However, the lack of adequate guarantees on privacy and the use of smart metering data may be considered as a policy failure, which hinders the take-up of smart metering.

All in all, a mixed picture emerges from the analysis above. On the one hand there are clear reasons for public intervention notably the public good character of data, and economies of scale and scope in data handling. On the other hand, innovation incentives are likely to be stronger in a competitive environment.

5.6.3 Roles for the DSOs

Table 5-6 shows the results of the assessment of monopolistic and competitive characteristics of data handling. Several market failures such as public good characteristics and economies of scale indicate a clear need for public intervention, while some characteristics of a natural monopoly (non-storability and location rents) are absent. At the same time there are some strong competitive characteristics like the prospect of product diversification if market entry would be allowed. As a result, both regulated and commercial stakeholders could play a central role in data handling. Strengths and weaknesses of the three described data models will be discussed in more detail in Section 6.5.

Table 5-6 Monopolistic and competitive characteristics of data handling

Monopolistic characteristics	Public good characteristics	Non-rivalrous, (partly) non-excludable by legislation
	Economies of scale and scope	Substantial economies of scale
	Other externalities	Lack of adequate guarantees on privacy and use of smart meter data, data security
Competitive characteristics	Incentives for innovation	Many suppliers and users, market entry may promote product diversification
	Customer orientation	
	Other	Low transaction costs

5.7 Summary of new or extended roles for the DSOs

Five smart grids services have been identified and have been consecutively assessed for their fit with a regulated or a competitive environment. Table 5-7 summarizes the scores of the services and allows for identification of similarities and differences between them.

Table 5-7: Summary of monopolistic and competitive characteristics of five selected Smart Grids services

		Flexibility services	*Infrastructure provision for electric vehicles*	*Ownership & management of metering equipment*	*Energy efficiency services*	*Data handling*
Monopolistic characteris-tics	Public good characteristics	Network and system management are public goods	None	None	None	Non-rivalrous, (partly) non-excludable by legislation
	Economies of scale and scope	High economies of scale	Limited economies of scale, some economies of scope	Some economies of scale and scope	Some economies of scale	Substantial economies of scale
	Other externalities	Other characteristics of natural monopoly (non-storability of electricity, location rents, direct connections to customers)	Chicken-and-egg problem, positive externality on travelling distance of all EV	Stimulates flexibility supply, positive externality (‘enabler’) for other system segments, potential possibility for better system recovery of system with prosumers	Lack of awareness of benefits and costs of energy efficiency, negative externalities not included in energy prices, split incentives, high transaction costs EPC projects	Lack of adequate guarantees on privacy and use of smart meter data, data security
Competitive characteris-tics	Incentives for innovation	Large potential for flexibility supply, ICT allows for aggregation of small flexible DER	High number of technology providers	High number of technology providers	Limited entry and exit barriers for technology providers	Many suppliers and users, market entry may promote product diversification
	Customer orientation		Experience with market segmentation and customer oriented retail processes by commercial actors	Possibility to leave decision to install a smart meter to customers		
	Other	Increasing number flexibility providers, limited number of flexibility categories, widely available price information				Low transaction costs

The **procurement of flexibility services** for network purposes shows several monopolistic characteristics i.e. characteristics of a public good, economies of scale and other externalities which together make it part of the natural monopoly of a DSO. Therefore, in the future smart grids environment the role of the DSOs should be extended with the procurement of flexibility services for network management tasks, notably by involvement of DER in congestion management. In this way it allows for active network management while network investments that are likely to be inefficient can be postponed or avoided. This specific task fits in the current legal framework, since article 25 (7) of Directive 2009/72/EC allows for the involvement of DER 'that might supplant the need to upgrade or replace electricity capacity by the distribution system operator'. Opposite to procurement of flexibility services, provision of flexibility services is clearly a task for market actors due to its competitive characteristics.

Data handling is characterized by public good characteristics, economies of scale and other externalities, but also by higher innovation incentives in a competitive environment. Since data handling does not constitute a natural monopoly, in principle data handling is not necessarily to be performed by a DSO but could also be performed by other regulated or commercial stakeholders. At the same time there is a very clear need for public intervention.

Infrastructure provision for electric vehicles, **ownership and management of metering equipment**, and **energy efficiency services** show no public good characteristics and limited or uncertain economies of scale and scope, but at the same time also exhibit some important externalities. Therefore, public intervention maybe beneficial, depending on whether positive effects of public intervention do outweigh potential negative effects of public intervention on innovation and customer orientation.

For **infrastructure provision for electric vehicles** holds that the chicken-and-egg problem as well as the realization of the positive externality of EV charging points on the travelling distance of all EV users imply that public intervention is desirable, although only in the initial stages of EV uptake. In principle both DSOs and market actors can play a role in this stage. After the market uptake phase, there is no need any more for public intervention and the task should be left to market actors.

Concerning **ownership and management of metering equipment**, economies of scale and scope and positive externalities of installment of smart meters for making available the demand response potential point to a need for public intervention. On the other hand, high prospects for further technology development as well as efficient market segmentation point to a competitive approach. The size of external effects should be assessed through a societal cost benefit analysis (SCBA) to determine under which circumstances and to which extent the benefits of public intervention would outweigh the benefits of competitive action. In case benefits of the former do outweigh the latter, DSOs can play a role, while in the opposite case a role for suppliers is most logical.

Concerning **energy efficiency services**, its monopolistic characteristics indicate a number of clear reasons for public intervention including split incentives between building owners and tenants, negative externalities such as resource depletion that are not included in the energy market price, and spillover effects to other parties than the investors inducing too low investments in energy efficiency measures. However, the characteristics do not point to a natural monopoly and consequently an exclusive role for DSOs, implying that also other actors such as suppliers and ESCOs may qualify for the provision of energy efficiency services.

Given the different starting points of DSOs – both within and across member states – with respect to the penetration of DER, the amount of small-scale prosumers and the different network management philosophies, the extent to which DSOs have to fulfill new roles or have to expand existing roles differs widely. Broadly two categories of DSOs can be distinguished; (1) DSOs that are responsible for complex systems; and (2) DSOs responsible for less complex systems. DSOs in member states with a higher penetration of DER and a higher number of small-scale prosumers (i.e. more complex systems) are likely to perform already the initial steps of active network management, while DSOs in member states with a lower penetration of DER may still operate their network on the basis of passive network management. Therefore, for the DSOs that manage more complex systems the number of new roles may be lower and the extension of existing roles higher, than for the DSOs that manage more conventional type of distribution systems.

Finally, the role of DSOs also depend on the market structures in which they operate. Chapter 6 will assess the role of DSOs in Smart Grids services in two different market structures, in order to provide more clarity on the choice between a DSO or a market-oriented role.

6 Task 3: Analysis of DSO tasks in the context of different market structures

6.1 Introduction

In Chapter 5, based upon the monopolistic and competitive characteristics of tasks and services, it was discussed whether or not tasks around future smart grids services are in the remit of DSOs, could be potentially provided by DSOs, or are probably out of scope for DSOs. The tasks of the DSOs were discussed while taking into account the heterogeneity of DSOs related to their operation in either a complex or a less complex system. As discussed in Chapter 5, a complex system exhibits a higher penetration of DER, a higher number of small-scale prosumers, and the application of (first stages of) active network management. The less complex energy system exhibits these features to a far lesser degree or not at all.

Another important dimension influencing the tasks for DSOs are the market structures. For that reason, we evaluate in this chapter the DSO tasks in the context of two different market structures; a DSO oriented market structure and a liberalized market structure where (part of the) tasks are assumed by market actors.

In Section 6.2 first two fundamentally different energy market structures are identified. We evaluate the effects of each market structure for three selected Smart Grids services that may or have to be provided by DSOs. For each Smart Grids service we identify the specific barriers and risks (regulatory, financial, market complexity etc.) within each market structure. Section 6.3 discusses market structures for flexibility services, Section 6.4 infrastructure provision for electric vehicles, and Section 6.5 data handling. Section 6.6 concludes and derives policy implications.

6.2 Definition of two different market structures

Two fundamentally different, but generic market structures can be distinguished; a DSO and a liberalized market structure respectively.

In the framework of the **DSO market structure** it is assumed that services are organised in the following way;

- *Uncoordinated procurement of flexibility services*, DSOs procure flexibility separately from the market by bilateral contracts with network users or through own flexibility platforms;
- *The integrated infrastructure model* of network infrastructure and publicly accessible EV charging points, with DSOs as owner and operator of EV charging points (only technically, or both technically and commercially);
- *The regulated DSO or CDH data handling model* where either the DSO or an independent entity operates a data hub and provides data to the market.

In the framework of the **liberalised market structure** it is assumed that services are organised as follows;

- *Coordinated procurement of flexibility services*, integrating demands from regulated network operators and commercial market actors respectively;

- *The independent e-mobility model*, where e-mobility service providers assume the publicly accessible charging infrastructure activities. New connection points for charging stations are treated as any other new connection points to the distribution grid.
- *The liberalized DAM model* wherein no official data hub exists, but one or more data access-point managers (DAMs) guarantee data access at each meter point. These DAMs can be any certified commercial company.

Market structures of ownership and management of metering equipment as well as energy efficiency services are not discussed. For ownership and management of metering equipment holds that an advanced discussion on market structures has already taken place and Member States have already taken their positions. For energy efficiency services holds that only limited literature on different market structures is available, hence there is insufficient basis for a fruitful discussion.

The analysis of the market structures in the remainder of this chapter should be considered as a first step of the barriers and risks of different market structures. A detailed analysis of market structures falls outside the scope of this report. We refer to several ongoing EU & national (stakeholder) projects that are aiming to explore and discuss some of the envisaged Smart Grids services in more detail. One example is the FP7 Green e-motion project for electric vehicle charging infrastructure.

6.3 Flexibility services

6.3.1 Definition of market structures

Two types of market structures for flexibility procurement can be distinguished; separate DSO procurement as an example of the DSO market structure and coordinated procurement as an example of the liberalised market structure. A distinction can be made between aspects that are similar for both market structures and aspects that are different. We first highlight some common aspects that are assumed to be valid in both market structures andsubsequently elaborate on the specific issues and risks of the separate and coordinated procurement market structures.

Common market structure aspects

The role of DSOs in flexibility procurement is ex-ante limited by two types of conditions:

(1) Technical and economic restrictions to flexibility procurement;

(2) Legislation to guarantee transparent, non-discriminatory market facilitation role of DSOs.

Technical and economic restrictions to flexibility procurement

Although better day-to-day network operation will become more important in the future smart grids, deployment of flexibility services is not always technical feasible and/or economic efficient for four reasons. First, distribution networks should dispose of sufficient equipment for remote monitoring and control and do have a transmission function (i.e. meshed operated networks with single contingency redundancy) (Hakvoort et al. 2009). Meeuwsen (2007) expects that MV networks may be increasingly meshed (or ring shaped) operated since this type of operation provides possibilities for rerouting of energy flows and more optimal use of existing distribution assets. Hence, flexibility services may be deployed in networks with a voltage level of 20 kV or higher i.e. in HV and part of the MV networks. Second, Kok (2013) notes that the number of network nodes and connected actors is much larger in distribution networks than in transmission networks, resulting in a heavier computational burden if a large number of network constraints has to be accounted for. Hence, smart algorithms are needed to select the most relevant network constraints. Third, the difference between demand and supply in the regional network to be overcome by congestion management should not be too large to prevent long periods of standstill of production facilities which with concomitant monetary costs. Integrated assessments such as SCBA should allow for finding the optimal amounts of network reinforcement and congestion management. Fourth, market power issues in congested areas are likely to occur more often in distribution networks than in transmission networks since the number of market actors that can play an active role to remove the constraint is more limited in distribution networks than in transmission networks. Hence, the number of market agents should be not too small. All these conditions should be taken into account, independent of the type of market structure chosen for flexibility procurement by DSOs.

Legislation to guarantee transparent, non-discriminatory market facilitation role of DSOs
DSOs will be involved in commercial tasks when they purchase services with economic value from commercial stakeholders. As purchasing commercially provided flexibility services by DSOs may affect market prices this may be considered against the legal unbundling requirement for DSOs as defined by Article 26 of Directive 2009/72/EC which requires legal, organizational (functional) and operational (staff) separation of distribution tasks from other tasks in the supply chain. However, as TSOs, despite often stricter unbundling requirements as stated by Directive 2009/72/EC, are allowed to procure system services (balancing as well as congestion management services) in competitive markets, this clearly illustrates that unbundling requirements do not have to be a show stopper for DSOs in purchasing services from commercial stakeholders, such as aggregators, suppliers, ESCOs, producers and consumers. A precondition is that, like the procurement of balancing services by TSOs, DSOs' procurement of services from commercial stakeholders is supervised by the regulator to guarantee that the procurement is transparent, non-discriminatory and neutral and does e.g. not favour the incumbent supplier with which the DSO could be vertically integrated. This requirement holds independent of the type of market structure chosen for flexibility procurement by DSOs.

Diverging market structure aspects

Two types of market structures for flexibility procurement can be distinguished;

1. **Separate DSO procurement** is characterised by a lack of coordination between regulated network operators such as DSOs and market solutions for suppliers and BRPs, which results in separate DSO flexibility procurement;
2. **Coordinated procurement**: for aligning private interests of network operators and commercial market actors, flexibility procurement is coordinated between DSOs, TSOs and market actors, either by the regulator or market, thus achieving system optimization.

Separate DSO procurement

DSOs can procure flexibility services in different ways: either by procurement auctions or flexibility platforms (Ruester *et al.* 2013, Eurelectric, 2013a), direct contracts between DER and DSOs, as well as through indirect contracts between DER aggregators and DSOs. Variable network access contracts (Jamasb *et al.* 2005; Eurelectric, 2013a) are either direct or indirect and can be considered as a sophisticated variant of the former. Text box 6.1 discusses these options in more detail.

Box 6.1 Options to guarantee transparent, non-discriminatory market facilitation role of DSOs

Procurement auctions are already common for TSOs that procure balancing services. Eurelectric (2013a) proposes specific auctions for procurement of flexibility services from network users (DG and load) via flexibility platforms in order to solve network constraints for DSOs and TSOs, as well as the provision of balancing services for the TSO. Such platforms are intended to allow small DER to make flexibility available through aggregation and are especially suited for the yellow system state, i.e. when a network congestion is emerging. Given network congestion, flexibility platforms should account for the location of the offers, as flexibility provided ‘behind the constraint’ in the network is especially useful for the DSOs to deploy.

Variable network access contracts can be contracts with DG or load (aggregators) for a non-firm connection. Current network access contracts are by definition entirely firm given connection obligations for network operators. Since the full capacity of a connection is used seldom by variable generators, the marginal capacity will be used for only a few hours a year. In case the marginal capacity, say the final 5%, is non-firm in infrequent situations with high simultaneity of peak production of DG and low local demand, the need for network capacity may exceed the available network capacity. If DG reduces their output in these infrequent situations, which are expected during only a limited number of hours a year, network capacity can be used more efficiently. The network capacity costs that can be saved, translate into relatively lower connection costs for all network users.

Furthermore, limits to peak production during a few hours a year ‘would be more than offset by an additional DG output in all other hours due to a higher installed DG capacity up to a certain point where the cost of net losses and curtailed generation become relevant to justify network reinforcement’, Eurelectric (2013a). Given a variable access contract, direct contracts between DSOs and network users as well as indirect contracts between DSOs and aggregators (‘flexibility platforms’) are possible.

Direct or indirect contracts are also particularly suited for the yellow state. DSOs could contract larger DER directly to allow for better utilization of existing distribution assets and hence to defer network investments. Another option for DSOs is to contract smaller DER indirectly through aggregation.

Coordinated procurement

It is assumed that the procurement of flexibility by DSOs and commercial market actors is coordinated. Text box 6.2 discusses two different options to realize this coordination, given the current unbundling legislation of Directive 2009/72/EC. Coordination in flexibility procurement is secured either by an independent market actor such as a power exchange or through regulatory supervision.

Box 6.2 Options to secure coordination between market and network actors for achieving an optimal overall system result

In order to secure an optimal system-wide solution, coordination can be established in at least two different ways.

Possibility 1: Regulatory rules for sharing of flexibility potentials

First of all, in Germany a method is being developed for sharing the flexibility potentials of interruptible load over network operators and market agents.[20] The method assumes that the total interruptible load capacity is higher than the interruptible load capacity required by DSOs; the remainder is available for the market. The method foresees a substantial role for the regulator in securing a minimum amount of interruptible load capacity available for market participants as well as a maximum to security of supply interventions (red system state). In fact it is left to the regulator to issue rules to divide scarce demand response flexibility over market participants and network operators.

Possibility 2: Deploying an auction platform for market-based flexibility sharing

Another possibility is using an auction platform for the provision of flexibility services to both network operators and market participants. It is essentially applying the implicit auction method that currently is

[20] The description of the German method is based upon comments received from Bundesverband Neuer Energieanbieter to an earlier version of the report.

used in transmission networks to distribution networks at MV and HV level that are technical suitable and can be cost-efficiently prepared for congestion management. An implicit auction allows for optimising the use of flexibility for both market and network purposes in a single step (i.e. a single market), allowing for directly comparing the bids of both stakeholders, so that flexibility is used where it is most valuable. Given the competition for provision of flexibility between network operators and market participants, for the management of these type of auctions an independent stakeholder like a market operator is required.[21]

In an implicit auction (e.g. using zonal or nodal pricing) the available network capacity is included as restriction in the optimization algorithm (run by the market operator) for electricity trading. This results in an implicit price for network capacity when insufficient, and only bids that are most cost-efficient in terms of both electricity price and network capacity are successful. Disparities between local and national situations are explicitly and immediately reflected in prices that differ between regions instead of corrected afterwards with a separate congestion management scheme which causes the possibility for conflicting signals and actions. Such implicit auctions are already common practice in both cross-border electricity markets, as well as within countries participating in the Nordic electricity markets on transmission level.

Comparable with other auctions, regulatory supervision of such auctions is required for transparency reasons as well as for limiting the number of auction platforms for efficiency reasons. Concerning the latter, auction platforms do have substantial fixed costs and hence economies of scale, which provides them with a monopolistic characteristic. Hence, regulatory supervision should not be limited to transparency issues but also to prevent too many auction platforms that increases the amount of costs to be recovered from society.

Coordination between DSOs and TSOs

Coordination among TSOs and DSOs prevents potential conflicts that may harm system security, decrease system efficiency or leave the economic viable flexibility potential of DER unused, deteriorating its business case. Coordination to secure sound competition between active DSOs and TSOs for the same congestion management and balancing services may take different forms, see text box 6.3.

Box 6.3 Options to secure coordination between DSOs and TSOs

Batlle and Rivier (2012) distinguish basically two types of system designs that allow for coordination. First, the DSO could procure services to satisfy its own needs and procure services also on behalf of the TSO. Second, both system operators could procure services simultaneously.

In the first case, the DSO may procure services for the TSO from several distribution networks, in order to find the cheapest sources within a larger geographical area. For that purpose, Ruester *et al.* (2013) foresee protocols for DSO-TSO interaction which are hierarchal and where the TSO is the final responsible system operator. TSOs and DSOs are allowed to procure their flexibility services first from transmission networks and distribution networks respectively, and subsequently the TSO can procure services from distribution networks, which have to be agreed and executed by the DSO.

An alternative solution could be the implementation of one common auction platform for DSOs and TSOs operated by an independent market operator. Both DSOs and TSOs have to report all network constraints to the market operator such that prices for balancing services reflect these constraints at those times they apply. Some offers of flexibility services providers would be less attractive for DSOs or TSOs due to the location of the providers in the network (see for more information Ramsey et al. (2007a)). Equally, some

[21] Note that in the context of procurement of DER resources by DSOs, Ruester *et al.* (2013) suggest procurement auctions with a single buyer for each region i.e. the DSO. Instead, here we suggest auctions that are not one-sided but do have both network operators and suppliers as buyers.

bids are spatially constrained since DSOs operate different regional networks and hence do have a specific regional demand for flexibility services. A common auction platform may allow for optimal solutions during green and yellow system states, assuring that the cheapest sources within the relevant geographical area (as bounded by network constraints) are found for each system operator. Furthermore, it helps to guarantee a transparent and neutral procurement process that prevents that either DSOs or TSOs could unduly benefit, easing regulatory oversight.

Finally, regulatory supervision will have to guarantee that flexibility services are available for DSOs for procurement of flexibility services at all times; otherwise they cannot count on these services for their day-to-day grid operation and system operation. Likewise is the case in system balancing, both DSOs and TSOs need to have access to some residual flexibility services for securing short-term reliability and system stability in emergency (force majeure) situations. Given the need for very fast actions during such emergency situations, DSOs and TSOs should dispose of possibilities for direct intervention in electricity production or consumption.

6.3.2 Assessment of barriers and risks

As in the preceding paragraph, a distinction can be made between barriers and risks that are similar for both market structures and those barriers and risks that are different. We first discuss some major barriers and risks that are valid in both market structures. Subsequently, we discuss the barriers and risks for the separate and coordinated procurement market structures separately.

