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IX.54 A legal framework for smart grids

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Abstract

Smart grids facilitate the coordination of connected system users' flexibility capacity via information and communication technology. Ideally, this would reduce the need for grid expansions, which may otherwise be necessary to accommodate increasing amounts of decentralised generation from renewable energy sources and support the increasing electrification of certain sectors (*e.g.* the transport sector). Smart grids are multifaceted systems and have a broad impact on the operation and use of the electricity system. This chapter focuses on the EU and identifies the main issues that must be addressed by a legal framework for smart grids in a liberalised electricity sector.

Keywords

Smart grid, electricity sector regulation, flexibility, distribution system operator, consumer, prosumer, renewable energy, decentralisation, Electricity Directive 2019/944/EU

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IX.54.1 Introduction

Smart grids are considered essential for the energy transition and modernisation of electricity systems by policymakers around the globe.¹ Electricity grids facilitate the transport of electricity from the production site to the point of consumption. The addition of the prefix 'smart' essentially entails upgrading the distribution system with information and communication technology (ICT) to facilitate data exchanges between all connected system users, *i.e.* consumers, producers, or prosumers, for more efficient grid operation.² The focus in this chapter is on the distribution system level, where the need for smart grid implementation is most urgent. This chapter discusses the regulatory

¹ Brown and Zhou (2012); Brown, Zhou and Ahmadi (2018).

² Prosumers are commonly understood as energy consumers who start generating energy, primarily for their own use and on their own premises. For more on this, see Chapter 61 of this book.

framework for smart grids in a liberalised energy market. The focus is on the EU, but the legal issues identified are also relevant for other jurisdictions.

The distribution system was originally designed for ‘forwarding’ electricity from the transmission system to consumers connected to the distribution grid (usually households and small enterprises). This also implied that the operation of the distribution grid did not require the active balancing of production and consumption. This paradigm is changing with increasing amounts of decentralised generation (DG)³ from renewable energy sources (RES) and growing electrification (*e.g.* in the transport sector).⁴ The distribution system is thus set to be used more extensively for both production and consumption. More extensive use requires either expanding capacity (*i.e.* thicker cables) or a different way of operating the grid (*i.e.* the operation needs to become ‘smart’, by facilitating data exchanges among all system users).⁵ This data needs to contain information on available capacities and flexibilities of connected system users. Through this, instead of expanding grid infrastructure, smart grids integrate consumer flexibilities to enable more efficient grid operation.⁶ This is also referred to as ‘demand flexibility’, and requires the ability and willingness of consumers to adjust their electricity consumption, for example by incentivising or disincentivising consumption of electricity through dynamic prices that are aligned with RES generation and available grid capacity.⁷ Potentially, consumers might even gain a new role in a smart grid setting, allowing them to take more precise control over their electricity consumption and, ideally, benefit from dynamic prices.⁸

Overall, smart grids could thus accelerate the energy transition by facilitating the efficient use of RES at the distribution system level.⁹ Ideally, this would reduce both the need for grid expansion and the need for (non-renewable) balancing generation reserves.¹⁰ In the EU context, smart grid developments still remain on pilot project scales, and depend on private investment or specific regulatory schemes seeking to promote grid innovation.¹¹ To make smart grids an integral part of electricity system planning and operation, the legal framework applicable to the electricity sector needs to define functions and assign roles for the duties which potentially emerge in a smart grid scenario. This chapter identifies the main regulatory issues regarding these potential new functions and roles.

The chapter begins by introducing the concept of smart grids alongside the main underlying policy objectives and technical functionalities. Following this, the main issues to be addressed by a legal framework for smart grids are identified. The chapter’s conclusion notes that the legal framework enabling smart grids needs to extend beyond

³ Decentralised generation relates to production facilities which are connected to the distribution grid.

⁴ For more on the decarbonisation of the transport sector, see Chapter 49 of this book.

⁵ Poudineh and Jamasb (2014) 223.

⁶ Spiliotis and others (2016) 621.

⁷ In the EU, demand flexibility is currently mainly offered by large consumers, usually industrial consumers, and not by household consumers and small enterprises connected to the distribution system. See: Bertoldi, Zancanella and Boza-Kiss (2016) 127.

⁸ Verbong, Beemsterboer and Sengers (2013) 120.

⁹ Battaglini and others (2009) 914.

¹⁰ For more on system balancing, see Chapter 32 of this book.

¹¹ Gangale and others (2017) 28.

facilitating technologies while also considering the economic and social impacts of smart grids.

