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List of abbreviations

Abbreviation	Definition
AMI	Advanced Metering Infrastructure
CEP	Clean Energy for all Europeans package
DMS	Distribution Management System
DSO	Distribution System Operator
FlexiGrid	Enabling flexibility for future distribution grid – FlexiGrid
GDPR	General Data Protection Regulation
ICT	Information and Communications Technology
IoT	Internet of Things
SCADA	Supervisory Control and Data Acquisition
TSO	Transmission System Operator

Contents

Executive summary

This report constitutes the first deliverable from work package 2 of the FlexiGrid project, with the intention of providing input to subsequent project tasks on the topic of potential barriers for successful implementation of flexibility markets at the DSO (distribution system operator) level. By initiating an early discussion about potential barriers, this task aims at raising awareness of potential pitfalls and thereby improving the ability for the FlexiGrid project to take such issues into account in future research and development activities.

The discussions in this report, which are based on literature reviews as well as input from project partners, cover a broad range of potential barriers. The following 10 types of barriers are discussed:

DSO unbundling and related regulations: Due to unbundling regulations, DSOs are prevented from engaging in certain activities. Depending on the type of flexibility market, this could make implementation legally complex.

DSO regulatory incentives: DSOs are treated as natural monopolies with revenues regulated by national regulators. Depending on how these regulations are designed, DSOs may not have any financial incentives to engage in flexibility markets.

Industry culture: The electric utility industry is often perceived as giving priority to stability and safety rather than innovation. This type of organizational culture could hamper the implementation of innovative flexibility markets.

Security of supply: Flexibility markets depend on the availability of flexibility providers that are somewhat outside the control of the DSO. This lack of control may be viewed as a potential risk that could jeopardize security of supply.

End-user privacy: Some end-users are, due to privacy concerns, likely to resist the implementation of high-resolution metering devices which may be necessary for flexibility markets.

Metering and IT infrastructure: Flexibility markets are likely to require modern and advanced metering infrastructure and IT systems capable of handling the information effectively. A lack of such infrastructure would be a costly barrier to overcome.

Data access: Even if the right data is collected, it may not always be accessible to the parties that need it. This can be related to end-user privacy, but also to questions such as third-party access for aggregators.

Recruiting participants: Flexibility markets require participation of end-users who may not be interested in, or aware of, the possible benefits that the market can deliver. Difficulties with recruitment of end-users would provide a barrier to successful implementation.

Operational costs, lack of value and Complexity: The value of flexibility markets, such as from a reduced need for network reinforcement, need to exceed the costs associated with the market for the concept to make economic sense. Compared to traditional network reinforcement measures a flexibility market is likely to be more complex, technically as well as in terms of organizational and business complexity.

Timing and the risk of stranded investments: The future need for flexibility markets is currently uncertain in many areas. Given that flexibility markets require investments to implement, as well as continued research and development, DSOs may prefer to wait until the concept is more mature.

1 Introduction

1.1 Aim and scope of the work

This report constitutes the deliverable of Task 2.1 of the FlexiGrid project. Task 2.1, which is titled *Analysis of barriers for adoption of innovative market design*, takes place at the initial stage of the FlexiGrid project with the intention of identifying and analyzing potential barriers for adoption of flexibility markets. This work aims at informing subsequent tasks and work packages about potential issues that may hamper implementation in practice. By raising awareness of these issues, Task 2.1 aims at increasing the likelihood that they can be successfully addressed or avoided.

In similarity with the FlexiGrid project as a whole, this report takes a distribution system operator (DSO) perspective. The type of flexibility markets considered in this report is therefore markets where DSOs can procure flexibility services from end-users. When geographical scope is of relevance, such as when discussing regulatory aspects, the report focuses on Europe.

The list of potential barriers for implementation of flexibility markets can be made very long. The intention of Task 2.1. and the discussions provided in this report has not been to analyze these barriers in detail. Instead, the report provides background information that can be used to inform further discussions and guide more detailed analysis.

1.2 Methodology

A first list of potential barriers was made based on a review of academic literature and trade publications in combination with lessons learnt from other European research projects (e.g. Fossil-free Energy Districts (FED) project [1], UNITED-GRID project [2], and the m2M-GRID project [3]).

At the beginning of the project, the work was introduced to members of the SAT (situation analysis) team from both ISGAN (Karin Widegren) and InnoEnergy (Johan Söderbom). Their first inputs to the project and the tasks were collected and summarized in a presentation on the kickoff meeting (Gothenburg, December 2019) called '*Smart Grids Foresight - What's on the horizon? Putting FlexiGrid into a context and perspective*'. This session was followed by an interactive DSO panel, where challenges and expectations were discussed through the use of structured questions. The partners were also invited to visit the site of the FED project and learn from the experiences and finally there was an online interview with the Canadian sister project NESTNet.