Common barriers and risks

Lack of sufficient incentives for investments in conventional network reinforcements

Given the limitations to the deployment of flexibility services in distribution networks as outlined before, also in a Smart Grids environment incentives for conventional network reinforcements remain important. Market stakeholders are sometimes not in favour of such congestion management actions by DSO to limit conventional network reinforcements by smart grids as they fear that network operators will not invest enough in new network capacity.

Lack of effective unbundling of DSOs and commercial market actors

Regulatory supervision may be cumbersome if current unbundling practices are ineffective. In this respect CEER (2013a) indicates that in many countries the process of legal unbundling of DSOs is ongoing, since they did not yet fully transpose the third energy package (including EC, 2009) in national legislation. Furthermore, with new flexibility procurement tasks for DSOs -mainly for those which are situated in a complex energy system- new interactions with new market participants develop, which may aggravate the negative effects of limited unbundling on the level playing field of competing suppliers (Ruester et al. 2013).

Diverging barriers and risks

Separate DSO procurement

Risks due to separate procurement of flexibility services by commercial market actors and network operators

Different procurement auctions or direct contracts are foreseen for different flexibility services (congestion management, balancing services, portfolio management). If commercial market actors and regulated DSOs optimize their flexibility procurement individually, this is likely to result in free riding issues and hence a suboptimal overall system and societal result.

Since flexibility is scarce, stakeholders could reserve flexibility in long term bilateral contracts without use-it-or-sell-it features, which causes two types of disadvantages. First, this would mean inefficient allocation of flexibility since long term in advance it is very difficult to determine whether flexibility is most valuable for either market or network purposes. Second, such contracts have the risk that flexibility may not be deployed for service by actor A, although it would have been used if available for another service by actor B. Hence, the value of the flexibility is lower than in a less fragmented market. These type of situations are likely to occur more often in the future since the need for flexibility is increasingly variable and unpredictable in a system with increasing amounts of intermittent generation.

Dijkstra & Van der Welle (2012) illustrate the effects of the lack of coordination in the case of separate procurement of flexibility services for portfolio management by suppliers and congestion management by DSOs. The starting point is the fact that flexibility is scarce and hence has a price. DSOs will provide demand management signals to consumers based on the local or regional grid state, while retailers will provide demand management signals based on a country-wide uniform electricity price. This can lead to conflicting signals to consumers. An example: Imagine that a region has abundant electricity from renewable energy sources (solar panels and wind turbines) but overall supply is on average, while the demand is high. Since the system-wide demand for electricity is large, the national electricity price is high. Locally, the electricity supply exceeds demand by far; there exists an electricity excess that needs either to be transported to other regions of the country or resolved locally by active network management. We assume the DSO has chosen to deploy active network management instead of passive network management for accommodating emerging network congestion situations that happen infrequently i.e. when the yellow traffic light is on. Hence, as the transformer capacity between the regional MV and national HV network has not been increased, the congestion is resolved in day-to-day grid operation by issuing economic signals to invoke demand response.[22] Hence, the DSO provides the energy management systems of consumers a signal that they will obtain a large premium if they use more electricity in the next couple of hours. However, nearly at the same time the supplier/BRP observes portfolio imbalance and sends a signal to the same consumers to reduce their consumption. This results in part of the earlier demand response action from the DSO being undone. This approach therefore does lead to economic signals that at the aggregate level do not deliver the required reaction by consumers, for neither the DSO nor the supplier. As a result, the distribution system may face a contingency as network overload occurs since the demand response action was not as firm as expected, while the supplier/BRP reduces his portfolio imbalance less than expected with concomitant financial consequences. Furthermore, the combined action is not achieved at lowest cost; the consumers and suppliers involved in the demand response receive, after all, double compensation – once for their contribution to congestion management, and once for their contribution to portfolio optimization. These costs are socialized to network users who pay through network tariffs, which in many member states are (for the largest part) the consumers.

Risks due to lack of coordination between DSOs and TSOs in flexibility procurement

In a smart grids system, besides TSOs also active DSOs require congestion management and possibly balancing services for securing short-term reliability and system stability. DSOs perform congestion management as part of day-to-day grid operation in order to avoid or postpone network reinforcements in certain regions that dispose of enough flexibility resources to allow for shifting of production or consumption. Similarly, the development of smart grids might ultimately result in balancing taking place partially at local levels by DSOs, implying sharing of the balancing tasks between TSOs and DSOs.

[22] This could also be signals to flexible generation and/or storage.

Actions of TSOs and DSOs respectively may influence each other. In case flexible DER is procured by the TSO for balancing market purposes, transport capacity of the distribution network is used which could lead to distribution network constraints. When the DSO then deploys congestion management, this may impede the delivery of flexibility services to the TSO for balancing market purposes. Separate procurement actions of DSOs and TSOs for provision of these services would entail a similar coordination problem as for the provision of congestion management and portfolio optimization services.

Coordinated procurement

Coordinated procurement may also bring along barriers and risks. First of all, it is not yet clear what is the most optimal type of regulatory involvement. Concerning option 1 it remains to be seen whether a regulated approach to divide scarce flexibility between regulated DSOs and commercial market actors would allow for an efficient and indisputable allocation of flexibility. Concerning option 2, such an auction platform for market-based flexibility sharing has a monopolistic character and therefore requires regulatory supervision. Such regulatory supervision may be complex due to the large, and diverging (national) interests at stake.

Furthermore, in the discussion of one integrated market for flexibility procurement for congestion management and energy trading purposes at *distribution level*, similar arguments pro and contra integrated markets play a role as in the discussion of integrated markets at the *transmission level*.[23] On the one hand, one integrated market allows for a better alignment of market structures with physical reality, allowing for achieving higher system efficiencies through better incentives for network users in connecting and using the system and reduced possibilities for gaming of market participants between separate energy and congestion management markets. On the other hand, one integrated market induces a more complex market structure than separate markets for energy and congestion management and may raise concerns on market liquidity in case flexibility procurement by DSOs implies different electricity prices at both sides of the resolved network constraint.

6.4 Infrastructure provision for electric vehicles

6.4.1 Definition of market structures

The **integrated infrastructure model** is an example of the DSO market structure. In the integrated infrastructure model the publicly accessible charging infrastructure is fully integrated into the DSOs assets i.e. part of the regulated business of network management by the DSO. Costs related to EV charging points are therefore recovered from the network charges i.e. socialized to network users. The DSO is in charge of installing and operating the publicly accessible charging points. A variant is that DSOs only technically operate the charging stations and leave the commercial provision of services fully to e-mobility service providers thus establishing a multi-vendor platform (Eurelectric, 2013d). The DSO disposes of an ICT back-end system to link the customer to an e-mobility service provider. The ICT system is used for clearing house purposes between e-mobility service providers (financial, authorisation, information, billing, etc.). The integrated infrastructure model is currently being implemented in Italy and Luxembourg (Eurelectric, 2013d).[24]

The **independent e-mobility model** is an example of the liberalised market structure. In the independent e-mobility model, the publicly accessible charging infrastructure is provided by market actors. Costs of EV charging points are solely recovered by its beneficiaries i.e. e-mobility

[23] However, there are also some relevant differences between integrated market platforms at transmission and distribution level. We refer to Section 6.3.1 for some specific technical and economic restrictions to flexibility procurement in distribution networks.
[24] According to CER, the Irish regulator, Ireland does not have an integrated infrastructure model in operation.

customers. New connection points for charging stations are treated as any other new connection points to the distribution grid. In a regulated metering market the DSO provides a “network” meter for the charging station, while in a liberalized metering market a third party may perform the duties of the Metering Point Operator and provide relevant data to the DSO for the networks fees calculation (Eurelectric, 2013d). The independent e-mobility model is currently being implemented - with some minor variations- in Denmark, France, Germany and Spain (Eurelectric, 2013d).

6.4.2 Assessment of barriers and risks

Integrated infrastructure model

The integrated infrastructure model brings along some specific barriers and risks. First of all, consequences of the choice in the initial phase for the level playing field in next phases of the innovation cycle should be accounted for. Allowing for a role in e-mobility infrastructure provision to regulated actors such as DSOs, would imply that the latter do obtain a very good starting position for the commercial phase later on, which may negatively affect future competition by impeding market entry of potential competitors (Ruester et al. 2013). This holds even if charging services are separated from other DSO services' in a separate private firm once the market uptake phase is reached, since this private firm might act as an incumbent towards new entrants. Hence, an appropriate exit strategy for DSOs is key, implying that the absence of such strategy is an important regulatory risk. This may also explain the position of the Commission, which only allows for a competitive market in establishing and operating EV charging points in the proposed legislation (EC, 2013b). This draft Directive obliges Member States to assign the tasks of development of EV charging points to market actors. In the proposed Directive it is explicitly states that “The establishment and operation of recharging points for electric vehicles should be developed as a competitive market with open access to all parties interested in rolling out or operating recharging infrastructures”.[25] DSOs should only act as market facilitators: “Publicly accessible recharging points are currently not part of the regulated activities of a distribution system operator as defined in Chapter VI of Directive 2009/72/EC”.[26] Furthermore, DSOs are not allowed to supply electricity and respect the unbundling rules established by the Third Energy Package as “Member States shall ensure that distribution system operators cooperate on a non-discriminatory basis with any person which establishes or operates recharging points accessible to the public”.[27]

Second, the development of smart charging options such as V2G by DSOs may be impeded by the lack of innovation incentives that level the playing field for conventional and smart grids network solutions. In the absence of such incentives, DSOs will be tempted to continue the application of low risk fit-and-forget type of network planning which discourages the development of flexibility solutions such as smart charging and V2G.

Third, there might be lack of standardised data exchange between DSOs, both within and across countries due to lack of international or European standards. Hopefully this can be mitigated by the additional EU requirements for enhanced interoperability of recharging points foreseen by recital 26 of (EC, 2013b). Furthermore, in case several DSOs operate EV charging points (internationally), a need for a “higher level clearing house” evolves that encompasses information of the ICT back-end systems of different DSOs (Eurelectric, 2013d). In case DSOs do not coordinate this on industry level, additional legislation may be needed.

[25] Recital 12 of EC (2013b)
[26] Recital 14 of EC (2013b).
[27] Article 4(9) of EC (2013b).

Independent e-mobility model

Likewise, the integrated infrastructure model brings along some specific barriers and risks. First of all, an important risk is the lack of sufficient public intervention measures to address the identified market failures (a.o. chicken-and-egg problem) in the market uptake phase. This may imply that the infrastructure of charging points for electric vehicles is build-up at a very low pace, with some countries waiting for further cost reductions of charging points due to public intervention efforts of other countries before actively promoting the installation of EV charging points in their own country. This first mover disadvantage effect may slow down the development of a full EV charging infrastructure that covers the entire EU to the detriment of EV users as well as EV technology providers. Such issues at the initial market phase may be overcome with tendering of EV charging points or subsidizing private entities. In some member states[28] certain specified categories of network users are allowed to issue a public tender for the realization of new network connections. Thereby, they are obliged to request approval from the network operator and the network operator is only allowed to withhold its approval in case the reliability of the grid cannot longer be guaranteed. Since EV charging points can be interpreted as simple grid connections with a similar kind of procedure also EV charging points could be tendered. Such a competitive tender may yield the required number of charging points at suitable locations while DSOs can keep good oversight of the need for electricity transport due to EV charging in their networks.

Second, policy measures such as tender procedures or subsidies to private entities may deliver too few EV charging points if they are not updated to changes in the actual need for EV charging points. Therefore, a recent analysis of the required number of charging points at suitable locations should be the basis of the tendering procedure or subsidy scheme design. Such a tender procedure or subsidy scheme should also foresee in an easy extension of roll-out of charging points in case the need for charging points is larger than initially expected.

Third, market actors such as e-mobility service providers could either block charging of their EV customers at publicly accessible charging points operated by other e-mobility service providers or block the charging of EV users that only express interest in infrequently use of their charging points. This would imply that part of the publicly accessible charging stations is not accessible by a group of customers which necessitates the installation of additional EV charging points, slowing down the development of the e-mobility market. For allowing non-discriminatory third party access for using a charging station by all e-mobility customers, roaming of charging services should be provided by e-mobility services providers. One could think of a roaming agreements between the “standard” e-mobility service provider of the EV user and e-mobility service providers that are operating other publicly accessible charging stations. Article 8a of the proposed Directive on the deployment of alternative fuels infrastructure (EC, 2013b) stimulates the closing of such roaming agreements by stating that all charging points accessible to the public also should provide for an ad-hoc charging possibility.[29] Direct payments systems seem to be the logical solution for ad-hoc charging, since they allow e-mobility customers to pay by credit card or SMS.

Fourth, lack of standardised data exchange between e-mobility services providers, both within and across countries due to lack of international or European standards. Hopefully this can be mitigated by the additional EU requirements for enhanced interoperability of recharging points foreseen by recital 26 of (EC, 2013b).

[28] Examples are the UK for offshore wind connections and the Netherlands for connections larger than 10 MVA.

[29] In principle such type of roaming agreements might also evolve between commercial actors without legislation, like in the market for mobile phone calls.

6.5 Data handling

6.5.1 Definition of market structures

Three data models have been discussed within the EG3 Smart Grids Task Force with central roles for the DSO, an independent third party operating a central data hub, and a data access-point manager respectively. In the first model the DSO operates a data hub and provides data to the market through this hub, while in the second model these tasks are performed by an independent entity. In both cases the central actors are regulated as a natural monopoly and thus can be considered as an example of the DSO market structure. In the third model no official data hub exists, but one or more data access-point managers (DAMs) guarantee data access at each meter point. These DAMs can be any certified commercial company. The DAM model can be considered as an example of the liberalised market structure. For further background information on the three data models, we refer to EC (2013a).

6.5.2 Assessment of barriers and risks

DSO data handling model

For the data model where the DSO plays a central role the following risks need to be addressed: (1) potential lack of a level playing field for all data users; (2) given the regulated nature of the model, potential lack of sufficient innovation incentives.

In order to guarantee a level playing field, the data handling role by the DSO should be performed in a transparent, non-discriminatory and neutral way. The DSO should not be able to realize a competitive advantage given its real-time insights in data for network operation. DSOs with less than 100,000 customers which are exempted from legal unbundling rules by member states might induce a higher risk for tilting the level playing field than (larger) DSOs which are not exempted.

One possible measure to prevent level playing field issues and to stimulate innovation maybe to mandate DSOs to ensure access compatibility to **part of** its ICT infrastructure for all market players (Ruester et al. 2013). This enables the latter to deploy the preferred technology standards for their own ICT infrastructure and avoids technological lock-in to the choice the DSO made earlier in time. Thereby also potential negative impacts of regulation of data handling on incentives for innovation are reduced. Besides, it prevents also that insufficiently unbundled DSOs could use ICT standards to the disadvantage of competing suppliers. At the same time it is essential that data security is guaranteed by preventing unauthorized access which might put network security at risks. Hence, a well-established protected data interchange is key and some ICT infrastructure should therefore not be accessible by any third party.

An alternative model that allows for gathering of data by market actors and hence innovation, while at the same time ensuring data security is the Appliances Management Support Unit (AMSU) concept. The Appliances Management Support Unit (AMSU) is a means for the market to collect and/or present data, insofar the consumer desires this and data is not yet gathered by the DSO. DSOs do only need data for network management, and hence may not gather all data that market actors need for provision of value adding services. The AMSU can range between a simple and cheap means of data extraction from the DSO-owned smart meter or database (without collecting data on its own) and a more complex standalone system (in fact an extra unofficial smart meter). The AMSU should be able to extract information from the DSO database (using internet) and/or from the smart meter (using a physical link), using a one way data stream, guaranteeing data safety in the DSO database.

The possibility to collect additional information through the AMSU prevents that several market actors collect the same data. Using this data, market actors can develop a new range of services, for example for domotics purposes. Summarizing the AMSU:

1. is a concept which encompasses a wide range of functionality: collecting, presenting and/or making use of smart meter data and perhaps a variety of other data for services related to the users' appliances;
2. is optional (market actors who are interested in the additional functionality install the AMSU, depending on consumer consent);
3. does not replace but is complementary with DSO data collection;
4. makes use of a standardised data extraction.

In this way, the development of innovative services using smart meter data is open to a competitive market.

Another issue related to level playing field and innovation is whether there should be any limits to the cooperation between DSOs and ICT companies. Hermans (2012) proposes a joint venture model where communication infrastructure is part of smart grids infrastructure of DSOs i.e. regulated, but built and operated by ICT companies i.e. a commercial task. This gives rise to a number of questions around the competitive position of ICT companies and allocation of costs and benefits earned by the joint venture of DSOs and ICT companies. If ICT companies are active both for DSOs and other market actors such as suppliers, this could potentially give rise to unfair competition between ICT companies. Concerning the allocation of costs and benefits, it should be prevented that costs are mainly allocated to network users, while the benefits accrue mainly to ICT companies. This holds for networks users of both large and small DSOs. It may not be easy, however, for the regulator to assess this type of issues in such integrated ICT-DSO business models. Alternatively, if DSOs would retain complete ownership but outsource ICT operations, these issues can be addressed. Hence, regulatory risks from cooperation between DSOs and ICT companies are more limited with outsourcing than with joint ventures.

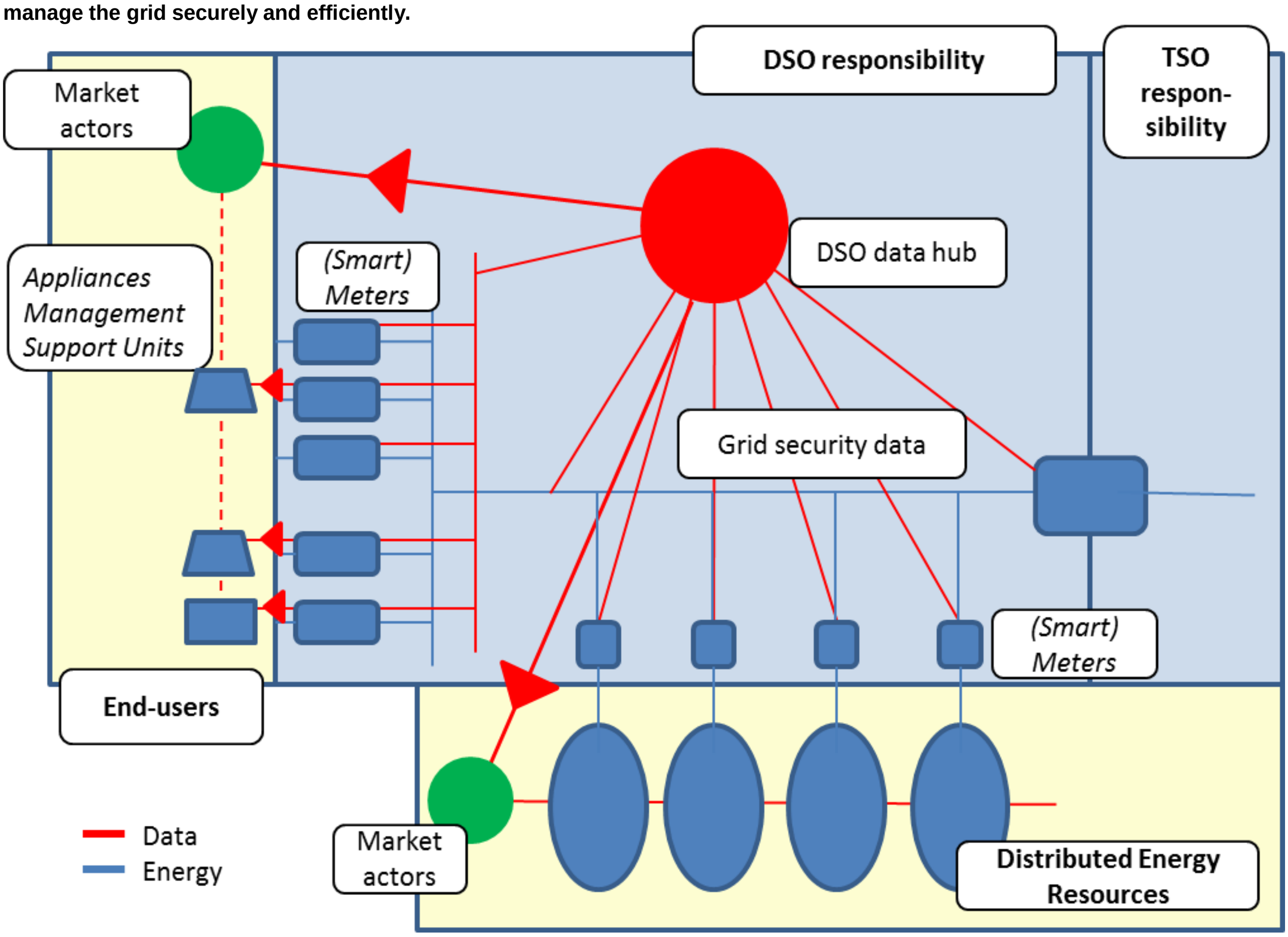
Outsourcing ICT operations to a common platform owned by multiple DSOs provides opportunities for efficiencies and transparency in data collection. A cooperation by multiple DSOs increases economics of scale, providing potential savings for the DSOs and simplifying regulatory enforcement of non-discriminatory data provision. Furthermore, one national data platform instead of multiple DSO data platforms allows for lower efforts by market actors to access the data.