IX.54.2 Smart grids

As there is no universally valid definition of what smart grids are or could be,¹² smart grids can be better understood as a mode of system operation and system usage. Operation and usage are geared towards specific objectives which need to be implemented via functionalities of the electricity system. Defining smart grids in terms of their ascribed objectives and functionalities allows the implications for the legal framework governing the electricity sector to be identified, as will be done in section IX.54.3.¹³

IX.54.2.1 Smart grid objectives

The objectives of smart grids are closely linked to the overall policy goal of achieving a secure, affordable, and sustainable electricity sector (also referred to as the energy triangle or trilemma).¹⁴ Meeting these objectives becomes more challenging in a society with increasing energy demand and a need to reduce greenhouse gas emissions. The core objective of smart grids is to address this dichotomy by enabling more efficient and cost-reflective grid use and electricity consumption. The International Energy Agency (IEA) compiled a consensus view of various governments, industry, academia, and consumer representatives on the term ‘smart grid’ and devised the following definition:

Smart grids can play an important role in addressing increasingly untenable economic, environmental, and social trends in the supply and use of energy. By enabling increased awareness of system operation and better informed participation by electricity users, smart grids will increase electricity end-use efficiency while optimising network asset utilisation and increasing grid resiliency. They will also enable efficient integration of variable renewables and electric vehicles, as well as new products and services.¹⁵

The first sentence of this definition promotes smart grids as part of the solution to the energy trilemma and refers to four goals, namely: participation of electricity user (demand side); energy efficiency (in system operation and end-use); grid resilience (maintaining grid stability); and integration of variable RES. Similarly, the EU also identifies smart grids as a way of ensuring a secure, affordable, and sustainable electricity sector, defining the term ‘smart grids’ as follows:

‘smart grid’ means an electricity network that can integrate in a cost efficient manner the behaviour and actions of all users connected to it, including generators, consumers and those that both generate and consume, in order to ensure an economically efficient and sustainable power system with low losses and high levels of quality, security of supply and safety.¹⁶

¹² Beaulieu (2016); Muench, Thuss and Guenther (2014) 82.

¹³ Diestelmeier (2019).

¹⁴ Clastres (2011); Oliver and Sovacool (2017). For more on this issue, see Chapter 3 of this book.

¹⁵ IEA (2011) 6.

¹⁶ Regulation (EU) No 2013/347 of the European Parliament and of the Council [2013] OJ L 115/39, art 2(7).

These two definitions of smart grids illustrate the most common objectives ascribed to them. While both definitions do not suffice for analysing the legal implications of smart grids, they provide a starting point by suggesting the four overarching objectives of smart grids: integration of RES in the electricity system; improving energy efficiency; maintaining grid stability; and increasing levels of participation of system users, *i.e.* producers, consumers, and prosumers.

IX.54.2.2 Smart grid functionalities

There is no single smart grid technology, and indeed, achieving smart grid objectives requires a range of technologies to be utilised. As the legal implications do not depend on specific technologies, this section suggests some overarching categories of technologies which are a prerequisite for the functioning of smart grids.

Smart grids generally require three main technologies to be added to the electricity system. Firstly, consumers must have access to flexibility technologies, such as storage or smart home technologies (*i.e.* household appliances which are able to reduce load in response to price signals), thus allowing them to shift their demand to different times of day.¹⁷ Secondly, all system users and system operators need access to communication networks. Thirdly, real-time data exchanges (on generation, consumption, and flexibilities within one system) are required among systems users, and between system users and system operators. Together, these technical upgrades constitute a smart grid.

Flexibility is not a new concept and is already well-integrated in the electricity system.¹⁸ It is relevant for grid operation, particularly in respect to balancing supply and demand. From an individual system user perspective, flexibility can be defined as:

the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system. The parameters used to characterize flexibility in electricity include: the amount of power modulation, the duration, the rate of change, the response time, the location¹⁹

In the EU electricity sector, the ability to offer demand flexibility based on dynamic prices is mostly tailored to large consumers (*e.g.* industries with high electricity consumption).²⁰ The flexibility capacity offered by small consumers at the distribution grid level remains largely unused.²¹ Unlocking these potential flexibilities requires electricity systems that enable, incentivise, and coordinate efficiency gains (flexibility) at the distribution grid level.

Communication networks are relevant for coordinating the consumer flexibility and system operators, and are thus an integral part of an electricity system seeking to facilitate smart grid operations. In contrast to the electricity grid system, which usually includes one network – the electricity cables – communication networks include a variety of technologies. The most tangible distinction is between wired and wireless technologies

¹⁷ Wilson, Hargreaves and Hauxwell-Baldwin (2017) 72.

¹⁸ For more on demand response, see Chapter 64 of this book.

¹⁹ Smart Grid Task Force EG3 (2015) 12.

