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WHAT POLICIES FOR A EU SMARTER GRID ENVIRONMENT? A DELPHI-BASED FORESIGHT ANALYSIS ON DSOS

Guillermo Ivan Pereira [1 2 4 *], Patrícia Pereira da Silva [1 2 3], and Deborah Soule [5]

[1]Energy for Sustainability Initiative, Faculty of Sciences and Technology, University of Coimbra, Portugal
[2]INESC Coimbra, Institute for Systems Engineering and Computers at Coimbra, Portugal
[3]Center for Business and Economics Research, Faculty of Economics, University of Coimbra, Portugal
[4] MIT Portugal Program in Sustainable Energy Systems, 77 Massachusetts Avenue, Cambridge, MA, USA
[5] MIT Initiative on the Digital Economy, 77 Massachusetts Avenue, Cambridge, MA, USA

* Corresponding author: gpereira@student.dem.uc.pt, University of Coimbra, Portugal

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ABSTRACT
The transition toward a smarter and cleaner electricity sector represents opportunities for service innovation at the distribution system operator level. However, these opportunities are associated with uncertainty regarding how the natural monopoly characteristics of distribution network operations could or should be combined with the new services possible in a smarter grid framework. For instance, distributed energy resources flexibility management services can be provided by DSOs, as well as by competitive market participants. This context requires a more detailed understanding of the policies most suited to facilitate this transition. This paper presents a foresight study on policy alternatives for a smarter grid environment in the European Union. For this purpose, a Policy Delphi methodology was applied, through which 208 experts evaluated 57 policy alternatives comprising institutional, organisational, and technological aspects. The results highlight the need for a common vision for market design. In addition, the need to develop an innovation supportive regulatory framework is emphasised. Our findings offer valuable insight for policy makers responsible for the Clean Energy for All European policy package and associated electricity sector market design proposals.

INTRODUCTION

The ongoing energy transition is driving a shift toward a smarter and more sustainable electricity sector. For electricity distribution system operators (DSOs), this represents new service possibilities resulting from increased levels of automation and monitoring, as well as from the growth of electricity storage solutions, electric vehicles, smart meters, small scale distributed generation, and appliances automation (Mallet et al., 2014). These new services include flexibility facilitation and coordination, energy efficiency promotion, data access, deployment of smart meters, and facilitation of electric vehicle infrastructure (Gellings & Lordan, 2004; Oosterkamp et al., 2014). In the context of the European Union (EU) electricity market, DSO responsibilities have been shaped by successive implementations of policy packages. This situation can be considered as a two-staged market restructuring process. In the first stage, policy actions were taken to deliver on the ambition of a liberalized electricity market, and implemented through Directives 96/92/EC, 2003/54/EC e 2009/72/EC. These policies forced a shift from a vertically integrated industry toward more competitive markets for generation and retail, in combination with natural monopolies for network operations. Through this process, DSOs were separated (i.e. unbundled) from the vertically integrated utilities (VIU). In the second stage, policy actions target the ambition of a smarter and clean electricity sector, through initiatives such as the Energy Union, the Digital Single Market strategy, and the more recent Clean Energy for All Europeans policy package. These initiatives introduced a set of policy recommendations for shaping the electricity market. They include specific proposals for how DSOs should or could be involved in the delivery of new services associated with a smarter grid framework (European Commission, 2016). The evolution of DSO responsibilities throughout the different stages of EU market restructuring is presented in Figure 1. The ongoing transition has raised concerns about how DSOs should position themselves, given the potential for conflict between responsibilities for electricity distribution under natural monopoly conditions and smart grid innovation under competitive market conditions (Meeus & Hadush, 2016; Oosterkamp et al., 2014). In this research we define a smarter grid environment as comprising advances on two fronts: 1) the integration of information and communication technologies (ICTs) to facilitate distribution network activities, and 2) the integration of distributed energy resource technologies such as electric vehicles and the necessary charging infrastructure, distributed generation technologies, electricity storage technologies, and smart metering equipment.