The installation and operation of smart meters can be procured in a competitive market (DSOs hire installation and maintenance companies), insofar this is optimal. In this way, DSOs retain ownership of metering equipment and are able to adequately manage the grid whilst cost efficiency and innovation are stimulated in a competitive market. This can stimulate cost reduction and innovation in smart meters (in the technological suppliers market) and data management (in the ICT-market).

We conclude that the DSO model probably contains the most efficient data handling of the three models. Furthermore, it provides some transparency in data handling (though less than CDH) and allows for innovation (though less than DAM). If the emphasis is placed on these advantages the DSO model is most suitable.

Should this model be chosen, the resulting allocation of responsibilities is shown and explained schematically in Figure 6.1 and further elaborated on in the text box below.

Figure 6.1. Overview of the responsibilities and data streams in the Member States with DSOs that are also responsible for metering. The "nice to know" information for market actors, which is not already collected by DSOs, is generated by so called Appliances Management Support Units connected to the smart meter. In the model shown in this picture the DSO is only responsible for the data needed to manage the grid securely and efficiently.



Source: Ecorys.

Technical and regulatory elaboration on the allocated responsibilities

- The physical (one-way) connection between the AMSU and the smart meter should be standardised, allowing for efficient market development.
- Different actors should be able to easily access data on the DSO data hub (under relevant privacy restrictions including consumer consent). This calls for standardisation of this data access, perhaps towards the extent of Member States or the EU.
- Security issues with grid data should be researched further. The relevance of these issues go beyond the scope of smart grid development.

Central data hub model

For the data model where an independent third party plays a central role (the CDH model) the following preconditions need to be fulfilled: (1) a level playing field for all data users; (2) given the regulated nature of the model, measures to guarantee sufficient innovation incentives.

For guaranteeing a level playing field, the data handling role should be performed in a transparent, non-discriminatory and neutral way by an independent third party. It may be easier to guarantee a level playing field for data users by regulation if an independent actor fulfils a central role; if this third party does not have to fulfil other roles a decrease in the administrative burden associated with supervision may result. Furthermore, the CDH model requires that a new regulated agent is set-up.

This could be politically complicated, and if the DSO is the designated provider of all other regulated tasks including smart metering, two monopolies working in tandem will have to be regulated.

Securing innovation incentives might be easier in this model compared to the DSO model given that an independent third party does not have an interest in a certain technology standard as it does not perform other tasks. As in the DSO data handling model, the independent third party could be legally obliged to ensure access to part of its ICT infrastructure for market players, by organizing access compatibility while preventing unauthorized access to data with a high security risks by a well-established protected data interchange. Alternatively, innovation may also be enabled in the DSO model by deploying the AMSU-concept.

We conclude by comparing the CDH model with the DSO model. The CDH model contains more guarantees for transparent, non-discriminatory and neutral data handling than the DSO model. On the other hand, it requires the set-up of a new regulated agent and, which is not required in the DSO model. We conclude that the CDH model is suitable if emphasis is placed on transparent, non-discriminatory and neutral data handling.

Data access point managers model

In the data handling model wherein one or more data access point managers operating in competition play a central role, the preconditions are comparable in some respects, but somewhat different in others. The following preconditions need to be fulfilled: (1) a level playing field for all data users; (2) measures to realize that the efficiency of the data model is maximized, i.e. economies of scale are realized and excessive profits are prevented; (3) additional measures to guarantee simplicity and clarity for consumers.

For guaranteeing a level playing field, it is important that the data handling role is performed in a transparent, non-discriminatory and neutral manner. As Ruester et al. (2013) note "…the performance of new business models, as well as the functioning of retail market competition, will rely on comprehensive consumer data." Non-discriminatory access to data allows for the provision of multiple smart grids services based on the data of one meter instead of requiring every actor to install its own meter for obtaining the necessary data to provide smart grids services. However, the DAM model assumes full excludability of data consumption/use and hence defines the role of the data access point managers as 'provisioning and prioritizing rights' (EC, 2013a), implying that data cannot be accessed and utilized by third parties on an equal basis. Prioritizing rights seems at odds with non-discriminatory third party access of smart grids data. Therefore, rules are necessary to safeguard that the conditions for data access are equal for third parties.

A second issue is that the model allows for several DAMs, while the economies of scale are significant due to the high fixed costs and the low marginal costs of data provision. Since data is typically homogeneous, the opportunity for data handling providers to differentiate seems limited and therefore their profit margins maybe insufficient for the recovery of fixed costs. This may result in underprovision of data handling. To realize economies of scale and to achieve high efficiency in data handling, it appears therefore favourable to limit the number of DAMs by regulation. At the same time, it should also be prevented that a commercial actor earns excessive profits due to a monopoly position. Both risks can be mitigated by regulation.

Finally, compared to the other data model additional measures might be required to guarantee simplicity and clarity for consumers (Ruester et al. 2013) in order to reduce consumer acceptance risk. This risk results from the fact that more efforts are needed by the consumer as data owner to deal with the higher number of interfaces and the higher number of decisions to be taken. Without such risk mitigating measures for the consumer, this data handling model may be far less attractive if not impossible to handle.

6.6 Conclusions and policy implications

Table 6-1 summarizes main barriers and risks of both types of market structures as identified in the preceding sections. These market structures are two extremes, in reality mixtures of both market structures are most logical; often it is left to Member States to make choices on specific regulation for Smart Grids services; a Member State may choose for a DSO type of market structure for data handling, while selecting a liberalized market structure for infrastructure provision for electric vehicles.

Table 6-1 Summary of barriers and risks under DSO and liberalized market structures

	DSO market structure	Liberalized market structure
Flexibility services	• Inefficient allocation of flexibility between DSOs and market actors • Fragmented demand for flexibility lowers its value • Inefficient allocation of flexibility between DSOs and TSOs • Lack of information exchange between DSOs and TSOs	• Market based coordination not technological feasible and economic efficient in all types of distribution networks • Regulatory supervision required for coordination • More complex market structure lowers understandability for non-experts • Concerns on market liquidity in case of congestion
Infrastructure provision for electric vehicles	• Lack of well-thought exit strategy may create incumbent in commercial phase • Lack of innovation incentives discourages flexibility provision through smart charging and V2G • Lack of standardised data exchange between DSOs, both within and across countries due to lack of international or European standards	• First mover disadvantage effect in the absence of public intervention • Inflexible tender procedures or subsidy schemes that are not able to adapt to changes in need for charging points. • Lack of roaming agreements between e-mobility service providers • Lack of standardised data exchange between e-mobility services providers
Data handling	• Competitive advantage for DSO by real-time insights in network operation data combined with ineffective unbundling • Lack of innovation incentives • Data security risk	• Non-discriminatory third party access to data not secured • Too high number of DAMs, preventing cost savings by realization of economies of scale • Lack of simplicity and clarity for consumers • Data security risk

These barriers and risks give rise to a number of policy implications related to the DSO and liberalised market structures for each of the three Smart Grids services discussed in this Chapter.

Flexibility services

Stimulate coordinated procurement of flexibility services to achieve higher system efficiencies

Coordinated procurement of flexibility services should be favoured against separate procurement by DSOs and market actors respectively since the former allows for higher system efficiencies due to system-wide optimization in the deployment of flexibility. As an example of coordinated procurement by DSOs and market actors the study outlined the need for regulatory rules for sharing of flexibility potentials as well as regulatory supervision on the deployment of an auction platform for market-based flexibility sharing. For the same reason, coordinated procurement of flexibility services by TSOs and DSOs should be favoured against separate procurement by DSOs and TSOs respectively. This requires better information exchange between DSOs and TSOs by either hierarchical protocols or well-coordinated simultaneous procurement procedures. Again coordination requires regulatory rules and supervision. Further research in the different coordination approaches between DSOs and market actors, and DSOs and TSOs respectively, and their limitations is needed.

<u>Allow for sufficient incentives for investments in conventional network reinforcements</u>
Sometimes investments in smart grids are not feasible from a technical and/or economic perspective. Policy makers and regulators should allow for adequate incentives for network investments in conventional network reinforcements. For securing that market and societal benefits of such network investments are adequately taken into account in investment decisions of DSOs, the network operator may be obliged through regulation to perform an integrated investment assessment, preferably by performing a societal cost benefit analysis (SCBA). The Spanish "Evacuation Boards" approach can be considered as an example of some elements of such an integrated investment assessment (Eurelectric, 2013a). Such a SCBA should take into account the robustness of the network investment for different plausible generation and demand scenarios. For limiting administrative burdens, a SCBA might be limited to all investment proposals that meet a certain minimum monetary size.

<u>Promote level playing field for investments in conventional network reinforcements and smart grids</u>
Network operators increasingly will have to consider a menu of options for accommodating network demand i.e. conventional network reinforcements as well as smart grids solutions. The higher risks of innovative smart grids solutions for DSOs compared to conventional network reinforcements should be properly accounted for in regulatory assessments.

<u>Guarantee effective unbundling of DSOs and commercial market actors to enable efficient flexibility procurement by DSOs and market actors</u>
Current unbundling provisions of Directive 2009/72/EC should be fully implemented in national legislation of all Member States prior to allowing DSOs to procure flexibility services in the competitive market. Given the emergence of new interactions between DSOs and commercial market actors (producers, consumers) for flexibility procurement, DSOs should only be allowed to perform flexibility procurement if Chinese walls between DSOs and their subsidiary suppliers are in place that prevent barriers for market entry of new market participants. Additional requirements may include measures to secure transparency and non-discrimination in procurement, e.g. by ex-post publishing of procurement related data or the requirement to deploy a public auction mechanism. In this context, special attention should be paid to DSOs with less than 100,000 customers, which sometimes have been exempted from DSO unbundling rules by member states. If these DSOs do obtain an additional task with the procurement of flexibility services it is unclear why they should be exempted from application of current and possible additional unbundling rules in order to guarantee a level playing field between incumbent suppliers and new market participants. Therefore, further reflection on the desirability of a distinction between DSOs with more and less than 100,000 customers is advised.

Infrastructure provision for electric vehicles
<u>Support the introduction of the liberalized market structure</u>
The analysis showed that in the initial phase both DSO and liberalized market structures are possible as long as public intervention is accounted for. After the market uptake phase, when no

public intervention is needed the liberalized market structure is most adequate. The liberalised market structure is preferred as it is adequate for both innovation / market development phases. Moreover, unlike the DSO market structure the risk of the lack of a well-thought exit strategy which may create an incumbent market player in the commercial phase and may hamper innovation, is absent.

Strive for international or European standards for data exchange of charging point utilization
For both market structures holds that the lack of standardised data exchange is a risk, since it may limit the accessibility of charging stations. Hence, international or European standards are urgently needed to guarantee interoperability of EV charging infrastructure. Moreover, in case of the DSO market structure data exchange between DSOs, both within and across countries is needed, while in the case of the liberalised market structure roaming agreements between e-mobility service providers are required.

Data handling

Secure non-discriminatory third party access to data
Non-discriminatory third party access is not secured in the liberalized market structure (DAM model) and may also be at risk in the DSO market structure (DSO, CDH model) in case of ineffective unbundling. Hence, public intervention is needed to secure data access.

Guarantee realization of economies of scale
Without public intervention, a liberalised market structure will achieve a too high number of data access point managers, and therefore realize lower economies of scale than socially optimal. This might be a reason to prefer the DSO and CDH models over the DAM model.

Promote sufficient innovation
Innovation is best guaranteed in a liberalized market model, such as the DAM model. However, with regulatory measures innovation can also be stimulated in the DSO and CDH market models. The AMSU concept and outsourcing of ICT operations to a common platform jointly owned by DSOs but operated by ICT companies (DSO model) can be conducive to innovation.

Enforce simplicity and clarity for consumers
The DAM model requires more efforts from consumers as data owners to deal with the higher number of interfaces and decisions to be taken. Regulatory measures are needed to limit these numbers to the absolute minimum. This issue is less pronounced in the DSO and CDH market models due to the lower number of data handling entities.

Stimulate data security
For both market structures data security risks are an important issue. Further research is needed to identify the size and frequency of security risks as well as most appropriate mitigation measures.

7 Task 4: Learning from international experience: drawing conclusions from the smart grid roll-out in different countries

For the purpose of discussing the role of DSOs in smart metering and smart grids, the roll-out of the Smart Grid in five EU countries were examined: Sweden, Italy, Denmark, France, and the UK (Scotland). These countries were chosen as they are either forerunners in the roll-out of the Smart Grid or have applied a distinctive approach to the roll-out and/or to the management of the meter data. By examining these countries cases, lessons can be learned on successful market models in support of a large scale roll-outs and on potential pitfalls and challenges. The information on the roll-outs has been collected through literature research and complemented through interviews with regulators and DSOs in the countries mentioned.

To widen the view on smart activities, some specifically interesting demonstration projects have been reviewed. The main findings from these projects are represented at the end of this chapter.

7.1 Lessons learned from large-scale roll-outs

7.1.1 Italy

Background

The roll out of smart meters in Italy started in 2001, resulting in 95% of the meters being smart by 2011. In Italy no National Cost Benefit Analysis was performed by the Regulatory Authority on electricity smart metering roll-out. Interestingly, the roll out has started long before any regulation was in place, solely for economic reasons. The metering service is performed in Italy by the DSOs who own the meters and are fully responsible for installation, maintenance, meter reading and data management activities. The initiator of the roll-out was Enel, Italy's largest DSO. Today, Enel is supporting smaller DSOs with their experience on data handling and the management of the data hub.

The main reasons for the roll-out were:

- Efficient remote meter reading;
- Reducing electricity losses;
- Reducing fraud;
- Improving responses to delayed or lack of payment by consumers;
- Many new services, including energy efficiency services, for customers.

Remote meter reading is considered the most important reason for the roll out. In the case of unsettled energy bills, Enel can reduce the maximum capacity of a consumer, so that the consumer will still be able to use light and other low power appliances, but not the heavier appliances. This method is considered more socially acceptable compared to completely disconnecting households. The possibility of shutting down or reducing maximum capacity of end-users has shown significant benefits. Smart meters owned by DSOs show a clear advantage in this respect, because as regulated entities DSOs are better able assess whether or not actually using the possibility of shutting down users is socially acceptable.
Energy efficiency services are not provided by Enel directly, but they have a data facilitating role.

Although the Italian smart meters do provide the possibility of a load shedding, currently it is not used frequently. However, under an increased DER penetration this might be used more often. Furthermore, also when break-down facility functionality is used infrequently, the benefits can still be significant, if network constraints during red light system states can be solved more efficiently. All in all, the extent of quantitative benefits derived form this deserve further research.

Market model

The roll-out of the smart meters has been the task of DSOs. They also own and manage the meters and are responsible for the associated data management. Currently, the Italian regulator is discussing how DER should be implemented. Three potential models are considered, of which the one most preferred by DSOs has a programmed profile with respect to the connection with the TSO. DSOs can buy local services from local generators in order to fulfil their responsibility towards TSOs. Another point of discussion concerns the ancillary service market, which has no capacity tariff yet. An auction for capacity and interruptible loads could become necessary in the future.

Market response and information supply

Customers' reactions on smart meters are generally positive. There has been hardly any debate on privacy issues concerning the generated Smart Meter data. It is not clear whether this would have been different had a non-regulated entity rolled out the smart meters.

Lessons learned

We can conclude that Italy represents a well-working example of smart metering with the DSO taking a central role in the roll-out. Furthermore, it provides more insight in the range of potential benefits of a smart grid environment (more efficient management of payment and fraud issues) and the type of functionality which smart meters can offer (social minimum capacity). This is a significant contribution for policy makers who are considering a smart meter roll-out or have done so already, because it helps them in realising more (previously unknown) value with smart meters. Since the introduction of the smart meters, the DSO provides more information to customers. The information is also considered of a higher quality and more user-friendly. Furthermore, the lack of debate on privacy issues is remarkable. An important prerequisite for this is a neutral DSO that provides a high level of security.

7.1.2 Sweden

Background

In Sweden the rollout of smart electricity meters is 100% complete. In 1991 there were already some smart meters for high voltage users, this has been initiated by DSOs. However the large scale roll-out is the indirect result of regulation. In 1996 the Swedish energy market has been deregulated. Many consumers had complaints about unclear and estimated electricity bills, only settled once a year. For this reason, the regulator demanded more transparency and effectiveness from the energy companies and suggested in 2003 the introduction of monthly meter reading. Therefore, a new regulation was enforced in 2009, stating that all consumers should have monthly meter readings. Because of the anticipated new regulation, many of the DSOs were early adapters and decided to start an implementation of smart meters ahead of 2009.

DSOs also discerned an opportunity for a cost reduction in metering. These cost reductions (as identified by interviewees) turned out to be much higher than expected, mainly due to reduced non-technical costs (e.g. administrative costs for billing). Before the large scale roll-out there has been campaigns to inform consumers, initiated, executed and paid for by the business parties. Furthermore elaborate stakeholder participation sessions have been organised by the business, one of the goals being to design a glossary, so that all DSOs and market players use the same definitions for the same practicalities. According to the business, this glossary greatly improved clarity for the consumers.

Since October 2012 hourly data on energy use have to be supplied by the DSO to those consumers who have a supply contract demanding hourly metering. So far very few customers have chosen these types of contracts. In some cases, the DSO has replaced its smart meters to more advanced meters with hourly metering or remote controls. However the sunk costs for some of the DSOs who were early adapters are deemed limited.

Market model

In Sweden the energy market is deregulated and the DSOs with more than 100,000 customers are fully legally and functionally unbundled.

Connecting households to Smart Meters has been done by the DSOs. DSOs also own the meters and manage the data, which includes providing it to suppliers, balancing responsible parties and customers. Consumers are free to choose their supplier. However, if they remain passive the DSO will appoint a supplier to them. The Swedish regulator performed in 2012 a study on possible market models for smart metering services. The results indicated that leaving the responsibility for smart metering services to market parties could result in a small gain as a result of competition.

However, the risk related to a competitive market model was considered higher than having DSOs performing the smart metering. This risk mainly involves instability of the market, an energy supplier going bankrupt for example, which would lead to several technical and legal difficulties concerning meter ownership. Another point of concern was data security, due to its neutral and regulated status the DSO is considered the best candidate to manage the data and supply it the third parties. A special benefit of the DSO market model in Sweden concerns quality testing. The testing is done through random sample testing. This method is very cost efficient, but requires a nationwide database and cooperation, which is more difficult to achieve with market parties. During 2013 the Swedish NRA has performed a study on possible future supplier market models. The NRA suggests that Sweden should head towards a supplier centric market model. In this supplier centred model the supplier handles consumer contact, including billing. The energy bills will clearly distinguish between network cost and the cost for electricity. The supplier centric model is considered to be more customer friendly and will result in less passive consumers and decreased numbers of cases where the DSOs will appoint a supplier.

Market response and information supply

The introduction of smart meters resulted in very little debate. The information campaign had a large positive effect on consumers attitudes, especially the possibility of having bills based on actual monthly consumption persuaded most consumers. Most of the concerns focussed on the hassle of replacing the meter. A very small group raised some questions about possible health effects caused by the radiation from the smart meters. Privacy has only recently become a subject of discussion. Because of the privacy debates in other EU countries, the Swedish are wondering whether they have to be concerned as well.

Main lessons learned

The main lessons learned from the Swedish roll-out are:

- A clear plan should be designed first, including the goals to be reached and the market model to be applied, before considering technical solutions.
- A societal demand for smart metering functionality is key for a smooth smart meter roll-out.

- When multiple DSOs are involved in a roll-out, clarity towards consumers can be greatly enhanced by using a uniform set of definitions.
- The importance of installing good quality meters that can be remotely updated, otherwise the cost will increase significantly due to extra visits to consumers, furthermore life span of the meters and the time needed to educate the technicians should be taken into account.
- Smart meters are a means to an end, regulation should focus on specific goals (i.e. accurate monthly billing, accurate info on the grid, etc.) instead of on a certain percentage of smart meter coverage.

7.1.3 Denmark

Background

Around 60% of the Danish electricity meters are already smart or are in the process of becoming smart. Smart Meters were rolled out ahead of a regulation of some Danish DSOs (e.g. due to the fact that remote data reading is cheaper). This first generation of meters were subject to regulations on e.g. quality. However, this set of rules was considered not fit to secure the roll out of remotely read meters. For this reason new regulation concerning smart meters has been applied. The regulation on the roll-out of smart meters is aimed at those DSOs who did not start the introduction of smart meters yet. In Denmark DSOs are legally unbundled. Furthermore, they are mostly owned by the consumer's co-operatives or municipalities. Thus, in Denmark, a bottom-up approach is applied, where consumers stimulate change. The load profiles are expected to be outdated before the roll-out is complete, mainly due to the increase in wind energy. Potentially the TSO managed data hub could improve future load profile predictions, by enabling a national overview to discern trends.