²⁰ Bertoldi, Zancanella and Boza-Kiss (2016) 127.

²¹ Gils (2014) 6.

for communication networks. Deciding which technology is optimal depends on the purpose that it serves. Communication networks fulfil several functions in smart grids. These include, for example, facilitating access for system users, enabling system state estimation and the real-time control of the distribution grid, the interconnection of local area communication networks, and delivering large amounts of data to remote control centres over long distances.²²

Data on production, consumption, and grid capacities must be exchanged in real-time among the system users and between system users and system operators to enable adjustments to their activity (grid usage or grid operation) to be made. In smart grids, system users should constantly be able to adjust their electricity consumption – this is only possible if data is exchanged. Data can include essentially anything, from simple consumption data, to grid state data, to information on weather forecasts.²³ However, it is not only the quantity of data that is relevant. Indeed, even more decisive for reliable and efficient smart grid operation is the quality of the data, with data quality influencing the accuracy of system operation in terms of reliability and efficiency. While many definitions aim to capture the concept of data quality, there is no exhaustive understanding. Instead, data quality can be measured by its characteristic, for example accuracy, integrity, consistency, availability, and timeliness.²⁴ Each of those characteristics can vary to a large extent and influence the overall efficiency of smart grids. Specifying quantity and quality aspects is therefore essential for enabling smart grids.

IX.54.3 A legal framework for smart grids

Describing smart grids on the basis of the three main functionalities identified above (flexibility, communication networks, and data) leads to the inference that smart grids are multifaceted electricity systems. From a legal perspective, it is therefore impractical to formulate an exhaustive definition of smart grids. Instead, it is relevant to identify how smart grids change the operation of the distribution systems, the role of system users connected to the distribution system, and transactions between system users, system operators, and possibly new actors. This further allows for the detection of legal issues regarding the development of smart grids.

IX.54.3.1 System operation

The distribution system was originally designed and operated as part of the electricity supply chain, which transports electricity from the transmission system and subsequent transformer stations via the distribution grid to the points of final consumption. Consumers were predominantly passive in their consumption of electricity, with consumption following largely predictable patterns.²⁵ In this setting, the transmission system operators (TSOs) have been assigned the task of balancing the transmission grid. Integrating increasing amounts of DG from RES (while maintaining affordability and reliability of electricity supply) requires redesigning the operation of distribution systems

²² Ancillotti, Bruno and Conti (2013) 1678.

²³ Aiello and Pagani (2014) 12.

²⁴ Chen and others (2017) 99.

²⁵ Blumsack and Fernandez (2012) 62.

around smart grids.²⁶ The technical functionalities of smart grids extend the distribution system beyond the electricity grid by adding communication networks for data exchanges in order to manage flexibility technologies. The resulting regulatory questions are whether and to what extent distribution system operators (DSOs), as regulated actors in a liberalised market, can engage in the operation of communications networks and can manage the flexibility sources of system users by processing this data.²⁷

Liberalised market settings are based on the principle of independent network operation. In essence, this entails system operators providing non-discriminatory access to the system, thus allowing any potential producer or consumers to participate in the market.²⁸ As communications networks and data are integral parts of smart grids, access to these becomes a precondition for participating in the market in the smart grid scenario.²⁹ Despite this, the operation of networks and the processing of data does not necessarily need to be entrusted to the DSO. Moreover, in 2011, the EU Commission recognised a potential risk to a competitive market setting by assigning the DSO tasks related to smart grid operation, stating the following:

DSOs would obtain access to detailed information about consumers' consumption patterns, which could give DSOs a considerable competitive advantage over other market actors in offering tailor-made services to consumers. The regulatory setting will need to ensure that these risks are properly addressed.³⁰

Ensuring a liberalised market setting for smart grids thus requires the legislator to carefully assess whether new tasks regarding (smart) grid system operation should be carried out by the DSOs, or whether this would foreclose potential markets. This requires finding a balance between the need for coordination (for the purpose of system operation) and the enabling of competition for flexibility services offered by system users.

Directive (EU) 2019/944 (the 2019 Electricity Directive) provides a new provision on data management.³¹ The provision leaves a considerable degree of discretion to the Member States (MSs) by requiring them only to specify the rules on the access to data of the final customer by eligible parties. The directive does not specify who eligible parties are, though it requires that access to data is simultaneously provided in a non-discriminatory manner to eligible parties, and that procedures for obtaining access to data are publicly available.³² Moreover, the directive provides extra provisions where DSOs are involved in data management. The directive provides additional safeguards for the situation where a DSO is still a part of an integrated undertaking (*i.e.* involved in production and/or supply) by requiring MSs to take 'all necessary measures to ensure

²⁶ Bell and Gill (2018) 766; Ruester and others (2014) 234.