Stage	Liberalized electricity market			Smart and clean electricity sector	
	1996	2003	2009	2015	2016
Policy Actions	Directive 96/92/EC	Directive 2003/54/EC	Directive 2009/72/EC	Energy Union	Clean Energy for All Europeans
DSO Responsibilities	-Operation, maintenance, and development of the electricity distribution grid; -Secure, reliable, and efficient service provision; -Neutral market facilitation; -Prioritised dispatching of renewable, waste and combined heat and power generation units; -Preserve the confidentiality of commercially sensitive data.	-Provide users with data for efficient access and use of the system; -Procure electricity to cover system losses and reserve capacity in a transparent way; -Perform system balancing in a transparent way; -Consider energy efficiency, demand-side-management and distributed generation when planning distribution network developments.	-Modernisation of distribution grids through smart grids.	-Procure non-frequency ancillary services in a transparent and non-discriminatory way considering all market participants; -Procure flexibility services to improve distribution system operation and development; -Develop electric vehicle charging infrastructure when no other parties manifest interest; -Provide non-discriminatory access to data through a transparent management model. -Own, develop, manage, or operate electricity storage when no other parties manifest interest.	

Figure 1: DSOs and the EU electricity market restructuring stages.

Collectively, these changes create uncertainty about appropriate roles for DSOs in future EU electricity markets, as well as uncertainty about appropriate market designs for these possible new services. Moreover, any DSO transition encompasses multiple dimensions: the *institutional* dimension, related to the policy framework under which DSOs must operate and adapt; the *technological* dimension, related to the introduction of innovative technologies and resulting impact for network operations; and the *firm-level* dimension, which includes the organisational capabilities of DSOs to adapt their business model and strategy in response to the institutional and technological dynamics (Markard, 2011; Pereira & Silva, 2016). Through this research, we aim to reduce this uncertainty by presenting a foresight study on the changes affecting DSOs. We were guided by the following research question: *What are the most suitable electricity sector policy and market design characteristics for DSOs operating in a smarter grid environment?* A Policy Delphi method was applied to develop a more detailed understanding of the policy alternatives associated with the transition towards a smarter electricity sector in the EU. The paper is structured as follows: the methodology section describes the Policy Delphi and its implementation; the results section describes a sample of the collected data and provides some complementary perspectives based on both the existing policy framework and the current data; finally, conclusions and policy implications are presented.

METHODOLOGY

The Policy Delphi method applied in this research is part of the group of Delphi techniques that are typically used to gain insight into topics marked by uncertainty and for which knowledge from experts is accessible (Linstone & Turoff, 2002). The Delphi method involves iterative steps through which experts' knowledge is collected and analysed. It aims for greater stability in responses across iterations, to inform and reduce the complexity associated with the subject of analysis. Notably, this method does not seek consensus. Instead, it aims for stability in responses from participating experts, which does not necessarily imply consensus among those experts (Linstone & Turoff, 2011). The Policy Delphi used for this research also follows an iterative process, but without aiming for response stability. Used as a tool for policy foresight, this method enables the generation of policy alternatives, where diverging opinions highlight the selection of options policy makers should consider (Hanafin, 2004; Makkonen, Hujala, & Uusivuori, 2016). This method has seen numerous applications in the energy and sustainability sector. Kayakutlu & Büyüközkan (2008) applied the method for the assessment of knowledge-based resources in a utility company in Turkey. Celiktas & Kocar (2010) applied a Delphi technique to explore Turkey's renewable energy. Mirakyan & Guio (2014) presented the Delphi method as part of an integrated energy planning process, for a case study in Singapore. Galo et al. (2014) explored smart grid deployment criteria for Brazil through the Delphi. Billig & Thrän (2016) combined a Delphi-based survey and multi-criteria analysis for the assessment of biomethane technologies in Europe. Nguyen et al. (2017) used this method to research how local communities adapt to climate change, focusing on Vietnam's coast. These studies, representing a sample of recent applications, demonstrate the flexibility of the method, which is valuable as it enables the exploration of policy options by testing different scenarios and future hypotheses. The implementation of the Policy Delphi consisted of the following steps:

- Literature review: scientific and policy documents were reviewed to identify relevant areas of analysis.
- Industry insight collection: semi-structured interviews were conducted with three DSOs of varying size and a NRA representative. Open-ended questions yielded new knowledge that complemented the literature review.

- Policy Delphi participants' selection: invited experts were selected based on the following criteria: affiliation in entities related to smart grids development and electricity market design; interest in future policies for the EU electricity sector; and willingness to collaborate in a foresight study for analysing policy issues of DSOs.
- Policy Delphi Questionnaire development: a questionnaire was developed based on input from the literature and industry interviews.
- Policy Delphi Questionnaire piloting and validation: the initial version of the questionnaire was distributed to a group of six experts: two from industry, representing DSOs, and four from academia, representing knowledge in electricity markets, energy policies, and organisational adaptation.