Market model

The roll-out and maintenance of Smart Meters are regulated tasks of the DSOs. DSOs also have to assure metering data is sent to a central data hub that is owned and managed by the state-owned TSO. Commercial parties provide services, such as management of energy consumption. The reason for a central data hub is the large number of DSOs (75) in Denmark. Having a central data platform provides consumers with a single data source. As of now, an end-of-year meter reading is performed based on data from the data hub and predictions provided by the DSOs. From October 2014 onwards, billing may be conducted on a monthly basis. On the regulators side, the responsibility on the smart grids is shared between the Danish Energy Agency and the Energitilsynet. The Energitilsynet focuses on the network companies and monitors the market functioning. The Energy Agency is responsible for the smart meters roll-out.
The market structure was introduced in March 2013. Regulatory authorities are testing and reporting on the system for possible problems and mistakes on a regular basis. To this end, the TSO report on the types of mistakes that occurred and under whose responsibility these mistakes were made on a monthly basis. Furthermore, a 'hotline' for consumers has been introduced. Switching between suppliers has increased, but reasons for this are not yet fully established. Probably the increased switching behavior can be contributed to the introduction of the data hub, or to the new regulation.

Market response and information supply

The data hub is accessible by consumers and consumer-approved suppliers. This particular model was chosen for reasons of simplicity for suppliers and for providing a flexible market to consumers and a broad spectrum of available data (e.g. for switching). Consumers seem to be satisfied with the new model. Furthermore, data on domotics is also available on the data hub. However, this information was already available to consumers before the introduction of the hub. In Denmark, there is not much discussion on privacy.

Main lessons learned

- Load profiles are expected to be outdated after the roll-out, possible due the previously segmented nature of data collection. This observation is useful when conducting a SCBA for a smart meter roll-out.
- A TSO managed data hub collecting consumer and supplier data can reduce costs for suppliers and more easily supply consumers with up to data information, which could promote switching for example. This central data hub is especially beneficial when the number of DSOs is large, showing the benefits of economies of scale in practice
- Collective ownership of DSOs by consumers and municipalities can stimulate the introduction of smart meters and logically reduce resistance. However a nation wide roll out required that some DSOs had to be forced through regulation. Should the roll-out of smart meters be desirable, this experience can useful.

7.1.4 France

Background

In France, the roll-out of 11 million gas smart meters will start in 2014 and is planned to be concluded within six years. The regulator invited GrDF (the main gas DSO in France, about 97% of distribution) to introduce pilot projects and experiments with smart meter roll-outs which have been performed starting from 2009. After discussions organised by the regulator and involving stakeholders (consumers, suppliers, manufacturers and the energy agency), the decision on the roll-out was made. Among others, the reasons to roll-out were that smart meters allow improving the quality of service (e.g. switching), improve the knowledge of gas flows in and the capacity of the grid (especially whether bio-methane injections increase and in case of emergency). Smart meters are also expected to enhance the energy efficiency and demand response. Nowadays, GrDF is involved in a tender process for smart meters, it is expected that several manufacturers will produce the smart meters.

Market model

DSOs own and maintain gas smart meters and manage a data platform. There is still some discussion on the implementation of the (single) platform, but it is expected that each DSO will have its own data portal. DSOs will also provide data to consumers and suppliers, however consumers need to authorise whether suppliers can have daily consumption data. Nowadays, there is a discussion on aggregated data availability for municipalities. This aggregated data will probably be linked to the central data platform provided by the regulator.

This model was chosen for the fact that a single experienced entity (DSO) can provide secure metering and data management, without complicating the system by introducing new parties. Furthermore this model is expected to be the most cost effective and the most secure since only one experienced party will handle the data.

Market response and information supply

The French regulator involved end-users in the experiments and conducted surveys on consumer acceptance. Representatives of consumers were involved into discussions on smart meter functionalities. The main debates are concerned with the roll-out, how energy efficiency can be improved and how data availability could improve the energy efficiency. ICT and telecom companies were consulted on possible technologies. They were not involved in the discussions on which market model to use. It is interesting to mention that municipalities are enthusiastic about smart meters because they prefer a better, more modern level of services and more tools to control and analyse consumption and improve energy efficiency.

Main lessons learned

- A strong dialogue with all stakeholders organised by the regulator before the experiments and the eventual roll-out helped to avoid conflicts, the dialogues also provided information to stakeholders and promoted smart meters.
- GrDF covers almost the entire country, however involving all DSOs in an early stage of the roll-out offers opportunities for a uniform sett of definitions and cheaper standardised meters.
- Although smart metering in gas received relatively little attention in Europe, there is a hidden demand among consumers which can be invoked with some dialogue. This experience can be used to improve the business case of demand response schemes.

7.1.5 United Kingdom

Background

By the end of 2015 a new smart metering national infrastructure start to be rolled out in the UK by suppliers. This large scale roll-out has been mandated by the British government. Some energy suppliers are already offering smart meters using their own systems and technologies (though these are not necessarily compliant with the final smart meter technical specifications). Suppliers are required to offer their customers the possibility of a smart meter, but there is no obligation for households to accept one. Reasons for a large scale roll-out are a.o. a potentially more efficient energy use and the ability to provide energy bills based on actual use instead of an estimate. The management of the smart metering communications system the task of the newly licensed entity known as the Data Communications Company. DCC system users (suppliers, network operators, authorised third parties) will make requests to DCC to receive information from smart meters. DCC will schedule the provision of information to authorised users to an agreed format. Although supplier install, own and manage the meters, the collected data is owned by consumers and only stored in their smart meter, to which the DCC does not have access.

Market model

Suppliers are to roll-out and maintain smart meters. Management of the DCC has been appointed to Capita PLC, a business outsourcing company, which will be regulated by Ofgem, the UK Energy regulator. As mentioned before, the consumption information derived from the smart meter is officially owned by consumers. Authorisation for use of consumption information by suppliers and network operators is subject to justification of need and the demonstration of clear benefits to customers from the use of the information. Disconnecting consumers or switching them to a prepaid mode can be done by suppliers, but they need to follow several procedures which are closely monitored by Ofgem. Passive smart meter information can be used by authorised DCC users without explicit authorisation.. Discussion is on-going about this subject. It should be noted, however, that there are some strict rules and requirements set by the British government regarding smart meter data access and privacy.. These rules aim at protecting consumer privacy and focus on the following areas:

- Data access;
- Security;
- Technical standards for the smart metering equipment;
- Meeting the needs of vulnerable consumers.

Market response and information supply

Early surveys in the UK have revealed that the majority of consumers are not yet aware of the smart meter roll out but those that have an understanding of what a smart meter will offer are generally in favour of having one. Early survey results point to accurate billing as being one of the major areas of interest from consumers.   The UK government sponsored smart meter programme has put in place a Central Delivery Body (CDB) that will be responsible for co-ordinating a national smart meter communications campaign to inform consumers about the benefits from smart meters and help them understand how the roll-out programme will affect them. The CDB has not yet started their smart meter communications campaign.

Main lessons learned

- Suppliers can conduct a large scale roll-out, but in the case of multiple suppliers in one area, this may cause higher investment cost.
- Under clear regulation and communication management, a data platform can be outsourced , without too much apparent data security risks;
- A pro-active campaign with a focus on consumer benefits can smoothen the introduction of smart meters significantly;

7.2 Lessons learned from demonstration projects

To widen the view on smart activities, some demonstration projects were reviewed. The focus was on projects which explore a potential new approach to smart metering. For that purpose, our selection of demonstration projects is based on distinctive and/or unique features of a project (projects which ‘challenge the norm’), such as projects with an uncommon market model or a pioneering role in the field of consumer engagement.

The 2012 update of the JRC report on Smart Grid Projects in Europe has been used as the main source for demonstration projects. With a list of 281 smart grid projects and around 90 smart metering pilots and roll-outs, the JRC report provides a convenient base for the exploration of this rapidly developing field. Furthermore some conferences, meetings and symposia with a focus on smart metering and smart grids have been visited, in order to include the most recent smart metering initiatives.

The large majority of pilots and demonstration projects on smart metering and smart grids are initiated and implemented by DSOs. Among these demonstrations are many innovative and experimental projects, showing that DSOs are very well capable of identifying innovation potential smart grids. As an overarching initiatives the Meter ON project by EDSO can be mentioned. It is a FP7 project aiming at the coordination and support of the implementation of smart metering in Europe by collecting the most successful experiences in the field. The project forms a rich source of experiences and information and is available on the project’s site: http://www.meter-on.eu/about_meter-on/project_overview.

The demonstration projects selected are described in summary form and the main challenges are captured. These challenges can be technical, operational, financial or regulatory. Furthermore, for each project the learning points are highlighted.

Flemish Living Lab Electric Vehicles (EVs)

The goal of the Flemish Living Lab EV is to speed up the introduction of electric vehicles in Flanders; the initial aim was to add 300 electric vehicles and 600 charge points to the Flemish rolling-stock within 3 years. In order to nurture innovation the Living Lab supplies a structured real life environment where EV related innovations can be tested by representative end users in their own working and living environments. Participants have to arrange their own funding, but they can test their concept on the test population of the Living Lab. The Living Lab collects the users' data and provides this to all the participating companies, research institutes and public authorities in order to improve the design of future innovation- and research projects.

The Living Lab faces some regulatory challenges. Several governmental initiatives have been set up for the promotion of EVs, such as tax benefits, allowance for EVs to use the bus lanes during rush hour, reduced parking fees for EVs, etcetera. However, these benefits are not implemented nationally, but are mainly part of regional regulation.

The initial goal of the Flemish Living Lab has been reached after six months. Although this is also due to market effects outside the influence of the Living Lab, the Living Lab is considered at least partially accountable to the success. Since funding has to be arranged by the participating companies, the Flemish Living Lab should not be seen as a subsidy provider. Rather it services as a research facilitator, speeding up innovations coming from market companies. Combined with the open access of the Living lab, market distortion is likely to be very limited. For these reasons the Flemish Living Lab presents a successful approach to the stimulation of innovation by sharing data.

Main lessons learned:

- Market distortion can be reduced to a minimum by assuring open access and demanding own funding of participants.

Grid Teams

Grid Teams sell and install Smart Meters in individual households. By using smart metering data, Grid Teams can calculate on energy consumption for individual households using Design Based Standards. A web platform is used where actual current energy consumption is mapped and a target consumption is set. This target consumption consists of the lowest energy consumption reachable, which is determined by scientists from Mines Paris Tech and sociologists from Telecom Paris Tech. To act on the mechanisms of user involvement, Grid Teams offers a social experiment in the form of a loyalty program to save energy. This program is based on the following three principles:

- Create a mechanism for feedback and reward, for example by the accumulation of points redeemable against bonus based savings;
- Support consumers to make daily progress faster and prevent them from becoming lost in their decisions by lack of information or attachment to a routine;
- Create a "zone of no return" (offering the best customer benefits and rewards large enough to ensure sustainability).

Grid Teams received the Digital Green Growth Prize in 2011, which is a price for companies focusing in green growth through digital applications that manage to create public awareness and sets a standard for other market actors.

The Grid Teams project is a nice example of a project focusing on costumer participation, which is currently one of the main areas of development in the field of smart metering. Giving the consumers direct access to his or her data can lead to more energy efficient households through increased awareness, especially in combination with rewards for energy savings. It should be noted that the Grid Teams project is funded from public sources, which could lead to a competition barrier for commercial parties.

Main lessons learned:
- Direct consumer access to their energy use data, promotes energy efficiency.
- Small incentives can stimulate consumers to increase their energy efficiency.

FlexLast

FlexLast is a pilot project of IBM that focusses on flexibility services for three Migros cool storage warehouses in Bern. By linking the use of energy to the production of renewable energy, a buffer against the erratic production pattern of renewable energy is created. In this way overcapacity is utilized and there is less need for non-renewable back-up energy sources. Cooperation has been sought with national grid company Swissgrid and energy company BKW. Real-time energy data from BKW and Swissgrid are collected with smart meters and managed by data access-point manager IBM. IBM processes the gathered data with company software and algorithms. With this data an optimal use of the cooling elements of the warehouses and the most energy effective logistic plan for refilling and collecting goods from the warehouses can be determined. By making optimal use of renewable energy and the consequent reduction of the companies CO_2 output, Migros can obtain a tax exemption under the Swiss Energy Act. Migros has signed voluntary target agreements with the Swiss Energy Agency to reduce energy use by 10% and CO_2 emissions by 20% before 2020. By complying with the agreements under the Energy Act, Migros can be exempted from paying a carbon tax.

An operational challenge is to link the logistics schedule of Migros to the availability of renewable energy. As it is not always possible to change the logistics schedule on short notice a forecast on the availability of renewable energy has to be made. These forecasts are based on weather predictions, which have a relatively large error of estimate.

As smart meters are not actively promoted by the Swiss government, FlexLast provides an interesting example of market forces providing flexibility services using Smart Metering, without any form of regulatory enforcement. FlexLast indicates that flexibility services can be provided under a commercial DAM model, with a minimum of market distortion.

Main lessons learned:
- Flexibility services can be performed successfully by market parties under a DAM model.
- When a smart grid is in place, the market will initiate the provision of flexibility services.

Yello Sparzähler

This project is a cooperation of Yello Strom (a subsidiary of Germany third largest energy company Energie Baden-Württemberg, EnBW AG) and Cisco (a large ICT company). In Germany, metering is not a DSO activity but an assigned task to a MSO. Generally the MSO and the DSO are in the same group of legally unbundled companies. Only 5% of the German market is serviced by other MSOs. Since the introduction of the Yello Meter customers of the supplier Yello Strom can opt for a smart meter from the MSO (Metering System Operator) Yello Sparzähler. The Yello meter is sending encrypted data through the internet router of the customer to the Yello data centre. The customer is able to see the data on a website. The purpose is to create an intelligent energy system that allows customers to measure and control the power consumption of their electrical appliances, enabling them to reduce their monthly bills as well as carbon emissions, while significantly cutting down on peak-period demand.

The privacy and safety of the data transfer in the Yello system were debated. Yello has even received the Big Brother award in 2008 for its leading role in distributing smart meters without any information on the data protection.

A more technical operational challenge concerns the ownership of the meter. The Yello meter is only available for customers of Yello Strom and the meter stays in ownership of Yello Sparzähler. If the customer wants to switch energy supplier, the meter should be exchanged as well. Although Yello is delivering the meter free of charge this aspect probably forms a barrier and could distort the market. Another challenge relates to insecurity about regulation concerning Smart Metering. Germany was planning a large scale roll out of smart meters, which would reduce the need for a Yello Meter. However, due to privacy issues it is not sure when and if a large scale implementation of smart meters can be expected.

In the absence of a national policy, it is interesting to see that some market forces are interested in filling up the gap. Lately the project has been put on hold due to the uncertainty around the regulation, but Yello Strom believes smart metering holds economic potential. It should be noted that this claim is highly debated by many other actors on the German energy market. For example the representative of regulator BNetzA having been interviewed claims that metering in itself can not be profitable, because the potential benefits for consumers are too low. Furthermore, the same regulator does not see an increased role for an ICT company such as Cisco. Both BNetzA and EnBW AG agree that smart metering should not be a task of a DSO, for two reasons. First of all smart meters are not integrated in the grid operation itself, so a service operator or MSO would be a more likely candidate for the enrolment of smart meters. Second, due to the high number of DSOs in Germany, economies of scale cannot be reached by individual DSOs.

Main lessons learned:
- Whether smart metering can be a profitable activity for commercial parties is highly debated.
- A commercial party handling smart meter data triggers public debate on privacy.

CDMA-450, managed wireless network
The project is a cooperation between Alliander (DSO) and network provider KPN. The project aims to develop a private wireless network, which meets the specific requirement for a reliable, safe and secure network for a smart grid and the use of smart assets. Following a more customer oriented strategy, KPN intends in the CDMA-450 project to partner with the energy sector and to realize a tailor made energy industry solution; this is cheaper for both stakeholders and will meet the specific requirements of the energy sector (e.g. power autonomy, and cyber security). A wireless network has been chosen since this would avoid the high costs of connecting all meters. A 450 MHz frequency band is the most ideally suited spectrum for DSO Alliander, because the 450 MHz spectrum has the best building penetration to reach smart meters and has very low network cost. Furthermore, the licenses for the 450-470 MHz could be bought from KPN. Although Alliander owns the network, it is operated by KPN. A third partner, Entropia Digital, deals with the construction and maintenance of masts. One of the main reasons for Alliander to invest in its own wireless network is to ensure that the system will keep operating even if power fails or when commercial networks are overloaded. Furthermore exploitation costs are much lower compared to using a commercial network and a lock-in is prevented. To own and operate a separate network also provides better guarantees for a high level of security. Alliander expects that grid security will become more difficult to maintain when grids become smarter and the role of DER increases. Another good reason for choosing the 450-470 band for smart meter communication is that the General Packet Radio Service (GPRS), currently used for smart meter connectivity is not a long term solution. The reason

for this is that GPRS will be replaced with the 4G network, that will be fully focused on the broadband consumer market.

By allocating the network operation to a partner, the DSO loses some of the hands-on control over the performance of the wireless communication system. Furthermore the spectrum licences are valid for 15 years, although Alliander is currently negotiating an extension with the regulator (ministry of economic affairs Netherlands), it is yet unknown what happens after this period.

The CDMA-450 project shows a high commitment of a large DSO in the large scale enrolment of smart metering and innovative smart grid control. Although two partners are involved, the initiative and most of the investments have come from Alliander. This seems to be contrary to findings from Germany and the UK where the role for DSOs in smart metering is considered marginal. On the moment others Dutch DSOs are seriously considering to join Alliander in the CDMA-450 initiative; which could therefore evolve towards a Dutch Sector initiative. The 450-470 spectrum is still owned by the regulator in six EU member states, in several other countries the licences are owned by other parties, but the might be available for smart metering after negotiation with these parties.

Main lessons learned:

- Whether DSOs are willing to take the lead in a switch to smart grids and smart meters, seems to be dependent on the size of the DSOs.
- Using the 450-470 MHz spectrum for machine to machine communication provides smart metering with a high level of security compared to communication through a commercial network.
- Using the 450-470 MHz spectrum for smart metering could be an option in several EU member states.

Trentino Network spa

Trentino Network is a local public company fully owned by the Autonomous Province of Trentino. The projects aim is leveraging on digitalisation, innovation and the availability of broadband infrastructure to promote local economic growth. In order to reach this goal a medium-long term plan based on the following three steps has been designed:

1. Deployment of the territorial fibre optic backbone and fast connections;
2. Upgrade of the existing copper network;
3. Deployment of a Next Generation Access Network, with a fibre optic link to residential users and companies (FTTH).

By ensuring the necessary fibre network, smart metering becomes a possibility. The DSOs (Set Distribuzione) power grid needs more real time bidirectional communication, which is not guaranteed by all of the existing networking solutions. Taking into account several (utility) functions when installing a new network will lead to significant cost reductions, for the individual services that use the new network.

A main challenge for the network is financing. Due to the low population density the profitability of running the network is expected to be medium or low. For those areas with a low profitability expectation (40% of the population in the province) a public company has to be involved to run the network.

The Trentino Network spa case provides an example of an integrated approach resulting in synergies. Especially combining the goals in the roll-out phase can lead to significant cost reductions. Interestingly in the Trentino case the pursuit of two EU directives is combined, smart meter coverage is increased while the number of households with a broadband internet connection grows as well.

Main lessons learned:

- Combining goals can lead to a significant cost reduction in the roll-out phase, especially for sparsely populated areas.