With the context of those inputs from ISGAN, InnoEnergy, sister projects and literature study, an initial workshop called *'Barrier analysis workshop'* was organized by RISE at the kickoff meeting for all the FlexiGrid project participants, and especially the partners contributing to the task (EMAX, CTH, IMCG, EP, GE, OEDAS, ESR, SIV). The aim of the workshop was to gather additional input from partners in different countries, where DSOs might be facing other challenges that the ones anticipated in the first

list and to discuss the importance of each potential barrier. The outcomes of the initial workshop were presented at the end of the kickoff meeting and provided the basis for drafting this report.

Figure 1: Interactive workshop on 'barriers analysis' in Gothenburg, December 2019.

As described in the FlexiGrid Grant Agreement, Task 2.1 aims at organizing further workshops and interviews for more in-depth discussion among policy and industry experts about potential barriers, specifically including members from ISGAN. This report will be used as background material for these further discussions, and the results will be summarized in an addendum to this report. These interviews and workshops will also give first insights of FlexiGrid results to the SAT-team, sister projects and other experts.

A first workshop is planned as a collaboration between ISGAN, FlexiGrid, NESTNet and other partners during a workshop in Canada (October 2020) on the topic of '*Capturing flexibility from local energy systems'*. This workshop will results in a joint fact sheet on potential of flexibility and future directions for implementation, where the barriers analysis will be important input to the discussion. FlexiGrid also proposes to present and discuss some first results in a presentation called '*Enabling flexibilities for future power systems: Synergies from EU and Canadian collaborative activities*'.

Specific interviews or workshops with other SAT-members are already planned in close collaboration with the SAT-team (task 1.4) and will contribute to the WP2 deliverables, to address specific topics such as policy and regulation, flexibility markets design, innovation and so on.

1.3 Outline of report

The report begins with a brief background outlining the role of flexibility markets in the European electricity market landscape. This is followed by section 3 which describes the initial workshop session. Thereafter the main section of the report, section 4, discusses potential barriers, subdivided into 10 different sub-categories. Finally, section 5 concludes the report.

2 Background: The role of flexibility markets

In the conventional structure of the electricity grid, electricity is produced in large scale centralized power plants at the edge of the grid infrastructure, and transferred in one direction to the end-users. Electricity distribution systems are dimensioned to be able to accommodate the common maximum power output for a group of consumers in an area, which is lower than the sum of the consumer's individual subscribed power. This passive operation of distribution grids stands in contrast to the more active operation of higher-voltage transmission grids. Transmission system operators (TSOs) typically have the ability to activate flexible resources to manage, for example, congestion or voltage issues. Further, network limitations at the transmission level are managed by electricity market processes, by dividing the network into bidding areas for trading purposes.

Recent developments at the distribution level, such as the proliferation of distributed generation and electrification of transportation, are causing power flow patterns to change. The static design and passive operation of the grid infrastructure are not prepared for increasing amounts of distributed generation and a change in the operation of these networks, since the power flow becomes bi-directional. On the other hand, the availability of more advanced metering and ICT infrastructure improves the possibilities for DSOs to take on a more active role in managing end-user load and generation.

Against this background, it is highly recommended (see, for example, [4] and [5]) that DSOs should take on a more active role in managing the network, a role that more resembles that of a TSO. This is believed to reduce the need to undertake costly network reinforcement measures. The new electricity market design [6] also demands a more active role for DSOs in developing, managing, and operating their networks. The DSO should become a neutral market facilitator that coordinates the impact of flexibility operations on its network, irrespective of the flexibility model and the chosen technology. This will also require a transformation of the traditional DSO business model.

A more active management of distribution-level power flows in real time would most likely require DSOs to be able to directly influence the load or generation of end-users. Therefore, some type of platform or arrangement is needed that allows DSOs to access the potentially flexible resources and remunerate the end-users who provide the flexibility. This is the role of a flexibility market at the distribution level.

A key question concerning the development of flexibility markets is how exactly the flexibility service should be defined. For example, a flexibility service may or may not be considered to count as an energy trade for electricity market purposes, a choice which has significant implications for how a flexibility market fits into the existing electricity market structure and how it affects balance responsibility.

The idea of activating or incentivizing more flexibility at the distribution level is not new. Concepts such as demand response, demand side management, active network management and local energy markets are closely related to the concept of flexibility markets. These somewhat overlapping concepts are not always well-defined or used in a consistent way. Further, the flexibility term is used both at the transmission and distribution levels, referring to different types of services. This heterogeneity is

highlighted in [7], which provides a literature review and classification of different types of flexibility markets and products.