RESULTS

The Policy Delphi instrument was distributed to 1357 experts for the 1st round of data collection. Of these, 243 responded to the study, while 208 provided a complete questionnaire, yielding an 85.6% response rate. The study was conducted between November, 2016 and February, 2017. The experts represented 27 countries as follows: Austria (7.5%), Belgium (3.2%), Bosnia and Herzegovina (0.5%), Bulgaria (0.5%), Croatia (2.1%), Cyprus (1.1%), Czech Republic (1.6%), Denmark (0.5%), Finland (4.3%), France (3.2%), Germany (8.0%), Greece (2.7%), Ireland (1.6%), Italy (10.7%), Latvia (0.5%), Netherlands (7.0%), Northern Ireland (1.1%), Norway (2.7%), Portugal (20.9%), Romania (0.5%), Slovenia (1.1%), Spain (4.8%), Sweden (6.4%), Switzerland (1.6%), Turkey (1.1%), and United Kingdom (4.8%). The 208 responses included in the analysis spanned the following stakeholder categories: Distribution System Operators (40.9%), Electricity Generation Companies (4.3%), Electricity Retail Companies (1.4%), Electricity sector associations (1.4%), Industry analysts and Consultants (13.5%), Policy Makers (1.0%), Regulators (1.4%), Researchers and Academics (27.4%), Transmission System Operators (2.9%), and Others (5.8%). The final questionnaire included a set of 57 statements concerning business model innovation, technological adaptation, and policy and market design. We included this range of topics with the goal of obtaining a broad perspective, in terms of agreement, importance, and priority. For the evaluation of the identified policy alternatives, we chose a consensus threshold of 70%, in line with prior studies (Hasson et al., 2000; Keeney et al., 2010; Ribeiro & Silva, 2015). This resulted in consensus on agreement/importance with policy alternatives for 34 policy issues; consensus on disagreement/low importance with policy alternatives for 1 policy issue; and no consensus on 22 policy alternatives.

General Outcomes

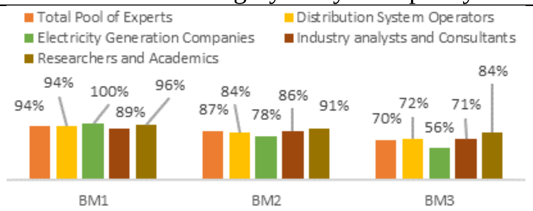
The following Table 1 presents the policy issues with high levels of consensus on agreement and importance.

Table 1: Policy issues exhibiting high levels of positive consensus

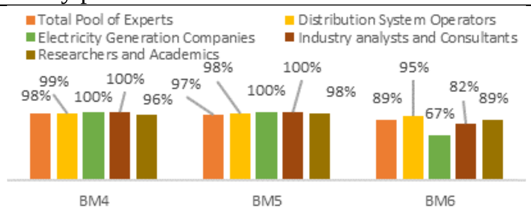
Area: Business Model Innovation		
Code	**How should DSOs position themselves regarding business model and organizational innovation?**	**Agree**
BM1	DSOs should focus on adapting their organisational structure to be ready for the smart grid opportunities.	93.8%
BM2	DSOs should provide innovative system services allowing for new sources of revenue.	86.5%
BM3	DSOs should test strategies that challenge the current regulation and disrupt the market.	70.2%
Code	**In the future DSOs, should be involved in the following activities?**	**Agree**
BM4	Grid planning (i.e. expansion and reinforcement).	98.1%
BM5	Grid management (i.e. operation and maintenance).	97.1%
BM6	Integration of distributed generation technologies.	88.9%
Area: Technological Adaptation		
Code	**What is the importance of the following digital capabilities for DSOs new roles?**	**Important**
TA2	Collection of data.	93.3%
TA3	Aggregation of data (e.g. from a diversity of sources to obtain meaningful decision-support information).	91.3%
TA4	Validation and quality certification of data (i.e. to ensure accuracy and validity of collected information).	90.9%
Area: Market Design		
Code	**How important are the following policy-oriented actions in the ongoing DSOs transition?**	**Important**
MD1	DSOs regulation should be designed to facilitate innovation and investments in smart grid technologies.	94.2%
MD2	DSOs should follow a common-vision of their most effective role in the electricity value chain.	83.7%
MD3	There should be specific support programmes for technological innovation at the DSOs level.	82.7%