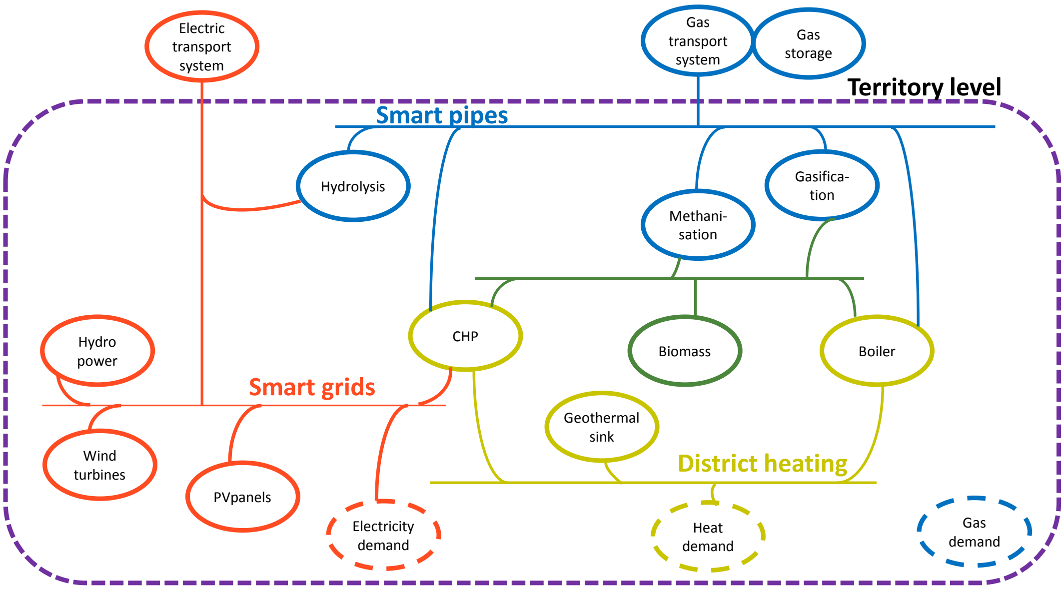
8 DSOs of the gas grid in the Smart Grid environment

- Introduction

The other chapters discuss the role of electricity DSOs. The role for gas DSOs is discussed separately in this chapter. The discussion also includes the results of the interviews with the DSOs of gas grids.

Although smart gas and electricity grids may look similar on the business / transactional level, a number of techno-economic differences justify a separate reflection. The smart gas grid may be defined as a maximisation of the efficiency of the overall energy usage while taking full advantage of all the flexibility opportunities that the gas grid can offer. Figure 7.1 provides an illustration of the opportunities smart gas grids can offer in combination with electricity grids and district heating. This chapter elaborates on the future role for gas DSOs, but does not in particular expand on the benefits of expanding the gas distribution network with new gas connections as such. The figure above demonstrates that there is a place for both smart gas and smart electricity grids in the energy system of the future.

Figure 7.1 Smart meter and Appliances Management Support Unit domains



This chapter is structured as follows:

- First, section 8.1 briefly reviews the key features that differ between gas and electricity systems and identifies (expected) trends in smart gas grids. Given the scope of this study, the focus is on the particular differences on the distribution system level;
- Section 8.2 proceeds with discussing the results of interviews with gas DSOs and business opportunities which can be formulated based on these results;
- Section 8.3 discusses how activities and services that have to be provided in a smart gas grid environment differ from activities in a smart electricity grid.

Finally, section 9.5 in chapter 9 summarises the key observations on the differences between (smart) gas and electricity distribution systems and concludes regarding the implications for the future role and activities for the DSOs in a smart gas grid.

8.1 Differences and trends concerning smart gas grids

This Section elaborates on the key differences between gas and electricity that should be taken into account when analysing the future role of DSOs in smart grids (Section 8.1.1) and lists the key trends currently observed or expected within the gas system (Section 8.1.2).

8.1.1 Differences between gas and electricity systems

Firstly, the key difference between gas and electricity, with potentially important consequences for future governance of smart gas grids, is the feature of *storability*. In general, natural gas is fundamentally easier and cheaper to store than electricity. Apart from large scale underground gas storage facilities, an important source for short-term flexibility is the storing of gas in pipelines, so-called line pack. The potential for line pack is dependent on factors such as the pressure level, the length and diameter of the pipes and the possibility to adjust the pressure levels during daily operations. This inherent flexibility in the gas grid is a marked difference with the electricity where an instantaneous balance in supply and demand of electricity is required. This implies that in comparison to electricity grids, there is relatively less need for, for example, real-time information or for control of end-user appliances.

Secondly, in contrast to (smart) electricity grids, (smart) gas grids may play an important role in bridging the difference in electricity and gas networks by, *allowing for flexible interaction of electricity and different types of gas*. Examples are the use of dual fuel appliances, combined heat and power or P2G technologies at the local or residential level.

Thirdly, the *potential for increasing energy system flexibility* at the end-consumer level varies for electricity and gas end-consumers. That is, residential end-consumers use gas mainly for very basic needs such as heating and cooking, which are relatively more difficult to avoid or postpone during the day than electricity demand. A large number of electrical appliances in the residential sector provides ample opportunities for consumers to optimise their electricity consumption and manage their peak demand. For gas, opportunities are much more limited, as a key driver for demand is the outside temperature. For industrial users, however, opportunities for demand side management are more promising. In fact, bilateral contracts between DSOs and industry already exist (notwithstanding that the number of bilateral contracts in the UK have declined in recent years).

Fourthly, the differences in market dynamics in gas and electricity warrants exploration. In the gas market the prices are usually based on daily prices. Only in countries with liquid intra-day market rest-of-the-day prices or sometimes even hourly products are available. In contrast, electricity production is priced on a more granular level. This is an important input into decisions on establishing a smart grid environment involving – for example – demand-side-management.

Finally, aspects regarding *safety* and *quality* may develop differently for gas and electricity. Gas quality is a relevant issue because of the variety of gases that may seek entrance to the gas grid. This, for example, concerns different grades of LNG, bio-methane or hydrogen. Either infrastructure or end-user appliances will impose strict limits on the quality of gas allowed into the grid.

8.1.2 Trends in gas distribution systems

In addition to the techno-economic differences, distinct or even contrasting trends may currently be observed (or expected) in the gas grids as compared to the electricity grids.

The *prospects of further growth in demand* varies across end-user groups and across countries. Drivers causing a decrease in gas demand are 1) further electrification (electric heat pumps and electric vehicles); and 2) energy efficiency efforts. Drivers causing an increase in gas demand are 1) increasing penetration rates of natural gas in the residential sector; 2) natural growth of commercial and industrial sectors using natural gas; 3) the expansion of district heating systems with combined heat and power plants; 4) substitution of oil-based fuels by gas-based fuels, especially bio-methane or hydrogen; 5) the role of 'green' hydrogen (i.e. hydrogen from renewable sources, notably wind and solar PV) in storing renewable electricity via power-to-gas technology or fuelling mobility may increase on the distribution system level; 6) development of the Micro-CHP market; and 7) development of the market for natural gas vehicles.

The number of *decentralised gas producers* and volumes of gas from their plants (mainly bio-gas or bio-methane) in the gas system are increasing. These may be fed in at the distribution level or at the transmission level , depending on gas quality considerations, the economics related to the feed-in profile, volumes and a required network connection. Although the trend for electricity grids also points to more local electricity generation, there is a large difference in the potential of the two. The feed-in of distributed gas sources is much lower than the feed-in of distributed electricity sources. Furthermore, local residential gas production sites as compared with electricity production sites, such as PV, are less feasible, though not necessarily infeasible in all situations.

In some parts of the European gas system, gas assets at the distribution level may require significant *replacements / refurbishments*. Given the inhomogeneous picture of (potential) gas demand in the future and the emergence of various electric technology options, the economics of replacements may not always be favourable.

The lifetime of existing gas assets at both the distribution and transmission levels may be given a new lease with the *penetration of hydrogen or syngas in the gas system*. The increasingly large amount of electricity generating capacity based on wind and solar PV energy is leading to the increasingly large challenges regarding the electricity system balancing. Apart from options such as demand response and expanding network connections, the conversion of electricity into hydrogen may provide a cost-efficient solution (i.e. power-to-gas). As onshore renewable electricity is produced mainly on the DSO level, the injection point of this electricity may be a gas DSO as well as a gas TSO. But also here, the questions remains on whether the consequently produced hydrogen or syngas (product of hydrogen and CO2) will feed into the gas system at the distribution or the transmission level. The viability of this power-to-gas route may be dependent on factors such as configuration of the electricity and gas grids and the density of producer and consumer sites. Another important aspect to be mentioned regarding power-to-gas is the usage of waste heat as a flexibility tool.

8.2 Interview results

In parallel with the main study, we have interviewed several gas DSOs. As follows, important <u>differences</u> in answers from interviewees are discussed. Furthermore, we identify specific business opportunities which resulted from interviews with gas DSOs.

Role of gas DSOs in smart meter roll-outs

Most of the interviewed DSOs see the smart grid as a mean to an end, a tool that simplifies and improves the functioning and control of the grid. Moreover, some DSOs insist that smart meters are not needed in the gas grid and that investments in/ extensions of the grid itself are preferable instead. The gas sector interviewees pointed out that the gas grid is more flexible than the electricity grid. That is, it is possible to use the grid as a temporary storage (line-pack). Also, the gas demand, especially for heating customers, is less unpredictable as it is temperature-driven. The need for smart gas grids is not felt as very urgent. The decision not to roll out smart meters was explained in some countries by the fact that there is a relatively low demand for gas, limited connections to the gas grid and a low expected response from end-consumers, such as in Spain. In other countries, such as Germany, smart meters for small gas consumers are installed only if the consumer wants it, and it will be attached to the usual gas meter. In contrast, a roll-out of 95% of smart gas meters is planned in France.

Metering (meter installing, operating, maintenance and reading) is mostly done by DSOs. This also holds for Germany, even though metering activities were liberalized (and DSOs act as metering parties of a last resort). The meter itself is mostly owned by DSOs (or metering operators).

Most of the gas DSOs state that residential users are not likely to respond to price incentives and have a stable demand on gas. Moreover, there is no day-ahead market in many European countries yet. However, there is also a view that more frequent meter reading could improve customers' awareness. To add, more frequent data may allow (biogas) producers to decide on timing of injections or improve it. Also, it may speed up switching of suppliers. In Germany, historical data already includes information about differences in consumption patterns of large costumers. Moreover, promotion of energy efficiency is considered by DSOs as an important activity for them to execute, although most DSOs do not consider it their responsibility.

It was mentioned that gas grid operability could become more difficult when decentralized biogas injections develop further. This will also lead to a decrease in the required flows from the interconnection points from the TSO. However, in contrast to electricity DSOs, most gas DSOs disagree with the statement that smart meters can create potential benefits to network owners and network controllers due to improved operations of the network. This position is supported by the expectation that biogas injections will not develop rapidly. Moreover, in contrast to PV and wind, biogas injection is running fairly constant and it can be stored to a certain extent, before being injected into the grid.

With respect to the development of smart domotics and automobile filling infrastructure (natural gas vehicles), the position of gas DSOs is in line with electricity DSOs. They consider these activities not to be a part of the DSOs' tasks.

Business opportunities

Gas DSOs, like electricity DSOs, do not expect many new roles in a smart grid environment, but rather an extension of the current tasks. A few examples are: receiving and managing more frequent data, executing more active congestion management, and more active management of injections of gas of different quality. The latter is seen as one of the most significant aspects. As gas injections in a form of bio-methane and hydrogen (P2G) increase, gas quality management becomes a very important issue.

Load shedding is considered to be limited in the gas sector due to storage possibilities and the fact that gas demand of small consumers is relatively stable and less unpredictable. Nonetheless, disconnection / interruptible contracts with large customers are common in the gas sector (though, as mentioned, decreasing in the UK). The interviewees consider an extension of this practice to be sufficient for their grid operations. In line with this, a flexible capacity tariff (i.e. capacity tariff differing according to time and location) is not considered necessary by most of the interviewees. Some DSOs expect dynamic tariffs that vary too much over time and location can become a market barrier.

A compressor to feed gas into the higher pressure may constitute a solution for congestion problems that currently occur due to an increased injection from bio-methane and power-to-gas installations. Excess gas is compressed and transported to a higher pressure grid. Please note that other solutions are also under development, e.g. within network compression.

Savings opportunities due to remote (de)activation of connections are, compared to electricity connections, considered to be limited. The reason for this is that remote activation of house gas connections to the home is considered to be unsafe.

Technologies, including P2G, cooling using gas, and CHP, can provide flexibility tools for both electricity and gas networks. This connection between two networks is considered to be very important by the most of the interviewees. These technologies could provide flexibility at the distribution, and possibly in the future, at the transmission grid level. Also, new technologies to monitor gas quality could be helpful in the monitoring of the grid.

8.3 Smart gas grid potential

The potential benefits of a smart gas grid significantly differ from the smart electricity grid. We will discuss similarities and differences in terms of (business) potential, for the following smart grid services:

1. Flexibility services;
2. Local energy systems and decentralized gas injection;
3. Infrastructure provision for natural gas vehicles;
4. Grid operation and safety;
5. Energy efficiency services;
6. Data handling and meter ownership.

8.3.1 Flexibility services

As described in section 8.1, gas grids have storage possibilities within the grid. This allows for more flexibility in terms of spatial and temporal differences in supply and demand. Furthermore, gas consumption for heating customers follows the temperature making it easier to predict consumption patterns. Consequently, the potential cost savings using a smart gas grid are lower, because the initial costs on which can be saved are lower. This limited cost savings potential does not imply that flexibility services will never be beneficial.

Should congestion or shortage occur, coordination of storage and demand responses are required. A smart grid can improve the efficiency and effectiveness of this coordination. The extent of these improvement vary, depending on the type of consumer:

- Large scale industrial consumers can be incentivized to adjust their consumption. Currently, this practice already occurs, where the industry uses process gas, has smart meters and bilateral contracts with grid operators;
- Residential gas consumption is only susceptible to demand responses to a limited extent. Interviewees indicated that gas consumption related to heating cannot easily be delayed;

- Industrial customers producing electricity with gas can switch between producing or buying electricity.

Providing flexibility is a key role within smart gas grids. This role may be interpreted in two ways. First, one could point out the inherent flexibility of the gas grid through its storage capability (i.e. line-pack). Second, one could point out the role gas grids can play in optimizing local and regional energy systems by integrating the electricity, gas and heating / cooling markets and infrastructures.

Smart gas grids and smart gas-based technologies could contribute to an overall optimisation of local or regional energy systems by increasing the links to electricity, heating and cooling infrastructure and technologies. Peaks in, for example, electricity consumption (or in theory, any other mentioned energy carriers) could be mitigated by, for example, integrating power-to-gas or alternative storage technologies, heat buffers, duel-firing technologies, and combined heat and power technologies.

Specific functions that play a role in increasing gas grid flexibility and overall energy system flexibility at the distribution level may include (joint) planning of future infrastructure investments, monitoring of system operations in real time, optimisation of grid pressures and flows, and increased cooperation with actors regarding data exchange. Currently, it is common practice for larger DSOs with different pressure levels to have a detailed monitoring system in place.

In conclusion, in the gas grid, the demand for as well as the supply of flexibility services is limited. This does not imply that there is no potential at all: strong coordination between DSOs and large scale gas consumers can lead to appreciable benefits. Hence, we expect that the benefits of a smart grid in terms of improving flexibility services are not significant. This stresses the importance of conducting a SCBA to assess whether the development of an auction platform is at the smart grid level would be beneficial. A promising development, however, is the provision of flexibility services from the gas to the electricity grid and vice versa.

8.3.2 Facilitation of the injection of non-conventional gases;

The emergence of local energy systems is to a large extent focused on the self-sufficiency in electricity consumption and the wish to contribute to create a sustainable energy system. Possibilities for economically feasible gas production on a residential scale are very limited. Consequently, the emergence of local energy systems doesn’t significantly affect the gas grid. However, there may be the issue of decentralised gas injection for a range of DSOs at a more industrial production level.

The decentralised injection of non-conventional gases such as bio-methane, LNG, bio-SNG, coal-bed methane and hydrogen puts specific requirements on existing and future gas grids. A larger variety of gases in the gas grid will require an improved monitoring of gas quality in order to ensure optimal performance of end-use gas appliances. Specific smart gas grid features to this end are remote monitoring of gas quality, active flow and remote pressure control on knots in the grid, improved network analysis and capacity planning and facilitating bi-directional gas networks.
In some cases, island gas grids can emerge around a bio-methane plan if a DSO grid is not in the vicinity.

8.3.3 *Infrastructure provision for natural gas vehicles*

Similar to electric vehicles, the market penetration of natural gas vehicles may suffer from “the chicken and egg” problem. However, the potential benefits offered by a high market penetration of electric vehicles for grid management (storage capacity) do not hold for natural gas vehicles. Consequently, the extent to which DSOs are affected by the development of natural gas vehicle market penetration is, in comparison with electric vehicles, limited. We would like to stress that we have not further assessed the feasibility and market penetration of natural gas vehicles and draw no conclusions related to that. We do note that if natural gas vehicles are going to be adopted on a larger scale in the near future, then it could have implications for gas DSOs in terms of additional local or regional gas demand.

8.3.4 *Grid operation and safety*

Safety is a prime concern for gas systems and smart gas grids could further enhance the safety performance of gas grids, making the grids safer at a better cost-efficiency level. Improvements, such as enhanced automation, monitoring, protection and real-time information, could be induced by adapting smart tools in the field of pressure regulation, traceability, internal pipe inspection, odorisation, and cathodic protection. A prerequisite for a successful implementation of such options is that DSOs have proper incentives to strengthen operations on these aspects via innovation activities.

8.3.5 *Energy efficiency services*

The potential for energy efficiency services in gas consumption in a smart grid context is similar to the electricity consumption (e.g. insight in opportunities due to improved data availability). Consequently, we refer to our findings on energy efficiency services in the main report. Furthermore, in line with results from the French SCBA concerning a smart gas meter roll-out, we expect that energy efficiency potential might significantly contribute to smart gas meter potential.

8.3.6 *Data handling and meter ownership*

Data handling

Similar to the case of electricity, data acquired within the smart grid environment by either private or public actors may be beneficial for overall grid management and the optimal performance of other activities. The data generated may be beneficial for the various regulated and private entities. The handling of data may be arranged under either a regulated arrangement within the DSO or outside the DSO, or under a private arrangement (i.e. competitive market).

Smart meters

The function of owning and managing metering equipment within the smart grid environment is very similar to the case of smart electricity grids. The manufacturing and installation of (smart) gas meters is in practice a competitive market , whereas the ownership and management of metering equipment can be subjected to either a regulated or a liberalised market model.

Our findings with respect to the ownership and management of metering equipment as well as data handling for the electricity grid can in principle be applied to the gas grid as well. Though clearly there are differences which could be further explored. In addition to the findings in the main report, a combined roll-out of smart gas and smart electricity meters might be efficient. Furthermore, these efficiencies may arise in data handling as well. These potential benefits should be assessed in the CBA of the member state.

9 Task 5: Recommendations on the roles of DSOs in the future retail market

Translating the outcomes of the analysis into effective policies regarding the desired future developments in the European energy market is challenging, as the starting positions differ across Member States. Nonetheless, common goals have been agreed to realize an European energy market and the purpose of the policies is to realize these goals, irrespective the differences in national energy markets to date. Consequently, policy implementation will require tailoring at the level of the Member States. For instance, differences in the size of the DSOs have led to heterogeneity in the application of regulation. Moreover, differences in network size and the degree to which decentralized energy resources have been deployed provides for different challenges and possibilities. Hence a tuning in the policy implementation will be required, largely in terms of degree and timing. Differences in economies of scale suggests that ‘one size does not fit all’ and consequently a cost benefit analysis may be required as part of the tuning of proposed future policy measures at national or local level.

In this chapter the recommendations are positioned against the anticipated development of the ‘smart’ energy system. In the discussion of the ‘smart’ developments special attention is given to:
- the role and functioning of the market;
- the role of stakeholders and the DSO in particular; and
- the role of regulation.

The recommendations are provided related to the five smart grid services, which are considered the core of the smart grid and smart metering development. The recommendations are directly related to the role of the DSOs.

9.1 Flexibility services

Provision of flexibility services

We recommend that the provision of the full range flexibility services is performed through a competitive market. This recommendation is supported by product characteristics and a wide scope for innovation, for both of which a competitive market model is beneficial. The product characteristics enable competition, because of a large amount of active sellers, limited number of product categories and the availability of price information. A competitive environment provides more incentives for innovation, accelerating the development and utilization of flexibility services, benefiting society as a whole. We consider that these advantages outweigh potential market entry barriers for the provision of these services.

Procurement of flexibility services by DSOs

Because of their monopolistic characteristics, network and system management are necessarily performed by DSOs and TSOs. Consequently, the procurement of flexibility services for network and system management purposes is a task of the regulated DSOs and TSOs (who thus also remain responsible for decision making regarding optimisation of these tasks). Flexibility services are also required by suppliers and balancing responsible parties. With different objectives this may, at times, lead to conflicting interests. To safeguard the proper functioning of the energy system, a form of coordination will be required to address and resolve these conflicting interests. This coordination may be implemented through the market design and/or regulation. If, over time, the interdependencies and potential conflicts hinder the development and operation of a competitive market for flexibility services, alternative arrangements to match demand and supply may be considered, including the option of an auction under close regulatory supervision. The basis of this decision making should be an assessment of technical and economic feasibility. Amongst others it should be assessed whether distribution networks dispose of sufficient equipment for remote monitoring and control and whether the amount of buyers and sellers is sufficient for developing a competitive market. In addition, because of the international interactions in the market, the extent of required coordination on the European level should be explored.