In this report, the focus is on flexibility at the distribution level, using the term "flexibility market" to refer to any type of market-based approach where a DSO can access flexibility from end-users.

A large number of flexibility market projects has been initiated across Europe in recent years, ranging from academic research projects to commercial implementation. A review of 22 European flexibility market proposals focusing on the distribution level is provided in [8]. This review finds that most market proposals compensate flexibility providers for each flexibility activation rather than for the reservation of flexible capacity. However, only a small number of projects actually allows free bid-based price-formation. Instead, the review finds that most projects utilize some form of regulated or pre-negotiated prices.

Despite an identified need for flexibility at the distribution level, and a large number of research and demonstration projects in recent years, active and fully functional flexibility markets are still few and far apart. Therefore, it is valuable to analyze possible barriers for the adoption of flexibility markets in more detail.

3 Initial workshop

To provide some indication of the perceived relative importance of the different type of barriers among FlexiGrid project partners, a brief workshop session was held during the FlexiGrid kick-off meeting in Gothenburg on December 17, 2019. The main purpose of this workshop session was to get a sense of which barriers that project partners perceived as the most important. The specific question asked to workshop participants was:

"The year is 2023, and you are the CEO of a DSO. Alex, who happens to be your employee-of-the-month, comes to your office with the final report from the FlexiGrid project and suggests that your DSO should adopt the new innovative market model and integrated smart grid infrastructure that the project has developed. But you are a bit hesitant. Why?"

Workshop participants were asked to give points to different types of barriers. A list of types barriers was provided to workshop participants, and a few additional types of barriers were added during the workshop session. The resulting list of barriers correspond to the types of barriers discussed in section 4 of this report, with only a few exemptions[1].

The workshop participants spread their votes out over many types of barriers (all the types of barriers discussed in this report received at least one vote) and there was no clear winner. The single category

[1] "IT infrastructure" and "Unclear roles" were brought up as potential barriers but did not receive any votes and have not been given their own sections in this report.

receiving the most votes was “Operational costs and lack of value”, closely followed by “DSO incentives”, “Data access” and “Regulatory and legal framework”[2].

These results point at a broad interest across project partners for many different types of barriers, which clearly illustrates the complexity of this area, with no single barrier dominating the discussions.

4 Potential barriers

This section discusses a range of potential barriers for implementation of flexibility market. The discussion is subdivided into 10 subsections. The order of the subsections is arbitrary and should not be interpreted as an order of importance.

4.1 DSO unbundling and related regulations

The EU regulatory framework for the electricity industry is based on an unbundled approach, where transmission and distribution activities are separated from generation and retail activities. The rationale behind this is that transmission and distribution can be viewed as “natural monopolies” since large fixed costs and relatively low marginal costs would make it economically inefficient to introduce competition. However, electricity generation and retail can, if given non-discriminatory access to transmission and distribution grids, be liberalized and conducted in a competitive environment.

To ensure a level playing-field with non-discriminatory access to grid infrastructure for all market players, DSOs and TSOs are subject to various forms of unbundling requirements. These regulations attempt to prevent conflicts of interest by promoting the independence of TSOs and DSOs from entities that are active in other parts of the electricity value chain, such as generation and retail of electricity.

The main EU legislation concerning unbundling of TSOs and DSOs was introduced with the Third Energy Package in 2009, specifically the electricity directive [9]. The 2019 recast of the electricity directive [6] (part of the Clean Energy of all Europeans Package, CEP) introduced some changes relevant to unbundling, but the main unbundling provisions remain unchanged compared to the 2009 directive [10]. Since these legislations have been adopted as directives, they are transposed into national law meaning that the specific unbundling regulations differ across different EU member states.

The unbundling requirements set out in the directives are stricter for TSOs than for DSOs. TSOs are required to go through a certification process with their national regulatory authorities (NRA). Full ownership unbundling, where the TSO is not part of a vertically integrated undertaking[3], is the preferred regulatory approach and is the approach chosen by most member states. However, other unbundling

[2] The category “Regulatory and legal framework” was added by workshop participants. Since this is a very broad topic, questions related to regulatory barriers are discussed in several of the sections of this report instead of under its own heading.

[3] A vertically integrated undertaking is defined as “an electricity undertaking or a group of electricity undertakings where the same person or the same persons are entitled, directly or indirectly, to exercise control, and where the undertaking or group of undertakings perform at least one of the functions of transmission or distribution, and at least one of the functions of generation or supply of electricity” [9].

models are also allowed which allows existing vertically integrated undertakings to maintain ownership of transmission assets, provided that the TSO role is independent of any generation and retail interests.