In terms of business model innovation, experts strongly agreed on the importance of adapting the organisational structure to explore the opportunities of a smarter grid environment (93.8%). This input is complemented by their perspective on appropriate activities for DSOs. Experts agreed on the role for DSOs in ensuring the delivery of the core electricity distribution network activities, such as grid planning and management. In addition, they agreed that DSOs should be involved in integrating distributed generation technologies, deploying smart meters, and further evolving data gathering capabilities. For technological adaptation, most experts agreed on the importance of collaborative R&D (97.1%). They also agreed on the importance of digital capabilities like data collection, aggregation, and validation for DSOs. On market design, the experts agreed on the need for innovation supportive regulation (94.2%) and the need for a common vision for DSOs future roles (83.7%). For additional perspective, subsequent analysis examined the impact of respondents' stakeholder categories on assessments of policy alternatives. Table 2 shows the breakdown of responses by stakeholder category, for a selection of policy issues from Table 1. Table 2 reveals no significant variations in the levels of consensus regarding most of these policy issues. However, for the policy issue "BM6 – Integration of distributed generation technologies", a more conservative position is observed from the "Electricity Generation Companies" experts group. This may be attributable to the perception that distributed generation presents a market risk for traditional generation.

Table 2: Stakeholder category analysis of policy alternatives marked by positive consensus



How should DSOs position themselves for business model innovation?



In the future DSOs should be involved in the following activities?

The data presented in Table 3 provide a complementary perspective, highlighting policy issues with high levels of consensus but on disagreement or low importance.

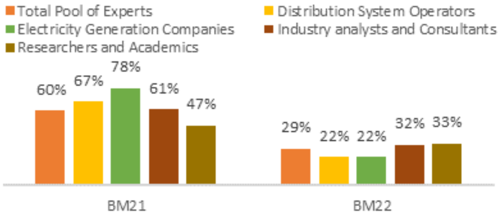
Table 3: Policy issues exhibiting high levels of negative consensus

Area: Business Model Innovation		
Code	**How should DSOs position themselves regarding business model and organizational innovation?**	**Disagree**
BM17	DSOs should focus only on grid operation and maintenance, planning and expansion, and quality of service.	70.2%
BM18	DSOs should limit their business strategy to the possibilities allowed by existing regulations.	67.3%
Code	**How do you perceive the difficulty of DSOs adaptation to a changing electricity sector?**	**Difficult**
BM19	DSOs will be able to adapt their role in a timely manner.	65.9%
BM20	DSOs will be able to integrate new technologies to support the transition to smarter distribution grids.	51.4%
Code	**In the future DSOs, should be involved in the following activities?**	**Disagree**
BM21	Electricity retail.	59.6%
BM22	Electric vehicle infrastructure ownership.	28.8%
Area: Market Design		
Code	**How important are the following policy-oriented actions in the ongoing DSOs transition?**	**Not Important**
MD8	The role of the DSOs should only be specified at the Member State level.	41.8%
MD9	A new regulatory body should be established focusing on the transition to a smarter grid framework, with a strategy and incentives for DSOs to innovate.	27.4%

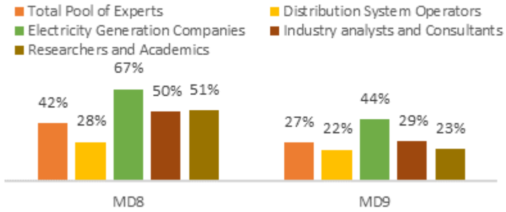
With regard to business model innovation, most experts disagreed that DSOs should stay limited to their current core activities (70.2%). They also signalled collective disagreement with DSO strategy being limited to any current regulations (67.3%). As for the challenges facing DSOs, many experts saw difficulties for DSOs in adapting their role in a timely manner (65.9%) and in adopting new technologies (51.4%). In terms of DSO activities, a large proportion of experts believed that DSOs should not be involved in electricity retail (59.6%). Considering market design options, many experts disagreed that DSO roles should be defined only at the Member State level (41.8%). This perspective complements the strong agreement on the importance of developing and following a common vision, as shown in Table 1. Experts also placed low importance on the need for a regulatory body dedicated to the electricity distribution segment (27.4%).