In cases where the DSO is not effectively unbundled, a conflict of interest may arise between the DSO and other parts of the business, e.g. the supplier or generator business. Flexibility procurement is an additional task leading to more interaction with market parties. To the extent that DSOs with less than 100.000 customers engage in flexibility procurement, this leads to possible conflicts of interest or the appearance of such a conflict. We recommend a market system with effective unbundling, a high degree of transparency (which is stimulated by automated ICT interfaces) and appropriate oversight by the regulator. This would mean that DSOs who are not effectively unbundled are not able to act on the market. Market transparency may be realized through a public auction, whereby all stakeholders are able to observe at what prices the (potentially internally provided) flexibility services are contracted.

Given the complexity of the market for flexibility services, in particular the need for coordination, it is recommended to secure coordination between market and network actors, as to achieve optimal overall system results. A promising option is deploying an auction model, in which there is one platform for each independent energy system, being characterized by a platform on which one TSO and multiple DSOs operate. This platform could be created and operated by an independent stakeholder like a market operator, and supervised by the regulator. It is, however, premature to select one option. We recommend to further analyse the advantages and disadvantages of the different options (of which an elaboration is provided in chapter 6).

Market for flexibility services: by design and supported by price signals

The market for flexibility services may develop from individual bilateral contracting between suppliers and buyers. The conflicting interests among buyers, and therefore the need to coordinate the market transactions, calls for the design and implementation of the market for flexibility services. As the market for flexibility services is a market derived from the primary market for energy supply, we recommend that the energy retail prices are changed from fixed, regulatory prices (where this applies) to market driven, variable prices.

Sufficient incentives for investments in conventional network reinforcements are needed

Sometimes investments in smart grids are not feasible from a technical and/or economic perspective, implying that investments in conventional network reinforcements are the only option and/or most social welfare enhancing. Policy makers and regulators thus should allow for adequate incentives for this type of network investments. For securing that its market and societal benefits are adequately taken into account in investment decisions of DSOs, the network operator may be obliged through regulation to perform an integrated investment assessment, preferably a societal cost benefit analysis (SCBA). Such a SCBA should take into account the robustness of the network investment for different plausible generation and demand scenarios. For limiting administrative burdens, a SCBA might be limited to all investment proposals that meet a certain minimum monetary size.

Level playing field for investments in conventional network reinforcements and smart grids is necessary

Network operators increasingly will have to consider a menu of options for accommodating network demand i.e. conventional network reinforcements as well as smart grids solutions. The higher risks of innovative smart grids solutions for DSOs compared to conventional network reinforcements should be properly accounted for in regulatory assessments for allowing smart grids solutions to be considered as a viable network planning option.

9.2 Charging infrastructure provision for electrical vehicles

Limited changes in role of the DSOs in providing connection to EV charging infrastructure

We recommend that DSOs closely monitor the deployment of EVs and the related charging infrastructure to assure timely availability of the right capacity connections to the grid and the transport capacity within the grid. DSOs should be informed by market participants in advance of proposals for the implementation of new charging points. In that way they are enabled to prepare adequately for adjustments in network planning (investments) and operation. Moreover, potential economies of scope in the development of the infrastructure can thus be identified and realized.

Involvement of DSOs in initial EV charging infrastructure development under condition of an exit strategy

In the long term the charging infrastructure should be in the market domain, to avoid market distortion. Therefore, the starting point should be that the market develops EV charging infrastructure. However, it could be the case that, possibly based on new EU legislation (EC 2013b), Member States decide that in the initial stages of development of EV infrastructure DSOs should be involved. In these cases a clear exit strategy is required so that a competitive market can be established once the market reaches the necessary level of maturity. It is advised either to limit the intervention period beforehand or to plan already a future evaluation moment before the intervention starts.

Guarantee non-discriminatory third party access for using public charging stations

Roaming of charging services is necessary when a customer wants to use a public charging station which is not operated by his own e-mobility provider. Without a roaming agreement, part of the public charging stations are inaccessible to a group of customers. This would slow down the development of the e-mobility market and diminishing positive external effects of charging points. Therefore, non-discriminatory third party access for using a charging station by all e-mobility customers should be guaranteed by legislation for roaming agreements.

9.3 Energy efficiency services

Implementation of energy efficiency services: through a competitive market

The provision of energy efficiency services through the competitive market, as is the case today, should be continued into the future.

The role of the DSO in the provision of energy efficiency services: informative and facilitating role

As a regulated entity the DSO has a limited role to play in the provision of energy efficiency services. However, Member States might decide that DSOs, ESCOs and/or suppliers could play a role in promoting energy efficiency services. To prevent market distortion, we recommend that

DSOs focus on non-discriminatory information provision. Moreover, should DSOs be obliged by Member States to pursue energy efficiency, we recommend them to strive to hiring market parties for the actual implementation. Furthermore, we recommend DSOs to incorporate developments in the energy efficiency services market in network planning and network operations.

The role of regulation: Regulate the use of retail pricing data provided by suppliers
We consider the provision of retail pricing data to consumers (we explicitly do not mean grid tariffs) to be the responsibility of the supplier. This bestows the suppliers with a comparative advantage over other potential providers of energy efficiency services, because suppliers might be active in the market for energy efficiency services. The comparative advantage comprises an informational advantage, which will distort the proper functioning of this competitive market. We recommend that regulation is provided to assure non-discrimination in the supply of pricing information to prevent this distortion.

The role of the supplier: Providing the consumer with retail pricing data
If and when the consumer intends to deploy energy efficiency services, it is his/her responsibility to provide data on energy consumption to the chosen actors in the energy efficiency services market. To allow consumers to do this effectively, suppliers should on consumers' request deliver such retail data in a suitable format. We recommend that market parties come to an agreement on the format for this data (self regulation). If this coordination fails, regulators should set a minimum standard for this type of data.

9.4 Smart metering and data handling

We simultaneously discuss ownership and management of metering equipment with data handling, for purposes of convenience.

Discern between types of data: the AMSU concept
We propose to create a clear distinction between activities related to DSO operations and (future) activities which create value and include but are not necessarily limited to the use of smart meter data. Based on this distinction, we put forward the concept of the Appliances Management Support Unit (AMSU). Specifics of the AMSU concept are elaborately discussed under chapter 6. We recommend to do further research to define where the border between the DSO Smart Meter domain (DSO) and the AMSU domain (market) should be.

Choose the appropriate data model
We propose to include the presented arguments related to ownership and management of metering when choosing an appropriate data handling model. Chapter 5 and 6 discuss the advantages and disadvantages of the three data handling models, which we recommend to use when deciding upon a data handling model. We specify the main advantages and disadvantages of the three models and indicate how the weight of different aspects of data handling can potentially influence the decision.

Concerning the DSO model, we conclude that it disposes of good prospects for the most efficient data handling of the three models. Furthermore, it provides some transparency in data handling by using the AMSU concept (though less than CDH) and allows for innovation through outsourcing of ICT operations to a joint platform (though less than DAM). If the emphasis is placed on the combination of these advantages the DSO model might be most suitable.

Concerning the CDH model, we conclude that it contains the most guarantees for transparent, non-discriminatory and neutral data handling. The most apparent disadvantage is increased regulatory and administrative costs due to setting up a new regulated agent who should cooperate with DSOs. Nonetheless, the CDH model might be suitable if emphasis is placed on transparent, non-discriminatory and neutral data handling.

Concerning the DAM model, we conclude that it provides a high level of innovation. The main disadvantage is required regulation of the metering companies to guarantee access of other market actors to smart meter data for developing new services as well as access of DSOs to smart meter data for network management. We conclude that the DAM model might be suitable if emphasis is placed on a high level of innovation.

Utilize efficiencies and innovation potential

We would like to stress that several opportunities exist to realise efficiencies under different data handling models:

1. Outsourcing the installation and maintenance of smart meters in a competitive market (DSO and CDH model);
2. Outsourcing data handling, jointly with several DSOs (DSO model);
3. Utilize non-excludability of data combined with economies of scale in data collection (all models);
4. Efficient roll-out of smart meters;

Ad 1. Outsourcing the installation and maintenance of smart meters in a competitive market

Should the DSO or CDH model be chosen, we recommend to consider outsourcing installation and operation of smart meters in a competitive market. In this way, the ownership remains unchanged and whilst cost efficiency and innovation are stimulated in a competitive market. This can stimulate cost reduction and innovation in smart meters (in the technological suppliers market) and data management (in the IT-market).

Ad 2. Outsourcing data handling, jointly with several DSOs

Should the DSO model be chosen, we recommend to consider outsourcing data handling. Outsourced data handling by multiple DSOs provides opportunities for efficiencies and transparency in data collection. A cooperation by multiple DSOs increases economics of scale, providing potential savings for the DSOs and of regulatory enforcement of non-discriminatory data provision. Furthermore, this increases transparency of DSO data provision benefits non-discriminatory access because of the resulting interactions amongst DSOs.

Ad 3. Utilize non-excludability of data combined with economies of scale in data collection

All data models show potential in terms of economies of scale to have one actor collect data for all other actors to use. However, as discussed in chapter 6, from the perspective of the actor collecting data, not all types of data are required. Furthermore, for types of data which are not required on a large scale, it might be inefficient to collect this data for all users. To utilize efficiency potential nonetheless, we recommend to regulate that the owner of the smart meter collects and shares[30] data which is required on a sufficiently large scale, while market actors might collect additional data themselves, should they require it for development of niche services. A possible option to realise this is regulating that smart meters should contain a standardised one way connection useable by an AMSU (DSO model).

[30] Of course under conditions of consumer consent.

Ad 4. Scale of smart meter roll-out

Chapter five discusses the (dis)advantages of a roll-out of smart meters in a competitive or regulated setting. These depend on the outcome of the SCBA of the smart meter roll-out. We recommend to conduct a SCBA to decide upon the smart meter roll-out. In a situation where the SCBA for a smart meter roll-out is negative or only slightly positive, a partial instead of total roll-out of smart meters can be considered. This should lead to a partial roll-out to consumers who sufficiently value smart meters will be supplied. A competitive market can more efficiently select and reach customers with higher willingness to pay. Therefore, should the DSO model be chosen, we recommend DSOs to consider outsourcing the selection of customers in the market.

Encourage consumer acceptance and stimulate data security

For all data models hold that simplicity and clarity for consumers need to be enforced. The DAM model requires more efforts from consumers as data owners need to deal with the higher number of interfaces and decisions to be taken. Regulatory measures are needed to limit these administrative interactions to the absolute minimum. This issue is less pronounced in the DSO and CDH market models due to the lower number of data handling entities, but equally important.

Finally, further research in data security is needed in order to identify the size and frequency of data security risks as well as most appropriate mitigation measures. Better insights in this issue may inform policy makers to choose the most appropriate data handling model(s).

9.5 Recommendations for the gas grid

The concept of smart gas grids is different from that of smart electricity grids. The key difference is the much larger possibility of storing energy, notably through the line-pack. Another important difference relates to the future potential of decentralised production. The expectations around decentralised green gas / bio-methane injections in the short to medium terms are rather small compared to the large-scale decentralised electricity production from solar PV, onshore single wind turbines and CHP units, both in number of installations as well as in terms of energy produced. This does of course not mean that decentralised gas production holds no potential.

Although the balancing of demand and supply in gas grids seems less of a challenging issue, the operation and management of gas grids could be enhanced by a smart gas grid and the smart end-use of gas. Smart assets within the grid could further enhance the storage capacity of the grid, whereas smart meter at the customer site could provide means of optimising gas flows throughout the year. However, one needs to realize that the potential benefits in the area of demand response and demand shift are significantly lower than in the case of electricity. The same holds for the potential value of smart gas grids in order to avoid new grid investments. Other activities, such as data handling and exchange, and ownership and management of metering equipment, are similar to the smart electricity grid case and warrant a similar treatment regarding allocation of roles and responsibilities in the private and the regulated domain.

Challenges

Based on the potential of a smart gas grid, we formulated several challenges:

1. The facilitation of decentralised gas production. The injection of ‘non-conventional gases’ (such as bio-SNG or hydrogen) should be properly facilitated with the necessary monitoring in order to guarantee gas quality for the end-users to prevent significant required investments in end-users appliances;
2. Optimal use of gas infrastructure as part of a future energy system. A smart gas grid can contribute to a further optimization of local and regional energy systems and is therefore a key part of the what could be called a smart *energy* grid. The gas grid can function as the inter-linkage between electricity and heat systems and thereby may contribute to an optimal management and development of a local or a regional energy system. A barrier in this respect could be the fact that gas, electricity, and heat systems are currently separately regulated. Here we mainly refer to the economic regulation set at the member state level (i.e. performance based regulation of gas and electricity networks at the transmission and distribution level). This needs to be reconsidered in the future if suboptimal energy infrastructure configurations are to be avoided;
3. Utilization of efficiencies in the roll-out of smart electric and smart gas meters. Potential savings could be obtained when installing smart gas and electricity meters simultaneously;
4. Utilization of efficiencies in jointly handling and/ or providing gas and electricity data. Potential savings may be obtained when handling or providing this data in a coordinated fashion (e.g. sharing a single communications connection).

Recommendations

Based on the smart gas grid discussion and the interview results, we provide a number of recommendations. These recommendations should be viewed in parallel with the recommendations formulated above. To stress this point, the recommendations below should not be interpreted separately from the recommendations above nor should the recommendations above be applied to the smart gas grid without the nuance provided below.

We put forward the following recommendations:

- The limited potential of flexibility services in the gas grid stresses the necessity of analyzing whether the benefits of a procurement model outweigh the resulting administrative burdens. We recommend that member states explore this, using a SCBA;
- Explore the potential of flexibility services provided by the gas grid to the electricity grid and vice versa;
- The development of natural gas vehicles infrastructure is best left to the market. Should a Member State decide to promote this via DSOs, a clear exit-strategy for the DSOs should be formulated and executed when the market is able to take over the infrastructure provision, preventing market distortion;
- If smart electricity meters are rolled out, efficiencies resulting from a combined roll-out with smart gas meters should be further explored, e.g. by conducting a SCBA;
- If smart electricity meter data is collected and provided to the market, explore efficiencies of collaboration between electricity and gas DSOs in data collection, transmission and handling.

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Annex A: Questionnaire

Three sets of questions for questionnaires and interviews have been used in the project and are listed below:

1. Questions for online questionnaire;
2. Questions for interviewing electricity actors;
3. Questions for interviewing gas actors.

Questions online questionnaire

Part 1: The following questions are meant to gather some background information about you and your company.

1. You and your company have been asked to participate in this survey. Are/were you personally involved in Smart Grids and/or Smart Metering projects?
    - Yes
    - No

2. -->IF NO: You are/were not personally involved in Smart Grids and/or Smart Metering projects. Is there someone within your company/organisation who is/was?
    - Yes
    - No

3. --> IF 2YES: Based on your answers, it seems that someone else within your organisation/company is better placed to complete this survey. We kindly request you to forward this survey to that person. You can now close the questionnaire and your colleague can continue at any convenient time before **September 18** using the same link in the email.

    Whenever forwarding this questionnaire to a colleague is not an option, we kindly ask you to continue completing this survey yourself. You can do this by clicking the 'next' button.

4. -->IF Q1 YES: What kind of Smart Grids/Smart Metering project(s) are/were you involved in? *You can select multiple options.*
    a. Development project(s)
    b. Roll-out project(s)
    c. Implementation project(s)
    d. Demonstration project(s)
    e. Other, please specify

5. --> IF D, Please specify which partners are/were involved in the project..

6. -->IF Q1 YES: What role did you/your company have in the Smart Grids/Smart Metering project(s)? *You can select multiple options.*
    a. Technical
    b. Regulatory
    c. Economic
    d. Advisory
    e. Other, please specify

7. Which sector is your company/organisation active in?
    - Public sector (government)
    - Regulation (federal or regional)
    - Transport System Operation
    - Distribution System Operation
    - Energy production
    - Energy supply
    - Energy metering
    - ICT
    - Telecom operation

- Household appliance manufacturing
- Technological Research Institute
- Consumer Association/Platform
- Renewable Energy Association/Platform/Network
- Energy Efficiency Association/Platform/Network
- Sector organisation
- Other, please specify

Part 2: Roles and responsibilities - General

8. Which tasks do you currently perform in your market?
   You can select multiple options.
   - Grid management (operation & maintenance)
   - Indirect grid balancing (for instance by sending price signals to aggregators, thus contracting flexibility)
   - Direct grid balancing (actively connect or disconnect final consumer to or from the grid)
   - Market facilitation
   - Energy supply
   - Energy production
   - Data collection (meter information)
   - Central data management and usage (use the data to benefit an efficient network and deliver real consumer benefits)
   - Services to final consumers (such as energy efficiency and energy savings advice, advice on energy usage, advise on flexible consumption, advise on flexible production etc.)
   - If other, please specify

9. According to you, which market player is best placed to be responsible for the following:

	TSO	DSO	Consumer	Metering company	ICT company	Aggregator	Energy supplier	Energy producer	ESCO	If other, please specify
Balance of demand/supply (frequency supply)										
Demand Side Management (direct load control)										
Demand Response (influence consumer decisions)										
Black Start capability										
Information exchange / Data handling										

	TSO	DSO	Consumer	Metering company	ICT company	Aggregator	Energy supplier	Energy producer	ESCO	If other, please specify
Meter ownership management										
Meter reading										
Operation of local energy markets										
EV charging										
Anti-islanding operation										
Islanding operation										
Security congestion management (short-term)										
Firm capacity management (long-term)										
Voltage and power quality control										

10. Is a specific role or task needed to aggregate small scale distributed generation? (for instance, for a neighbourhood of about 4.000 households, all producing electricity with solar panels on their roof tops)
    - Yes
    - No

11. -->IF YES: According to you, who would be best placed to take up this role/responsibility?
    a. TSO
    b. DSO
    c. Aggregator
    d. ESCO (Energy Service Company)
    e. Energy Cooperation
    f. Energy supplier
    g. If other, please specify..

12. In the new energy market with smart grids and smart meters, DSOs will neutrally facilitate the provision, by competitive players, of energy efficiency services
    - I agree with the above written statement
    - I do not agree with the above written statement
        - If needed, elaborate why

13. Demand Response of small consumers should be the responsibility of:
    a. TSO
    b. DSO
    c. Aggregator / Energy Cooperation

d. If other, please specify..

And please elaborate on your choice and how you see this role.

Part 3: Roles & responsibilities - focus on DSOs

14. In your opinion, which tasks should be performed by the DSO (in the future)?
 You can select multiple options.
    - Grid management (operation & maintenance)
    - Indirect grid balancing (for instance by sending price signals to aggregators, thus contracting flexibility)
    - Direct grid balancing (actively connect or disconnect final consumer to or from the grid)
    - Market facilitation
    - Energy supply
    - Data collection (meter information)
    - Central data management and usage (use the data to benefit an efficient network and deliver real consumer benefits)
    - Services to final consumers (such as energy efficiency and energy savings advice, advice on energy usage, advise on flexible consumption, advise on flexible production etc.)
    - If other, please specify

15. At the moment, most countries use passive network management (the “fit-and-forget” structure). When the concentration of Distributed Generation and Distributed Energy Resources increases, other ways of distribution network management might become more appropriate. According to you, which kind of network management is most suited?
    a. Passive network management*
    b. Reactive network integration**
    c. Active system management***

*This approach implies resolving all issues at the planning stage, which may lead to an oversized network.
** Congestions (or other grid problems) are solved at the operation stage by restricting both load and generation. This solution could restrict DG injections during many hours per year and lead to negative business case for DG if they are not remunerated for the restrictions.
*** The active approach would allow for interaction between planning, access & connection and operational timeframes. Different levels of connection firmness and real-time flexibility can reduce investment needs.

16. --> IF C: This system requires DSOs to have tools to maintain network standards. Additionally they should have the possibility **to buy flexibility** from Distributed Generation in order to optimise network availability in the most economic manner or to manage network conditions which are beyond the contracted connection of the customers.
    - I agree
    - I do not agree

17. With the implementation of more Distributed Generation and the electrification of appliances, more peaks in the usage of distribution grids is to be expected. In order to keep the distribution grids able to facilitate the demand and supply, roughly there is a choice between 1) investing in more grid capacity, which is quite expensive and will be the task/responsibility of the DSOs, and 2) restricting DG injections or parts of consumption during peak hours, which may be

inconvenient to electricity suppliers and consumers and can lead to a loss of income for electricity suppliers. When looking at this dilemma, an important question is: “how much grid-investment is required by society, or how many hours of peak-hour cut-offs are acceptable”?

- I agree
- I do not agree

18. --> IF YES. Who should solve this matter?
    - The European Commission
    - National Member States
    - Regulators
    - DSOs
    - Energy suppliers
    - DSOs + Energy suppliers
    - Aggregators
    - If other, please specify

19. Variable network access contracts, in which generation operators are incentivised to limit peak power in-feed, would be an option to help with possible network overload problems.
    - I agree
    - I do not agree

20. Variable network access contracts should be executed direct between DSOs and generators/load
    - I agree
    - I do not agree

21. Variable network access contracts should be executed indirectly between DSOs and aggregators who would pay a yearly option premium to DG/Load and then offer flexibility to the DSO.
    - I agree
    - I do not agree

22. Could services be supplied to DSOs <u>by commercial actors</u> in order to make grid management more efficient?
    - Yes
    - No

23. --> IF YES, could you specify which services could be supplied and how they can be valorised?