For DSOs, the directive does not require unbundling in terms of ownership. However, independence in terms of legal form, organization and decision making from activities not related to distribution is required. Member states may choose to not require such unbundling for DSOs with less than 100 000 connected customers. Irrespective of size, separate financial accounts for the distribution activities should be maintained. The regulations are intended to prevent any cross-subsidies to or from the DSO and other parts of a vertically integrated undertaking.

Although only about 10% of DSOs in Europe have more than 100 000 connected customers, they cover more than 70% of the European population [11]. Therefore, the majority of Europeans live in an area where the local DSO is subject to legal and functional unbundling requirements.

Some EU member states have adopted national unbundling requirements that go further than what is required by the EU directives. For example, the Netherlands require full ownership unbundling for all DSOs. At the other extreme, Malta has been granted explicit exemptions such that separation of accounts is the only unbundling requirement for DSOs, irrespective of size.

As mentioned above, the DSO unbundling requirements remain largely unchanged in the electricity directive of the CEP compared to the 2009 electricity directive. However, the CEP introduced some additional articles that relate to the roles and responsibilities of DSOs. Specifically, it requires that DSOs should not own or operate energy storage facilities or electric vehicle charging stations (except under some specific circumstances where exemptions may be granted).

From a flexibility market perspective, unbundling requirements could pose a regulatory challenge. This could, for example, be the case if the unbundling requirements have been implemented in a way that prevents DSOs from buying or selling electric energy and the flexibility market trades a product that may be considered electric energy. Further, questions regarding conflicts of interest may arise if the DSO and a flexibility provider is part of the same vertically integrated undertaking.

However, the electricity directive of the CEP includes an article specifically requiring member states to “provide the necessary regulatory framework to allow and provide incentives to distribution system operators to procure flexibility services, including congestion management in their areas, in order to improve efficiencies in the operation and development of the distribution system” [6]. Therefore, the directive is clear in its expectation that member states should implement regulations that both maintains the principles of unbundling and promotes the existence of flexibility markets. How member states choose to strike this balance remains to be seen, as the directive is transposed into national laws and regulations by the end of 2020.

In similarity to the EU legislation, Turkey also has an electricity market structure based on an unbundled approach. The Turkish Energy Markets Regulatory Authority regulates supply tariffs as well as distribution tariffs. The DSOs are unbundled regulated entities and are not allowed to engage in supply activities [12].

4.2 DSO regulatory incentives

The need to financially regulate DSOs stems from the monopoly nature of electricity network businesses, where high fixed costs and low marginal costs imply that competition would be both inefficient and unlikely to arise spontaneously. The standard static monopoly model predicts that an unregulated monopoly firm would deliver goods at higher prices and in smaller quantities than what would be desirable from a social welfare perspective. For electricity networks, ”quantity” can be interpreted as the amount of investments made in grid infrastructure and the reliability of service provided. The overarching goal for the financial regulation of DSOs is therefore to prevent DSOs from charging unreasonably high prices, and to ensure that DSOs make sufficient investments in grid infrastructure and deliver an adequate level of service.

The financial regulation of DSOs could, depending on how it is implemented, act as a barrier for implementation of flexibility markets, especially if it favors investments in capital expenditure over operational costs. As opposed to the unbundling requirements discussed in the section 4.1, the concern regarding financial regulations is not that they make it *illegal* for the DSO to engage in flexibility markets, but rather that they could make it *unprofitable*.

There are many different regulatory approaches available for how to financially regulate network industries. An overview is provided in [13], which discusses regulatory differences concerning, for example, the amount of price-flexibility that is given to the firm and the approach used for determining the asset base[4]. Concerning price-flexibility, the regulator may set the prices directly or allow some flexibility for the DSO:

- Explicit price regulation: The regulator explicitly sets the prices with the objective of achieving a regulated rate-of-return.
- Price or revenue caps: The regulator indirectly caps prices by capping either actual future revenues (revenue cap) or the revenues that would have been collected if volumes remain unchanged compared to a historical reference (price cap).

Both price caps and revenue caps give the DSO some flexibility in how to set prices. Price cap regulation and revenue cap regulation are similar as long as volumes do not change much over time, while price cap regulation provides an automatic adjustment if volumes change.

Concerning what to include in the asset base, a differentiation can be made between:

- Costs of investments made: The value of investments made, adjusted for depreciation. May be based on the amount actually paid, or a reference cost for each type of investment.
- Costs of a hypothetical benchmark: An estimated value independent of actual investment decisions, such as optimized replacement cost.