As before, subsequent analysis examined expert assessments by stakeholder categories, as shown in Table 4. This analysis revealed greater variability in assessments for policy issues for which there was overall negative consensus (i.e. disagreement/low importance). For instance, experts representing "Electricity Generation Companies" were more strongly opposed, than other stakeholder groups, to policy issues "MD8 – The role of the DSOs should only be specified at the Member State level" and "MD9 – A new regulatory body should be established focusing on the transition to a smarter grid framework, with a strategy and incentives for DSOs to innovate."

Table 4: Stakeholder category analysis of policy alternatives marked by negative consensus



In the future DSOs, should be involved in the following activities?



How important are the following policy-oriented actions?

Technological Adaptation

Since DSO electricity distribution activities are highly regulated, it is important to consider different alternatives for their technological adaptation. We prompted the Delphi experts to consider three alternatives, associated with different levels of technological development. The results presented in Table 5 provide expert insight about how DSOs should prioritize technology development in the course of their adaptation to a smarter grid environment.

Table 5: Technological adaptation alternatives for DSOs.

Adaptation alternatives	DSOs should conduct exploratory R&D activities for new technologies and innovative applications.	DSOs should pilot and demonstrate the potential and impact of emerging technologies.	DSOs should exploit proven technologies, deploying external R&D results from universities, ICT firms, and other DSOs.
Main Priority	26.44%	38.46%	37.02%

The data do not highlight any particular approach: 26.4% of experts prioritized exploratory R&D; 38.5% prioritized piloting and demonstration; while 37.0% placed priority on DSO exploitation of proven technologies. Analysis by stakeholder category revealed that experts representing “Electricity Generation Companies” and “Researchers and Academics” most strongly favoured the recommendation that DSOs pursue technological adaptation by exploiting proven technologies.

Market Evolution

In addition to exploring policy alternatives, the study also analysed market evolution trajectories. Experts were asked to consider a range of future scenarios regarding the timeframe for the transition of DSOs from Passive Network Manager (PNM) into Active Network Manager (ANM) roles. Passive network management describes the situation in which DSOs continue with their traditional activities, solving most grid related issues at the planning stage. Active network management describes the situation wherein DSOs incorporate smart grid capabilities, managing system flexibility as part of their operations (Oosterkamp et al., 2014; Pereira & Silva, 2016). Experts considered the likelihood and pace of this role change for both small DSOs and large DSOs. The distribution of their predictions is presented in Figure 2.

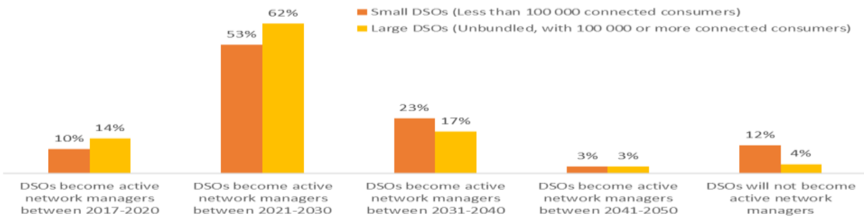


Figure 2: DSO market evolution trajectories.

Figure 2 shows that most experts believed that both small and large DSOs will shift from PNM to ANM operations between 2021 and 2030 (53% and 62% agreement respectively). In the transition from PNM to ANM, there were no significant differences associated with the size of DSO. However, the size of DSO is associated with whether experts believe they will transition to Active Network Managers at all: 12% foresaw that small DSOs will not become ANMs, while only 4% perceived this outcome for large DSOs. The analysis of these assessments by stakeholder category yielded analogous outcomes.

CONCLUSIONS AND POLICY IMPLICATIONS

This research applied a Policy Delphi method to identify the most appropriate policy characteristics for DSOs operating in a smarter grid environment. Our findings offer valuable insight for policy makers responsible for the Clean Energy for All European policy package and associated electricity sector market design proposals. In terms of business model innovation, the importance of facilitating the adaptation of organisational structures is highlighted, as is the need for DSOs to balance their traditional distribution activities with those related to the integration of distributed energy resource technologies. For technological adaptation, the relevance of pursuing collaborative R&D endeavours was highlighted, as well as the importance of digital capabilities around data collection, aggregation, and validation in a context of growing data generation. As for market design, the importance of innovation-friendly regulation is emphasized, in parallel with the need for a shared EU-level vision regarding DSO responsibilities. Future work includes further rounds of data collection, following the Policy Delphi methodology.

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