24. “DSOs should be allowed to coordinate the offering of new system services, as required by the new Energy Efficiency Directive (Art 15.1 of 2012/27/EC) while ensuring the security, integrity and quality of supply in their networks. The DSO is best placed to facilitate this mechanism as the data need to be gathered at substation level and in-depth knowledge of the grid layout and its behaviour is required. Moreover, the DSO has a legal responsibility to ensure that such technical constraints are mitigated”.
    - I agree
    - I do not agree

25. Active system management will affect the amount and structure of operational expenditure and would replace some CAPEX with OPEX.DSOs should be able to look at the business case for both the investment solution (CAPEX) and the service-based solution (OPEX), or a mixture of

the two, and decide which is preferable. DSOs need to be provided with adequate remuneration for the most adequate solution: investment or active system management tools including procurement of flexibility services from network users.

- I agree
- I do not agree

26. Should the <u>procurement</u> of flexibility services from network users be a regulated or commercial role?
    - Regulated
    - Commercial

27. --> IF Regulated. Should the cost of procurement of flexibility services from network users be remunerated through regulated DSO revenue?
    - Yes
    - No

28. DSOs should act as enablers of demand side participation in the form of information hubs
    - I agree
    - I do not agree

29. DSOs should be responsible for gathering consumption data (through meter readings) and dispatching it
    - I agree
    - I do not agree

30. Consumption data should only be provided to licensed service providers, thereby safeguarding confidentiality of information.
    - I agree
    - I do not agree

31. In order for DSOs to be able to manage their grids sufficiently in the future, it is required for them to invest in their own telecom system.
    - I agree
    - I do not agree

32. In order to help establishing ICT-standards for the energy sector, it is a good idea that ETSI (European Telecommunications Standards Institute) helps, because they can use their experience from the telecom sector. One could imagine that a telecom style standardisation would be beneficial to the Telecom industry, and would make it more difficult for purely energy market actors to control this market.
    - I agree
    - I do not agree

33. When drawing from past experience in the telecom industry, the business approach of network operators will move from 'managing assets' to 'managing a portfolio of services'. For instance, in stead of thinking in energy connections, network operators should think in terms of energy services, like the telecom industry has shifted from managing telephone lines to supplying (bundles of) services to the customer.
    - I agree
    - I do not agree

34. Please specify how you would describe each of the following services:
    - Access services
    - Market facilitation services
    - System operator services
    - Energy transport services

35. Access services should be
    - Regulated
    - Commercial

36. Market facilitating services should be
    - Regulated
    - Commercial

37. System operator services should be
    - Regulated
    - Commercial

38. Energy transport services should be
    - Regulated
    - Commercial

39. Advanced meters might become an object used to create barriers to competition by raising market entry and switching costs, especially in case the retailer is the owner of the meter. *Would that be a reason to assign metering equipment control to DSOs?*
    - Yes
    - No

40. The smart meters data should be managed by:
    - The DSO
    - A newly introduced regulated third party (central data hub)
    - Data access point managers; a commercial role played by certified companies

41. A joint venture model, where communication infrastructure for smart grids becomes part of smart grid infrastructure, i.e. falling into the regulated domain, but at the same time ICT/Telecom companies providing their expertise in building and operating this new infrastructure, thus generating revenue outside the regulated domain, is a good idea.
    - Indeed, this is a good idea
    - No, this is not a good idea

42. Who should own electric vehicle charging points?
    - The public lighting company
    - Private investors
    - The municipality
    - The DSO
    - If other, please specify

43. Should DSOs be allowed to purchase services with economic value from Distributed Energy Resources, such as network congestion management, voltage control, or support to system recovery after a local blackout?
    - Yes

- No

44. The potentials of Distributed Energy Resources can be used to support short- and long-term TSO and DSO duties. Therefore, the functions of DSOs will likely become more similar to the functions TSOs have.
    - I agree
    - I do not agree

45. --> IF DSO. If my company would be sufficiently incentivised, we would be willing to team up with other small DSOs to invest in ICT or EV infrastructure.
    - Yes
    - No

46. If you consider the future DSO to be a market facilitator, please define the new tasks/roles (which have not previously been identified) this facilitator should have.

47. Referring to the previous question, which new roles could/should be regulated or purely commercial?

Part 4: Roles & responsibilities - focus on DSOs

48. Task execution will differ between member states due to diversity of energy market design and network regulation across European member states. Hence an (qualitative) evaluation of the value of new tasks given this diversity is foreseen as well as identification of regulatory measures that either hinder or promote smart grids.

    Should new tasks be evaluated given current market design and network regulation or given changes in market design and network regulation?

    - Current market design and network regulation
    - Changes in market design and network regulation

49. Which energy market design and network regulation topics do you think are most important for enabling the valorisation of new tasks for DSOs and/or other stakeholders such as provision of flexibility services, energy efficiency services, infrastructure for electric vehicles, and facilitating local markets for energy?
    You can select multiple options
    - Minimum size requirements for market participation of DER (e.g. 1 / 5 / 10 MW)
    - Rules regarding symmetric upward and downward bids in balancing markets
    - Lack of markets for provision of system services
    - Lack of investments in stimulating smart grids involvement of DER
    - Lack of regulatory measures to enable a level playing field for smart grids
    - Cost allocation by network tarification in many Member States only aimed at consumers, excluding payments by generators

50. In a sustainable energy system with increasing amounts of DER there is a higher need for flexibility. Market actors need flexibility for limiting portfolio imbalance, network operators for limiting grid investments that are used very infrequently and marginally. In order to guarantee equal possibilities for commercial market actors and regulated DSOs to procure flexibility

services, an independent stakeholder like a regulated ‘flexibility services exchange operator’ is required.

- I agree
- I disagree

51. The deployment of innovative network technologies by DSOs is closely related to prevailing network regulation. The current regulatory environment governing DSOs tends to imply biases against the application of innovative network concepts to the advantage of conventional grid solutions. Deployment of innovative smart grid technologies that enable active involvement of network users in day-to-day grid operation carry higher risks for DSOs and therefore require higher remuneration compared to less risky passive ‘fit-and-forget’ oriented network management. However, network regulation generally offers compensation for investments based upon a standardized and uniform low risk profile assuming passive network management. Remuneration for DSOs investments should better reflect their individual risk profile to offer equal chances for smart grids.
    - I agree
    - I disagree

52. The present design of network charges does not provide a level-playing field amongst all distribution network users. The higher diversity of network users with more diverse consumption and production patterns, given the application of uniform charges over the whole distribution system, implies increasing cost-socialization and hence cross-subsidization. Network tariffs for users therefore do increasingly defer from the costs they cause to the system. Therefore the absence of economic signals to certain groups of grid users and the hidden subsidies to other groups will be more difficult to justify. Adaptation of network tarification (and/or energy market pricing as it is the aggregate economic signal that matters) is required.
    - I agree
    - I disagree

53. --> IF YES, Which potential solutions to improve economic signals to groups of grid users do you prefer?
    You can select multiple options
    - Differentiation of network charges according to zones within the distribution system
    - Differentiation of network charges according to different types of network user profiles
    - Introduction of generation use-of-system charges in countries with none or limited network charges for generators
    - Keeping the network charges uniform, but providing economic signals through changes to energy market granularity (zones or nodes within countries) and/or increased time dependency of retail prices

54. If you have anything to add, please feel free to use the textbox below.

Questions interview electricity actors

Introduction

5. Please provide a brief description of yourself, your company, your role and your involvement in smart meter and future energy market projects within the company / organisations you work for.

6. Please provide a brief description of the current electricity and gas market. Your answer should give an overview of the current market model, the functioning of the market, the roles of the stakeholders. Please also provide data on the structure of the market (how many actors are active in the field of TSOs, DSOs, suppliers, producers, metering companies, …). Please also provide more information on the current role and activities of these stakeholders. Please also indicate if, and to what extend, their role and activities are regulated or non-regulated.

7. Please provide a detailed view over the role, tasks, responsibilities of your organisation in the current market. How would you describe the relationship with other market actors / stakeholders?

8. If you are not acting as DSO, please describe your position in relation to the DSO. If there is interaction between you and the DSO, please provide a detailed description of how this works.

9. Please describe the current role and position of DSOs in your market. The information you provide should at least cover the number of DSOs active in the market, the services they cover (gas, electricity, water, etc), the (variation) in size between the DSOs (geographical, (geographical, number of clients).

The role of DSOs - Framework

10. Due to technological developments and smart grids, many new activities and roles can potentially develop. Based on your current thinking, <u>under what circumstances</u> should these new roles be taken up the DSO? Potential factors which could play a role are: is the activity "closely related" to the core business of the DSO (efficiency motive: other parties could only fulfil this role at significantly higher costs); could there potentially be a market for this activity (non-competition motive: DSOs should not distort competition); could the activity result in a conflict of interest for the DSO? Could the activity result in a conflict of interest if other parties were to do this activity?

11. According to you, when determining if something can / can not or should / should not be a task of DSOs, how do the following factors play a role in this decision?
    a. Public goods
    b. Economies of scale
    c. Incentives for innovation
    d. Customer orientation
    e. Non-discriminatory market access c.q. level playing field

12. According to you, when should something be <u>exclusively</u> be a task of DSOs?

Energy market activities

Because of the development of smart grids, this research has distinguished the following activities as becoming more and more important in the future energy market:

- Ownership and management of metering equipment;
- Data handling
- Flexibility services: i.e. congestion management, system balancing and ancillary services like voltage control;
- Infrastructure provision for Electric Vehicles;
- Energy efficiency advice and support;
- The following questions will relate to these activities.

Smart meters

13. Please provide a detailed overview of the current situation related to the introduction of smart meters (smart grids) in your market. Has a Cost Benefit Analysis been conducted? What was the outcome? What is the policy of the government in relation to the roll-out of smart meters?

14. Which role does you organisation play in the field of the introduction of smart meters in the market?

15. Please describe the current situation with regards to the roll out of smart meters in your country / region? Your answer should at least cover the national roadmap and possible implementation plan. Please also indicate which key functionalities for the smart meter will be included. Who are the main drivers behind the implementation of a smart meter roll-out?

16. Should the DSO have a role in owning and/or managing smart metering equipment? Why (not)? If yes, under what conditions (e.g. unbundling, strict rules on the use of data....) should the DSO be involved? If the DSO should have a role, would that be an exclusive role or should other parties be allowed to play a role in these areas as well?

17. In some countries, DSOs install smart meters at the customers' premises. Smart meters require technical maintenance and eventually software upgrades / updates. With more smart meters being rolled out, these activities could become more important and eventually generate advantages for the customer (e.g.; remotely installing new software programmes to improve the meters' performances). Do you see this as a role for the DSO? If yes, why? If no, who should offer these services?

18. Should a customer own a smart meter? In case you think customer should not own their smart meter, who should own the asset then? Why?

19. In a regulated market environment, the cost of metering – depending on the market model- can be recovered via the regulated tariffs. The cost is thus socialized. In a smart meter environment, technological innovation based on smart technologies could lead to improvements in operational efficiency, to the benefit of the DSO. Do you agree that in that case, depending on the market model, costs related to smart metering are not distributed over the customers because they are being compensated by the efficiency gains at the DSO-level? If not, please elaborate why.

20. Depending on the market model, how do you see the role of the metering company evolve in the future? Please provide details on the current metering activities in your market (who does

the metering, how does the data flow work? Which parties are involved?). Should the metering company be integrated in the DSO, should it be an independent entity? Could the metering activities be operated in a commercial environment or should this activity be regulated?

Data handling

21. Could more frequent and more detailed measurements increase the information flows to the customer? If you think this is true, please specify how you see this improvement? Please also describe if/where the DSO could play a role.

22. In order to assist you in deepening the answer given for question 7, you hereby find a list of specific data. Please elaborate for each of the data groups, how smart meters could improve the access to and use of these data by all market actors . Also indicate which (future) role DSOs can (not) play in relation to these data (data collection, data management, data communication, etc) and explain why.

- Access to actual consumption (and production) data
- Access to historical consumption and production data
- Access to information on cost and consumption data
- Access to information for *switching* and *contract changing*
- Access to information for actual accurate *consumption base billing*
- Access to information on actual consumption patterns for supply offerings
- Access to information on actual volumes consumed or fed in to the grid for flexible transport offerings

23. Who would be the best placed market party to collect smart meter data? Should that be a commercial or a regulated party? If the last, would a *legal* separation of a DSO and electricity (or gas) producer/supplier be sufficient to guarantee independent data collection and management, customer privacy and facilitation of the market (without creating a monopoly position for a specific market actor due to asymmetric information)?

24. If smart meters would allow for a swifter supplier switch and as such create advantages for the customer / end user, do you see any change in the role of the DSO in relation to this switching process?

25. Smart meters installed at the customer premises offer the possibility to collect data which in turn can be used by suppliers to offer real time pricing and other innovative tariff structures. Depending on the market model, do you see a specific role for the DSO in this field of data management, oriented towards a better load profiling and demand forecasting which helps suppliers in making tariff proposals to customers?

26. the THINK report identifies three models for data handling in the market: a. where the DSO is acting as market facilitator and is responsible for all processes and sub processes related to metering and metering data processing b. where an independent third party under a regulated monopoly regime is responsible c. where a trusted data access point manager with a commercial role is in charge of metering data management and metering data processing. Which model is, according to you, most suited and why?

27. ICT and telecoms could play an increasingly important role in the smart meters market, as data collection, data handling and data transfer are required to operate the market. From this

perspective, who should invest in the required ICT platforms? Why? Should the development of ICT platforms be developed in a regulated market or in a commercial market? In case you consider this should be developed as a joint approach by both the actors in the energy market and the ICT/telecoms sector, please describe how this could work.

Flexibility services

28. Please indicate how smart meters could eventually contribute to better load shedding (and reducing peak load). How could this work? Could smart meters play a role in this by remotely activating and deactivating connections? Please clarify how you see the roles of different market actors in this process and give arguments for this.

29. Which role could smart meters play in relation to the quality of the energy distribution? How do you see the role of smart meters in relation to for example voltage deviations and how could this work in favour of the customer? Do you see an extension or reduction in the role of the DSO in this field? Please provide argumentation.

30. In principle, DSOs ensure the system stability and grid operations. With DER becoming more and more available, the DSOs can use this DER to fulfil their tasks related to grid operations. Buying new energy- and capacity-related products from flexible DER could offer advantages to DSOs, in terms of quality of service, grid loss reduction, voltage control. However, if DSOs were to buy these products, they would enter a competitive market and would have to compete in a open market with other market actors (such as energy suppliers and aggregators). Please describe how this activity should be organized, depending on the market model, in order to avoid an abuse of a dominant position by the DSO, acting as market facilitator.

31. Please comment on the following statement: '*Making the capacity tariff flexible according to time and location is necessary for DSOs to develop other (transport) services next to managing the physical grid'.*

32. Please indicate whether you agree and comment on the following statement:

'*Smart grids and smart meters can only provide a solution for the changing energy landscape if:*

- Small companies and households will be offered flexible capacity connexions to electricity and gas (flexible contracts);
- SMEs' and household customer consumption data will be used to allocate their needs in a smart manner the settlement process. This means that **standard** consumption profiles will no longer be used;
- The intra-day commodity market will also be opened up to SMEs and households e.g. through aggregators

33. The following tasks could in the future energy market with smart meters (still) be executed by DSOs:

- Grid infrastructure management;
- Grid balance management;
- Grid congestion management

Please elaborate if and why (not) you think DSOs should be the ones (not) executing these tasks.

34. Please comment on the following statement:
'In the future energy market, consumers have to get used to being switched off (or down) from their networks from time to time and at times being restricted in feeding back energy into the grid. They should also get used to hedging for this risk by a tariff structure or a cooperation with an aggregator'. Please also indicate how you see a possible role for the DSO in this process and give arguments why or why not.

35. Please describe how you see the role of the aggregator as market actor. Please also elaborate how you see the relationship between DSOs and aggregators. Which interplay could there be and which roles and responsibilities could be taken up by the aggregator?

36. In relation to the products that DER could offer to TSOs and DSOs, please explain how you see the interaction between TSOs and DSOs. Which actions could a DSO take towards DER when it comes to congestion management? Which actions could a TSO take towards DER connected to the distribution grid? Please give arguments.

37. ERGEG stated in its report 'GGP on Regulatory aspects of smart metering for electricity and gas' (Ref. E10-RMF-29-05, page 19) that smart metering systems can create potential benefits to network owners and controllers, depending on the market model, *because of the better operability of the network*. According to ERGEG it would allow the network owners to check whether network operators do their job in the right way. Do you agree with this statement and please indicate why (not). How would you describe the activity of 'network operability'?

38. The European Directives state that both TSOs and DSOs are responsible for the operation, maintenance, grid planning and development of their systems. For the DSOs this includes voltage control and load/DG curtailment, in the event of emergencies. The THINK report labels the activities of the DSO as 'local congestion'. The TSO has frequency containment, frequency restoration and the replacement of generation in its tasks. The THINK report labels these activities as 'system balance'.
Given this situation, do you agree that DSOs are responsible for local congestion and TSOs for the overall system balance? If not, please indicate why.

39. Please describe how you see the process of allocation and reconciliation in the future energy market. Please also elaborate on the role of the DSO in the process. In case the future role should deviate from the current role, please elaborate on the differences and interplay.

Infrastructure provision for EV's

40. Please define which roles DSOs can play in the field of EV charging infrastructure. Your answer should at least cover the infrastructure (who installs the infrastructure and who owns the infrastructure?) and infrastructure investments (who pays for it and how could costs be recovered?). Do you see a specific role for DSOs in this field? Please give arguments.

Energy efficiency

41. Do you think smart meters could play a role in creating an energy efficiency awareness? For example: by providing the customer with updates on consumption and exceptional consumption. In case you are convinced that smart meters could enable this, where do you see a role for the DSO? Could you compare that scenario with the role DSOs currently play in the field of energy efficiency?

42. A combination of smart meters and smart domotics or smart household appliances could help customers to manage their consumption. As such, this could be beneficial to the customer. Do you see a role for the DSO in this interaction between the individual smart metering system and the energy network. Would there be a new role for the DSO in relation to this (new) grid/end user interface - interaction?

Concluding

43. What are the main business cases for smart grids in your opinion?

44. To which extent do you see scope for high value smart grid added services by market actors and network operators respectively?

45. Sometimes the smart grids development is characterized in the following phases: (1) smartening the grid by real-time network controllability; (2) involving producers and consumers in real-time smart grids operation; (3) local system balancing and micro-grids. What is your opinion about this distinction in smart grid development phases?

Questions interview gas actors

Introduction

1. Please provide a brief description of yourself, your company, your role and your involvement in smart meter and future energy market projects within the company / organisations you work for.

2. Please provide a brief description of the current electricity and gas market. Your answer should give an overview of the current market model, the functioning of the market, the roles of the stakeholders. Please also provide data on the structure of the market (how many actors are active in the field of TSOs, DSOs, suppliers, producers, metering companies, …). Please also provide more information on the current role and activities of these stakeholders. Please also indicate if, and to what extend, their role and activities are regulated or non-regulated.

3. Please provide a detailed view over the role, tasks, responsibilities of your organisation in the current market. How would you describe the relationship with other market actors / stakeholders?

4. If you are not acting as DSO, please describe your position in relation to the DSO. If there is interaction and contracts between you and the DSO, please provide a detailed description of how this works.

4a.What are the existing roles and activities of the DSOs?

4b. What are the national rules for suppliers of the last resort and metering company of the last resort?

5. Please describe the current role and position of DSOs in your market. The information you provide should at least cover the number of DSOs active in the market, the services they cover (gas, electricity, water, etc), the (variation) in size between the DSOs (geographical, (geographical, number of clients).

The future role of DSOs - Framework

6. Due to technological developments and smart grids, many new activities and roles can potentially develop. Which new roles do you see in the future for a DSO? Which new activities do you see in the future for a DSO? Please provide argumentation.

Based on your current thinking, under what circumstances should these new activities or roles be taken up the DSO?
Potential factors which could play a role are: is the activity "closely related" to the core business of the DSO (efficiency motive: other parties could only fulfil this role at significantly higher costs); could there potentially be a market for this activity (non-competition motive: DSOs should not distort competition); could the activity result in a conflict of interest for the DSO? Could the activity result in a conflict of interest if other parties were to do this activity? Please provide argumentation.