Traditionally, some form of explicit price regulation based on actual costs (sometimes called “rate-of-return regulation” or “cost-plus regulation”) has been common. However, it has long been known [14]

[4] The asset base is the value of investments on which the DSO is allowed to earn a specified rate of return. An alternative term for this is rate base.

that this model may provide inappropriate incentives for the DSO, not least with respect to cost prudence. Because of these shortcomings, many alternative models have been developed and tested, often under the umbrella term “incentive regulation”, including various combinations of price or revenue caps, benchmarking methods or outcome-based incentives. A thorough discussion about incentive regulations from a theoretical as well as practical perspective is provided in [15]. However, as emphasized by [16], the term incentive regulation is a bit misleading since all regulatory approaches provide the DSOs with incentives. Irrespective of how DSOs are regulated, the regulations will affect the behavior of DSOs in various (intentional and unintentional) ways.

The most common regulatory approach used to regulate DSOs in Europe today is some form of revenue cap, and only a few countries continue to use a more traditional cost-plus approach. For the capital cost component of the revenue cap, the asset base is most commonly based on actual historical costs. [17]

As noted above, financial regulations of DSOs may impose a barrier to the implementation of flexibility markets if the regulatory model implicitly favors capital expenditure over operational costs. This could, for example, be the case if investments in network infrastructure are financially attractive for the DSO due to an increase in the revenue cap because of an expanded asset base, while operational costs are subjected to efficiency requirements or benchmarking and therefore not fully recoverable for the DSO. Further, the type of investments that may be needed for a flexibility market (such as development of IT systems) could be more difficult for the DSO to include in the asset base. Finally, a flexibility market may require a larger amount of effort from staff and management compared to traditional options, an effort that the DSO may not be financially rewarded for if the asset base is not affected.

4.3 Industry culture

Electric utilities, including DSOs, are often perceived to be characterized by a relatively conservative and risk conscious culture. While this culture may be beneficial from some perspectives, such as for promoting safety, it could also act as a barrier for testing and adopting innovative solutions. Therefore, DSO culture may be a factor to take into consideration when developing flexibility markets.

Organizational culture is the topic of a vast academic literature, including disciplines such as management, sociology and psychology. A large number of models and methods have been developed to analyze and categorize different types of company cultures. In an attempt to synthesize earlier work, [18] identifies two primary dimensions that can be useful when describing the culture of a company: how people interact and how people respond to change.

The people interaction dimension ranges from highly independent to highly interdependent, where an independent organization places greater emphasis on individual actions while interdependent organizations are more concerned with coordinating group efforts. Concerning response to change, the scale goes from stable to flexible where organizations that lean towards the stable end of the spectrum emphasize consistency and predictability while flexible organizations prioritize innovation and openness.

Using these dimensions, the authors of [18] define 8 different cultural styles, and provide survey results on how organizations in different industry categories fit into these styles. As expected, companies in the energy and utilities industry score relatively high on a style labelled “safety”, which is a style characterized by stability and interdependency. It should however be noted that these industry categories are very broad and the observed differences across industry categories are quite small.

Further, DSOs may differ from the general energy and utilities category. Nevertheless, it is interesting to note that the "safety" cultural style has the opposite characteristics of the "learning" cultural style, which is the style most closely associated with innovation and creativity.

Given that the existing culture of DSOs may be appropriate for its core business of managing electric grid infrastructure, it is perhaps not advisable to attempt cultural change for the sake of implementing flexibility markets. But being aware of organizational cultural may help prevent unnecessary implementation hurdles. Further, although the culture of DSOs as a whole may be relatively conservative and risk conscious, larger DSOs sometimes have dedicated R&D departments with a different cultural style, that can help facilitate change within the organization.

In addition to DSOs, there are other organizations whose active engagement is needed for the development of flexibility markets. For example, many potentially flexible resources are controlled by real estate owners and property managers. In similarity to DSOs, the property management industry can also be relatively risk averse. Property managers may perceive flexibility provision as too risky, especially if could negatively affect the comfort of their tenants [19].

4.4 Security of supply

As discussed in section 4.3, DSOs are often characterized by a culture of risk consciousness. This is not surprising, given that maintaining a safe and reliable network infrastructure is one of the most important (perhaps the most important) objectives of DSOs. For example, the first paragraph in the article specifying the task of DSOs in the CEP, states that DSOs are responsible for operating a "secure, reliable and efficient" distribution system [6]. Further, DSOs are often subject to financial punishments or other disincentives if their customers experience long or frequent supply interruptions. It is therefore important for the success of flexibility market solutions that these solutions do not negatively affect security of supply.

Questions regarding security of supply often arise when a flexibility market solution[5] is proposed as an alternative to more traditional "poles-and-wires" network reinforcement measures. The technologically mature and well-known traditional approaches then have the advantage of familiarity: the DSO knows what to expect and have plenty of experience with the issues that may arise. However, whether flexibility markets actually would imply a greater threat to security of supply compared to traditional approaches is not obvious.

On the one hand, flexibility markets rely on third party flexibility providers for providing flexibility when and where it is needed. This means that the DSO will not be able to fully control or guarantee the availability of the flexibility, which introduces an inherent uncertainty. Further, compared to traditional approaches, flexibility markets may be more reliant on ICT systems. Depending on the implementation of these systems, they may introduce an additional source of potential failure.

[5] Note that this discussion also applies to any of the close cousins to flexibility markets, such as active network management, demand side management, demand response, etc.

On the other hand, flexibility markets can come with options and solutions that can improve security of supply. For example, a flexibility market could come with tools that improve the DSOs real-time observability of the network. Further, once a flexibility market is in place, it could provide a tool for managing unanticipated future development much faster than the time needed for network reinforcements.

4.5 End-user privacy

Flexibility markets, irrespective of type and purpose, likely require some form of collection, storage and processing of data about end-user's electricity consumption and production, possibly to a larger extent than what would be necessary without the flexibility market. With this comes potential concerns regarding end-user privacy.

The discussion in this section is kept at a general level, considering the type of end-user privacy issues that may be relevant for future flexibility markets. More specific matters concerning data privacy the demonstration sites of the FlexiGrid project is treated by Work Package 11 and Deliverable 11.1 '*Human Requirements*'.

This is mostly a concern if the flexibility market requires active participation of many small end-users (such as households). Depending on the type of flexibility traded, the flexibility market may, for example, require electricity metering at a more granular time-resolution or may involve sub-metering and control of specific appliances. The amount of data collected could also increase for end-users that are not actively participating in the flexibility market. For example, the DSO may need to collect more detailed real-time data from all end-users to assess when and where flexibility activations are needed.

Data on electricity consumption or production at a measurement point associated with a natural person is considered personal data and the General Data Protection Regulation (GDPR) is applicable [20]. Further, the recast electricity directive [6], adopted as part of the Clean Energy for all Europeans package (CEP), provides more detailed provisions that member states should follow when developing data protection regulation specifically for smart metering systems. Hence, EU-wide legislation is in place with the intent to protect potentially sensitive personal information and prevent inappropriate use of meter data. Nevertheless, some end-users may resist being subjected to such measurements.

End-user privacy concerns are especially important if the implementation of a flexibility market goes hand-in-hand with installation of smart meters. The roll-out of smart meters as a part of smart grids is an obligation under the Third Electricity Directive, but the practical implementation, regulatory arrangements, technical and commercial interoperability, data privacy issues and the minimum range of operations of smart meters are all largely dependent on the Member States and is therefore different among DSOs. According to a 2018 survey presented in [11], smart meter penetration was close to 100% in some European countries, for example Estonia, Finland and Sweden. In other countries, such as Ireland, Germany and Poland, penetration levels were found to be below 20%. Roll-out of smart meters has met significant resistance from a large number of end-users in several counties, not least due to privacy concerns. For example, end-users in the UK have shown significant resistance to adopting smart meters and preliminary results from a recent survey experiment shows that substantial monetary compensation often is needed for end-users to accept the installation of a smart meter [21].

A survey on smart meter data privacy is available in [22]. The authors describe the functionalities and communication methods used by smart metering systems and discuss various privacy threats and how they can be addressed technically. The discussion focuses on how to prevent unauthorized third parties from accessing or tampering with the data. While this may be one potential reason for why end-users may be wary of smart meters, it does not help if the end-user lacks trust in the DSO (or other metering entities) itself.

4.6 Metering and IT infrastructure

With the changing role of the DSO as a market facilitator, growing complexity and modernization of the electric grid and the need for managing large amounts of data, DSOs in Europe are moving from a 'blind' operation of the network to a more and more monitored and controlled one with improved IT and data communication and increased automation. DSO monitoring and control infrastructure range from basic SCADA systems for real-time monitoring and control to fully integrated with DMS (distribution management system) including more advanced functions [23].

The decision support and automatic control advanced applications included in a DMS require real-time and near-real-time data acquisition and control, which can be obtained through advanced metering infrastructure (AMI). It is this integrated system of smart meters, communications networks and data management systems that enables the DSO to automatically and remotely monitor and interact with the customers and that will facilitate innovative market design, providing a number of important functions that were not previously possible or had to be performed manually. An added functionality to the communication layer is the deployment of an IoT platform, such as the platform developed within FlexiGrid, which will help improve the monitoring and controllability of the grids.

The current level of implementation of advanced monitoring and control infrastructure is at different levels among European DSOs.

Potential barriers regarding metering and IT infrastructure for the DSO are two-fold.

In the first place, developing and operating an integrated system of advanced meters, communication platforms and advanced functionalities for data management can be a challenge for many DSOs, depending on the current level of automated monitoring and control. The complexity and the cost of installing and operating such a system might be higher than the potential savings, and it might seem opportune to use more robust, less flexible but cheaper solutions based on data modeling instead of actual full data acquisition.