7. According to you, when determining if something can / cannot or should / should not be a task or a role of DSOs, how do the following factors play a role in this decision?
a. Economies of scale
b. Incentives for innovation
c. long-term perspective
d. view of end-consumer
e. Non-discriminatory market access c.q. level playing field

f. strict governmental control and transparantcy requirements

8. According to you, when should something be exclusively be a task of DSOs?

Energy market activities

Because of the development of smart grids, this research has distinguished the following activities as becoming more and more important in the future energy market:

- Ownership and management of metering equipment;
- Data handling
- Management of flexibility services: i.e. congestion management, system balancing and ancillary services like gas quality information;
- Infrastructure provision for Gas in Transport;
- Energy efficiency advice and support;

The following questions will relate to these activities.

Smart meters

9. Please provide a detailed overview of the current situation related to the introduction of smart meters in your market. Has a Cost Benefit Analysis been conducted? What was the outcome? What is the policy of the government in relation to the roll-out of smart meters?

10. Which role does you organisation play in the field of the introduction of smart meters in the market?

11. Please describe the current situation with regards to the roll out of smart meters in your country / region? Your answer should at least cover the national roadmap and possible implementation plan. Please also indicate which key functionalities for the smart meter will be included. Who are the main drivers behind the implementation of a smart meter roll-out?

12. Should the DSO have a role in owning and/or managing smart metering equipment? Why (not)? If yes, under what conditions (e.g. unbundling, strict rules on the use of data....) should the DSO be involved? If the DSO should have a role, would that be an exclusive role or should other parties be allowed to play a role in these areas as well?

13. In some countries, DSOs install smart meters at the customers' premises. Smart meters require technical maintenance and eventually software upgrades / updates. With more smart meters being rolled out, these activities could become more important and eventually generate advantages for the customer (e.g.; remotely installing new software programmes to improve the meters' performances). Do you see this as a role for the DSO? If yes, why? If no, who should offer these services? Please provide argumentation

14. Should a customer own a smart meter? In case you think customer should not own their smart meter, who should own the asset then? Why?

15. In a regulated market environment, the cost of metering – depending on the market model- can be recovered via the regulated tariffs. The cost is thus socialized. In a smart meter environment, technological innovation based on smart technologies could lead to improvements in operational efficiency, to the benefit of the DSO. Do you agree that in that case, depending on the market model, costs related to smart metering are not distributed over the customers because they are being compensated by the efficiency gains at the DSO-level? Which efficiency gains do you see for DSO? If not, please elaborate why.

16. Depending on the market model, how do you see the role of the metering company evolve in the future? Please provide details on the current metering activities in your market (who does the metering, how does the data flow work? Which parties are involved?). Should the metering company be integrated in the DSO, should it be an independent entity? Could the metering activities be operated in a commercial environment or should this activity be regulated?

Data handling

18. Please explain, which data are currently sent between the different market participant e.g.

- from the DSO to the supplier,
- from the supplier to the end-consumer,
- from the DSO to the end-consumer,
- from the DSO to the TSO and vice versa
- from the DSO to the shipper
- from the metering service provider to the DSO
- from the metering service provider to the supplier
- from the metering service provider to the end-consumer
- from the meter to the end-consumer (in the house via HAN or self-reading on the display)
- from technical grid installments internally
- Metering data, core data of the costumers, allocation data, load profiles, etc.

17. Could more frequent and more detailed measurements and meter readings increase the information flows to the customer? If you think this is true, please specify how you see this improvement and how the information shall be transferred from the meter to the consumer (meter reading)? Please also describe if/where the DSO could play a role. Can you also indicate who is paying the telecommunication costs?

18. In order to assist you in deepening the answer given for question 17, you hereby find a list of specific data. Please elaborate for each of the data groups, how smart meters could improve the access to and use of these data by all market actors . Also indicate which (future) role DSOs can (not) play in relation to these data (data collection, data management, data communication, etc) and explain why.

- Access/sending the information on demand to actual consumption and biomethane/P2G production) data
- Access/sending the information on demand to historical consumption and biomethane/P2G production data
- Access//sending the information on demand to information on cost and biomethane/P2G consumption data
- Access//sending the information on demand to information for *switching* and *contract changing*
- Access//sending the information on demand to information for actual accurate *consumption base billing*
- Access//sending the information on demand to information on actual consumption patterns for supply offerings
- Access//sending the information on demand to information on actual volumes consumed or fed in to the grid for flexible transport offerings

19. Who would be the best placed market party to collect smart meter data? Should that be a commercial or a regulated party? If the last, would a *legal* separation of a DSO and electricity (or gas) producer/supplier be sufficient to guarantee non-discriminatory data collection and

management, customer privacy and facilitation of the market (without creating a monopoly position for a specific market actor due to asymmetric information)?

20. If smart meters would allow for a swifter supplier switch and as such create advantages for the customer / end user, do you see any change in the role of the DSO in relation to this switching process?

21. Smart meters installed at the customer premises offer the possibility to collect data which in turn can be used by suppliers to offer real time pricing and other innovative tariff structures. Depending on the market model, do you see a specific role for the DSO in this field of data management, oriented towards a better load profiling and demand forecasting which helps suppliers in making tariff proposals to customers? Does the DSO in your country provide the supplier with actual load profile data, that the supplier uses for balancing his portfolio? Will there be changes after the implementation of the new NC Balancing?

22. the THINK report identifies three models for data handling in the market:
where the DSO is acting as market facilitator and is responsible for all processes and sub processes related to metering and metering data processing
where an independent third party under a regulated monopoly regime is responsible
where a trusted data access point manager with a commercial role is in charge of metering data management and metering data processing. Which model is, according to you, most suited and why?

23. ICT- and telecom techniques could play an increasingly important role in the smart meters market, as data collection, data handling and data transfer are required to operate the market. From this perspective, who should invest in the required ICT platforms? Why? Should the development of ICT platforms be developed in a regulated market or in a commercial market? In case you consider this should be developed as a joint approach by both the actors in the energy market and the ICT/telecoms sector, please describe how this could work.

23a. What data do you see as DSO that are crucial for the safe operation of the grid? Who delivers these data today and how do you receive them? Which laws are in place regarding technical data (Cyber safety, national safety, etc…)

Flexibility services

Flexibility will be needed if

- the transportation capacity on the TSO level is not sufficient and the TSO is reducing the flows to the DSO in peak times
- the transportation capacity of the DSO is temporarily not sufficient in peak-times and the DSO has to reduce the load on consumer level to have a secure operation of the grid. After new investments this capacity shortages will be gone (temporal congestion)
- the transportation capacity of the DSO is never sufficient in peak-times and the DSO has to reduce the load on consumer level to have a secure operation of the grid. After new investments this capacity shortages will be gone. The flexibility service is used to lower the needed investment rates into the enlargement of the grid

What kind of flexibility measure do you envisage? Do you see this for all consumers or only above a certain threshold, and if yes where could this threshold lie? Could linepack be used as flexibility? Should line pack be sold to suppliers?

24. Please indicate how smart meters could eventually contribute to better load shedding (and reducing peak load). How could this work, what kind of data have to be communicated between which market roles?
DSO
TSO
Meter operator, metering data service provider
Supplier
Shipper
Consumer (residential, commercial, industrial)

24a. Could smart meters play a role in this by remotely activating and deactivating connections? Please clarify how you see the roles of different market actors in this process and give arguments for this. Do you see this possibility for residential/commercial or industrial consumers? Do you have experience with the interruption of consumers in the past? Which precautions have to be taken to secure the safety of the gas appliances/production plants? What problems with liabilities may occur?

24b. What kind of contracts will be needed?

25. Which role could smart meters play in relation to the quality of the energy distribution? How do you see the role of smart meters in relation to for example pressure and temperature measurement and how could this work in favour of the customer? Do you see an extension or reduction in the role of the DSO in this field? Please provide argumentation.

Future DER on the electricity side can lead to changes in the gas grid. This could be the installation of
Home fuel cells for heating of the premises + generation of electricity
Fuel stations of NGV
CHP plants that deliver small or large scale district heating systems
Biomethane injections
Power to Gas injections of CNG or hydrogen

26. DSOs ensure the system stability and grid operations. With DER becoming more and more available, the DSOs can use this DER to fulfil their tasks related to grid operations. Buying new energy- and capacity-related products from flexible DER could offer advantages to DSOs, in terms of quality of service, grid loss reduction . However, if DSOs were to buy these products, they would enter a competitive market and would have to compete in a open market with other market actors (such as energy suppliers and aggregators). Please describe how this activity should be organized, depending on the market model, in order to avoid an abuse of a dominant position by the DSO, acting as market facilitator.

27. Please comment on the following statement: '*Making the capacity tariff flexible according to time and location is necessary for DSOs to develop other (transport) services next to managing the physical grid'.*

28. Please indicate whether you agree and comment on the following statement:

'*Smart grids and smart meters can only provide a solution for the changing energy landscape if:*
Small companies and households will be offered flexible capacity to gas (flexible contracts);

SMEs' and household customer consumption data will be used to allocate their needs in a smart manner the settlement process. This means that **standard** consumption profiles will no longer be used;
The intra-day commodity market will also be opened up to SMEs and households e.g. through suppliers, aggregators

29. The following tasks could in the future energy market with smart meters (still) be executed by DSOs:
 Grid infrastructure management;
 Grid balance management;
 Grid congestion management

Please elaborate if and why (not) you think DSOs should be the ones (not) executing these tasks.

30. Please comment on the following statement:

'In the future energy market, consumers have to get used to being switched off (or down) from their networks from time to time. Biomethane and Power-to-gas plants have to get used to being restricted in feeding back gas into the grid. They should also get used to hedging for this risk by a tariff structure or a cooperation with an aggregator'. Please also indicate how you see a possible role for the DSO in this process and give arguments why or why not.

31. Please describe how you see the role of the aggregator as market actor. Please also elaborate how you see the relationship between DSOs and aggregators. Which interplay could there be and which roles and responsibilities could be taken up by the aggregator?

32. In relation to the products that DER could offer to TSOs and DSOs, please explain how you see the interaction between TSOs and DSOs. Which actions could a DSO take towards DER when it comes to congestion management? Which actions could a TSO take towards DER connected to the distribution grid? Please give arguments.

33. ERGEG stated in its report 'GGP on Regulatory aspects of smart metering for electricity and gas' (Ref. E10-RMF-29-05, page 19) that smart metering systems can create potential benefits to network owners and controllers, depending on the market model, *because of the better operability of the network*. According to ERGEG it would allow the network owners to check whether network operators do their job in the right way. Do you agree with this statement and please indicate why (not). How would you describe the activity of 'network operability'?

34. The European Directives state that both TSOs and DSOs are responsible for the operation, maintenance, grid planning and development of their systems. For the DSOs this includes pressure control and load/DG curtailment, in the event of emergencies. The THINK report labels the activities of the DSO as 'local congestion'. The TSO has to keep the overall system stability. The THINK report labels these activities as 'system balance'.

Given this situation, do you agree that DSOs are responsible for local congestion and TSOs for the overall system balance? If not, please indicate why.

35. Please describe how you see the process of allocation and reconciliation in the future energy market according to the Network Code balancing. Please also elaborate on the role of the DSO in the process. In case the future role should deviate from the current role, please elaborate on the differences and interplay.

Infrastructure provision for Gas Transport

36. Please define which roles DSOs can play in the field of EV charging infrastructure. Your answer should at least cover the infrastructure (who installs the infrastructure and who owns the infrastructure?) and infrastructure investments (who pays for it and how could costs be recovered?). Do you see a specific role for DSOs in this field? Please give arguments.

Energy efficiency

37. Do you think smart meters could play a role in creating an energy efficiency awareness? For example: by providing the customer with updates on consumption and exceptional consumption. In case you are convinced that smart meters could enable this, where do you see a role for the DSO? Could you compare that scenario with the role DSOs currently play in the field of energy efficiency?

38. A combination of smart meters and smart domotics or smart household appliances could help customers to manage their consumption. As such, this could be beneficial to the customer. Do you see a role for the DSO in this interaction between the individual smart metering system and the energy network. Would there be a new role for the DSO in relation to this (new) grid/end user interface - interaction?

Concluding

39. What are the main business cases for smart grids in your opinion?

40. To which extent do you see scope for high value smart grid added services by market actors and network operators respectively?

41. Sometimes the smart grids development is characterized in the following phases: (1) smartening the grid by real-time network controllability; (2) involving producers and consumers in real-time smart grids operation; (3) local system balancing and micro-grids. What is your opinion about this distinction in smart grid development phases?

Annex B: Interviewees

Respondents to the questionnaire. Answers provided by telephone or in a written form

Country	Organisation	Interviewee(s)
DSOs		
Electricity / electricity and gas DSOs		
Spain	Iberdrola	Miguel Angel Sanchez Fornie
	Union Fenosa Distribución	David Trebolle
Germany	Stadtwerke München	Richard Tretter
	RWE Deutschland AG	Dr. Andreas Breuer
Belgium	Eandis	Donald van Beveren
Netherlands	Alliander	Erik Linschoten, Paul Corton, Erik Moll
	Stedin	Peter Hermans
UK	SP Energy Networks	Graeme Vincent
Italy	Enel	Jon Stromsather, Carlos Costa, Marco Baron
Czech Republic	CEZ Distribuce	Radek Lamich, Janoušek Václav
Austria	LINZ Gas / Strom Netz GmbH	Dr. Karl Derler, Johannes Zimmerberger
DSO fulfilling also the roles of a supplier, producer, trader, and of a TSO:		
Germany	EnBW AG	Kai Hufendiek, Joachim Gruber
DSO fulfilling also the role of supplier:		
Sweden	Vattenfall Eldistribution	Peter Söderström
Gas DSOs:		
Spain	Gas Natural Distribution	Monica La Roche Sotelo, Alfredo Ingelmo
Netherlands	Liander	Joost Gottmer
France	GrDF	Roch Drozdowski, Benoit Chaintreuil, Anthony Mazzenga, Laurent Battut
Germany	Thüga AG	Eva Hennig, Dr. Gerhard Mener (Mainova), Noel Reagan (Eurogas)
DSOs' association:		
France	ADEeF	Christophe Chauvet
Sweden	Svenks Energi	Peter Silverhjärta
TSO:		
Belgium	Elia	Frank Van Den Berghe
Regulators:		
Denmark	Energitilsynet	Linda Aaberg
Spain	CNMC	Miriam Salguero
Belgium	CREG	Natalie Cornelis
France	CRE	Patricia de Suzzoni
Sweden	EI	Gunilla Eng Abrandt
Czech Republic	ERO	Miroslav Belica
Germany	BNeztA	Karsten Bourwieg, Diana Fricke, Christiane Berzel, Stefanie Fix, Ines Handrack, Daniel Bongart
ICT provider:		
Germany	Cisco Systems	Rolf Adam
Service provider:		

Country	Organisation	Interviewee(s)
Germany	smartOPTIMO	Fritz Wengeler

Other stakeholders that provided comments:

Country	Organisation	Name
Association of suppliers:		
Germany	bne	-
Europe	Eurelectric	Koen Knoyens
Energy and water association:		
Germany	BDEW	Roger Kohlmann, Michael Wunnerlich
DSO:		
Netherlands	Stedin	Peter Hermans
	Alliander	Paul Corton
Belgium	Infrax / EDSO for smart grids	Joris Knigge
Europe	Geode	Reinhard Brehmer and Jonas Persson
Regulator:		
Belgium	VREG	Thierry van Craenenbroeck
Other:		
Netherlands	GEN	Gaston Hendriks
Netherlands	Tilburg University	Prof. Leigh Hancher
Global	Global Smart Grid Federation	Ronnie Belmans

Annex C: Actors in the smart grid environment

The description of the different actors in this appendix is taken from EG3 (2011).

Grid Operators

The term „Grid Operators“, refers to the undertakings of operating, building, maintaining and planning of the electric power transmission and distribution networks.

Transmission System Operator (TSO): according to the Article 2.4 of the Electricity Directive 2009/72/EC (Directive): “a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity“. Moreover, the TSO is responsible for connection of all grid users at the transmission level and connection of the DSOs within the TSO control area.

Distribution System Operator (DSO): according to the Article 2.6 of the Directive: “a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity“. Moreover, the DSO is responsible for regional grid access and grid stability, integration of renewables at the distribution level and regional load balancing.[31]

Grid Users / Customers[32]

Generator: Generating electricity, contributing actively to voltage and reactive power control, required to provide the relevant data (information on outages, forecast, actual production) to the energy marketplace (see also the Articles 2.1 and 2.2 of the Directive).

Electricity Installer / Contractor: Electrical contractors design, install and maintain intelligent systems for all kinds of industrial, commercial and domestic purposes. Alongside the power and lighting applications, they equally install ICT and telecommunications, public street lighting, high medium and low voltage lines, control and energy management systems, access, fire and security control equipment, lightning protection systems, advertising and identification signs, emergency power generating systems and renewable energy systems.

Customer / consumer: Depending on their characteristics, consumers could be classified into one or more of the following categories:

Industrial customer: A large consumer of electricity in an industrial / manufacturing industry. May be involved in contract based Demand/Response.

Transportation customer: A consumer of electricity providing transport systems. May be involved in contract based Demand/Response.

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32 Please refer also to the Articles 2.7 – 2.11 of the Directive.

Buildings: A consumer of electricity which is a private or business building, may also be involved in contract-based Demand/Response.

Home customer: A residential consumer of electricity (including also agriculture users) may also be involved in contract-based Demand/Response.

Supplier: A grid user who has a grid connection and access contract with the TSO or DSO (see also the complementary description of supplier below). Moreover, suppliers are those actors which will provide new services, real-time information, energy efficiency services and dynamic energy pricing concepts with Time-of-Use (ToU). The suppliers also provide local aggregation of demand and supply, in order to increase the effectiveness and efficiency of the electricity supply at all voltage levels (including low / medium voltage levels).

Retailer: Entity selling electrical energy to consumers – could also be a grid user who has a grid connection and access contract with the TSO or DSO. In addition, multiple combinations of different grid user groups (e.g. those grid users that do both consume and produce electricity) exist. In the remainder of this document, the terms customer/consumer and grid user are used interchangeably where appropriate.

Energy Market Place

Power Exchange: Provides a market place for trading physical and financial (capacity/energy and derivates) contracts for capacity allocation by implicit auctions within the defined country, region or cross border.

Balance Responsible Party: Ensures that the supply of electricity corresponds to the anticipated consumption of electricity during a given time period and financially regulates for any imbalance that arises.

Clearing & Settlement agent: Assumes liability for clearing and/or settlement of contracts and provides contractual counterparty within a Power Exchange and for Over the Counter (OTC) contracts.

Trader: A person or entity that buys and sells energy goods and services in an organized electricity market (Power Exchange) or Over the Counter.

Supplier: Has a contractual agreement with end customer relating to the supply of electricity.

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.

Providers of Technologies, Products and Services

The actors listed below provide technology, products and services to the actors mentioned above. They have been classified into the following categories:

- Electric Power Grid Equipment vendors;
- Ancillary Services providers.

Metering operator: the entity which offers services to provide, install and maintain metering equipment related to a supply. In most EU Member States the DSO is also metering operator. In case of a specific contractual basis, the contract is mostly with the network operator, or may be with the customer or the supplier. The meter may be rented to, or exceptionally owned by, the customer.

Information & Communication Technology (ICT) service providers;

Grid communications network providers Plan, build and maintain the communications systems that enable the data communication required to maintain grid stability, load balancing and fault protection systems by a TSO or DSO. This function is mostly executed by the TSO or the DSO, or may be performed by an independent actor but the overall responsibility and ownership of information remains with TSO and DSO.[33] Grid communications network provider ensures compliance with the agreed service levels (Service Level Agreements including quality of service, data security and privacy) and compliance with any national and/or international regulations as necessary;

Home Appliances vendors

Building Energy Management Systems (BEMS) providers, delivering the systems which facilitate management and control of building facilities, realizing energy saving and increasing comfortability of users of buildings and making full use of the state-of-the-art Information Technology.

Electric Transportation / Vehicle Solutions providers.

Influencers

Grid User / Customer / Consumer: Entity or person being delivered electricity. How a customer perceives the value received from other actors in the electricity supply chain has a substantial influence on the economic viability of the grid in general and on the overall acceptance of how the electricity supply chain performs.

Regulator: Independent body responsible for the definition of framework (market rules), for setting up of system charges (tariffs), monitoring of the functioning and performance of energy markets and undertaking any necessary measures to ensure effective and efficient market, non-discriminative treatment of all actors and transparency and involvement of all affected stakeholders.

Standardization bodies: Responsible for standardization of all relevant elements and components within the electricity supply chain, which in turn leads to harmonization of relevant services, support towards removing barriers to trade, creating new market opportunities and reducing manufacturing costs.

EU and national legislation authorities: Entities are in charge of defining legislation and metrics for areas such as environmental policy, social policy, energy policy and economic policy. They are also responsible for the authorisation needed to develop the electricity grid infrastructure.

Financial Sector undertakings: Provide capital to other actors or invest themselves into the projects within the electricity supply chain (grid, generation, etc.).'

[33] An exception is the customers' data which are managed by the grid operator but belong to the customer.

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