Secondly, the development of advanced functionalities and platforms can be hampered by not having the data with the necessary granularity, which depends on the actual roll-out of smart meters and the level of functionality and interoperability. In reality, the available granularity and the type of data is not always sufficient for delivering system services as part of a flexibility market, and delays in data accessing might hinder the provision of services close to real-time operations.

4.7 Data access

The type and granularity of data that is available for processing is not only dependent on technical constraints of smart meters, but also on data access. Different existing and new parties will be involved

in flexibility markets and it is important that sensing data from smart meters can only be collected and processed by eligible persons. This generates data protection challenges and creates new risks for the data subjects with a potential impact in areas (e.g. price discrimination, profiling, household security) previously absent in the electricity sector. The new European market design legislation states that where Member States have implemented the deployment of smart metering systems, they have to guarantee that all actors have access to the correct data. The party responsible for data management shall be obliged to give those data to the undertaking. The DSOs on their side should maintain confidentiality of the data revealed during data processing.

The GDPR legislation lays down specific rules on the protection of data (see section 4.5 for further discussions). The regulation sets rules for handling personal data between the person or household and the data processor and controller and puts obligations on the processing of personal data from smart meters. The DSO can only process personal data if having a legitimate interest for processing, for example if it is necessary for the DSO to perform its other legal obligations. Therefore, they must minimize their processing activities as much as possible, define the right monitoring accuracy and cannot go beyond the purpose for which the data have been collected. This can be based on an impact assessment (Data Protection Impact Assessment or DPIA for Smart Grid and Smart Metering Systems). The GDPR requires the Data Controller to conduct a DPIA when the type of processing is likely to result in a high risk to the rights and freedoms of natural persons - especially caused by using new technologies, and taking into account the nature, scope, context and purpose of the processing.

While these regulations support the correct use of personal data, they could also be a barrier for the parties involved. For example, the access to the end user's data might be ineffective if it is anonymized through a central data hub.

An aggregator is a new type of energy service provider that coordinates units (consumers, producers and/or prosumers) in a certain area of the electricity grid. Aggregators might need to assess their customers electricity profile to provide offers that reflect their needs and lifestyle. To be able to offer a service to the DSO the aggregators also need the profile of others in the grid to know when to reduce or increase the electricity consumption from the customers attached to the aggregator. This third-party access might be an obstacle to provide this kind of service. There must also be a way to monitor so that the aggregator is not misusing the data information.

4.8 Recruiting participants

Flexibility markets require participation of end-users to function. The type and number of flexibility providers may differ from market to market, ranging from just a few large providers (such as industrial end-users) to many smaller end-users (such as households). The amount of active engagement may also differ, ranging from active day-to-day participation to passive participation through the installation of smart devices. Irrespective of the type of end-user and amount of engagement needed, insufficient recruitment and retention of suitable flexibility providers can be a barrier to successful implementation of flexibility markets.

Many end-users, especially the smaller ones, often have a very limited understanding of how their flexibility potential can be of value, and a limited interest in participating actively in various electricity markets. Financial compensation for providing flexibility is likely to be an important component for encouraging participation. However, the amount of compensation needed to financially incentivize end-

users to provide demand flexibility has been found to be very large, especially if it interferes with their day-to-day activities [24]. This is not to say that end-users are completely insensitive to smaller financial incentives (see for example [25] for a survey of experiments on household price response). But it appears to be highly advantageous if the flexibility can be provided in an automated way without much active participation from end-users and without the need for any lifestyle changes.

In addition to financial incentives for participation in flexibility markets, other options may be available that can increase participation in cost-effective ways. For example, the provision of information about the benefits (for the end-user itself and to society) can influence engagement and participation. Both the informational content and the way in which the information is provided can be of importance. For example, [26] shows that uptake of energy efficiency audits increased when households were provided with information about participation from other residents in the same area, and when the information included a handwritten personal note. However, not all information campaigns are cost-effective: [27] finds a relatively modest increase in participation in an energy efficiency program despite extraordinary information efforts.

Other potential methods for increasing end-user engagement includes gamification [28], as well as leveraging existing local community platforms and social structures such as local energy community initiatives, if available.

4.9 Operational costs, lack of value and complexity

The benefits of flexibility markets, such as the reduced need for network reinforcement, should be weighed against the costs associated with the implementation and operation of a flexibility market and the cost for procuring flexibility services. An obvious barrier to the implementation of flexibility markets is if the financial costs outweigh the benefits.

There are several different types of costs involved with the implementation and operation of flexibility markets:

First, as discussed in 4.6 above, advanced metering infrastructure is likely to be necessary for meeting the information needs of a flexibility market, which comes with costs in terms of metering equipment and IT infrastructure. In addition to meter data, additional information streams will be necessary, such as load and generation forecasts, to provide decision support for when and where to activate the flexibility.

Second, the operation of a marketplace comes with costs. For example, a financial settlement system is needed for handling the payments to flexibility providers and will require personnel to ensure that correct payments are made. Further, some form of market monitoring is likely to be necessary to prevent inappropriate market behavior, a task which is difficult to automate. Additionally, the recruitment and retention of flexibility providers is associated with costs for customer service and promotion activities.

Finally, the DSO needs to pay for the flexibility services delivered by flexibility providers. The cost of such services depends on the willingness-to-sell of flexibility providers and therefore is likely to vary considerable depending on the type of flexibility source. As discussed in section 4.8, the cost could be significant if the flexibility provision requires active participation from a large number of end-users.

These costs are to a large extent operational, whereas the cost-savings associated with a reduced need for network reinforcements are more associated with capital expenditures. The comparison between the (mostly operational) costs for a flexibility market and the (mostly capital) costs of network reinforcements can be challenging to carry out in practice, not least because of the risk considerations and regulatory aspects involved.

Implementation of a flexibility market would increase the complexity of a DSOs operation and business. Increased complexity does not necessarily constitute a barrier – it can be viewed as a natural consequence of the DSO taking on a more active role. However, it could also come with increased risk and make operations more difficult.

In addition to the complexity of technical systems and its associated risks and costs, increased organizational complexity can also provide a challenge. Compared to a more traditional DSO that focuses on passive infrastructure management, a DSO that engages in a flexibility market is a more complex business to manage. For example, costs and revenues may be more difficult to predict and understand and the DSO's relationships with its customers become more multifaceted. This is more likely to constitute a barrier for smaller DSOs with limited staff and managerial resources.

4.10 Timing and the risk of stranded investments

Many DSOs may not currently have an urgent need for flexibility in their networks but foresee an increased need over the coming years. Further, the implementation of a flexibility market can require significant investments from the DSO, financially as well as in terms of effort and time. This is especially the case if new ICT systems need to be developed, new commercial arrangements negotiated, and new market designs tested. Therefore, DSOs are likely to find themselves in a situation where they have the possibility to initiate flexibility market projects (or engage in a flexibility market organized by a third party), but where it is uncertain to what extent the DSO will actually need the services that the market can provide in the future.

Therefore, as with uncertain investments in general, there is a risk that the DSOs flexibility market investments end up being stranded. Depending on the possibility for the DSO to include flexibility market investments in the asset base (see discussion in section 4.2), the financial risk for the DSO may be greater if it chooses a flexibility market approach instead of a more traditional grid reinforcement option. This would be the case if the DSO is able to include the grid reinforcement costs in their asset base even in a stranded scenario, thereby passing the financial risk on to its customers.

Further, the concept of flexibility markets is evolving with continued efforts needed in research and development before reaching its full potential. Because of the monopoly status of DSOs, there may not be much of a first-mover advantage for DSOs who are early in investing in flexibility market options and who help in the development process. Instead, it may be beneficial for DSOs to wait and see, relying on other DSOs to go through the first stages of development and therefore delay the implementation of flexibility markets.

It may be advantageous if groups of DSOs could cooperate and develop flexibility market solutions jointly. However, from an individual DSOs perspective, a wait-and-see strategy may seem more attractive, making it more difficult to establish cooperation within this domain.

5 Conclusions and next steps

The previous section of this report discusses a range of potential barriers for the implementation of flexibility markets at the distribution level. The discussion is kept at a very general level, meaning that not all barriers are relevant in all cases, and the relative importance of the barriers will differ depending on national as well as DSO-specific circumstances.

The list of potential barriers for implementation of flexibility markets can be made very long. The intention of this report has not been to analyze these barriers in detail. Instead, the report provides background information that can be used to inform further discussions and guide more detailed analysis. This part of the FlexiGrid power project aims at organizing a second workshop for a more in-depth discussion among industry experts about potential barriers, using this report as background material.

The aims of the second work package is to inform subsequent tasks and work packages about potential issues that may hamper implementation in practice. By initiating an early discussion about potential barriers, the awareness of potential pitfalls and thereby improving the ability for the FlexiGrid project to take such issues into account in future research and development activities will increase.

A mapping of DSO's needs and challenges is currently carried by the DSOs participating in the FlexiGrid project, as part of an effort in work package 9. That mapping, along with the analysis of barriers in this report, will provide input to FlexiGrid Task 2.2, which will elaborate on plausible future scenarios for local energy exchange in distribution networks, identify suitable grid services, and design tradable products.

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