²⁷ Buchmann (2017) 64.

²⁸ Kruimer (2011) 270.

²⁹ Diestelmeier and Kuiken (2017) 9.

³⁰ Commission, Smart Grids: From Innovation to Deployment (Communication) COM(2011) 202 final, 10.

³¹ Directive (EU) 2019/944 of the European Parliament and of the Council [2019] OJ L158/125 (2019 Electricity Directive) art 23.

³² *ibid* art 23(2).

that vertically integrated undertakings do not have privileged access to data for the conduct of their supply activities'.³³

System operation of smart grids is much more complex than the current operation of distribution systems. Connected system users are not only consumers or prosumers, but can also contribute to system operation by offering demand flexibility. Access to communications networks and data becomes essential for system users, and must be granted in a non-discriminatory manner. Developing a legal framework for smart grids in a liberalised market thus requires carefully considering how to organise the governance of communications networks and data management without foreclosing markets.

IX.54.3.2 System users

Current legal frameworks applicable to the electricity sector generally establish two main categories of system users: producers and consumers. In a liberalised market setting, these roles are usually further elaborated in the legal framework, assigning producers specific requirements regarding the production process and system use, and providing protection to small consumers. This legal distinction is tailored to electricity systems in which system users either produce or consume electricity. The insufficiency of this distinction in today's world is already illustrated by the emergence of 'prosumers', and will further be challenged by smart grids. Smart grids add to the complexity of defining system users on the basis of their activity, as consumers may not only start producing electricity, but are incentivised to offer flexibility in consumption (demand flexibility). One of the central objectives of smart grids is to integrate the demand-side activities at the distribution system level as an 'active' part of the electricity supply chain. 'Active' denotes that consumers are not only consuming at their convenience, but are nudged, through dynamic price signals, to change their consumption according to the availability of production and grid capacities. This poses the question of whether electricity sector regulation needs to establish new categories of system users, moving beyond the distinctions of 'producer' and 'consumer'.

The electricity system was designed and built with the goal of securing supply at all times at affordable prices. Accordingly, generation and transport capacities must be sufficient to service demand continuously. This paradigm is challenged by both the increasing amount of variable RES connected to the distribution system and by the goal of expanding electrification. Enabling this shift efficiently requires demand flexibility – something that smart grids incentivise among system users. Demand for demand flexibility indicates that it has an intrinsic value, and thus, also a price. By offering flexibility, system users could thus, ideally, profit financially. However, this requires that system users (most commonly households at distribution system level) are able and willing to do so. The ability and willingness also depend on the technologies which enable flexible consumption.³⁴ Clearly, a consumer who possesses, for example, a home battery, an electric vehicle, smart home technologies, and solar panels can offer greater flexibility (larger capacity and across various timeframes) than a consumer who does not possess these technologies. Consequently, consumers, or system users, can vary to a large extent

³³ *ibid* art 34.

³⁴ Kubli, Looock and Wüstenhagen (2018) 546.

in their abilities to act and react as market participants, and it is the degree of ‘smartness’ (*i.e.* the ability to respond with flexibility technologies) which puts consumers in different categories. This would subsequently also change their protection needs and service requirements. It thus becomes necessary to consider, from a regulatory standpoint, how to translate the heterogeneity of consumers into the legal framework of the electricity sector.

The EU legislature introduced a new category of consumers in the 2019 Electricity Directive, namely ‘active customers’, which are defined as follows:

‘active customer’ means a final customer, or a group of jointly acting final customers, who consumes or stores electricity generated within its premises located within confined boundaries or, where permitted by a Member State, within other premises, or who sells self-generated electricity or participates in flexibility or energy efficiency schemes, provided that those activities do not constitute its primary commercial or professional activity;³⁵

This new consumer category extends beyond what is commonly known as ‘prosumers’ by also including participation in flexibility or energy efficiency schemes. The directive further elaborates the rights and responsibilities of active customers, for instance by clearly assigning them the financial responsibility for any imbalances they cause.³⁶ While they may delegate their balancing responsibility to third parties, this does indicate that the aim is to further integrate them in the market by making them financially responsible for their electricity consumption (and possibly production) and grid usage. However, they remain a ‘final customer’ and therefore are also subject to the applicable protection regime.³⁷

Smart grids thus not only provide a change in system operation but require the ‘activation’ of system users to offer demand flexibility. However, demand flexibility is not a ‘one-size-fits-all’ concept and depends to a large extent on the ability and willingness of consumers to offer their flexibility as a service. This results in a complex picture of consumers (or better ‘smart grid system users’) which cannot be distinguished by a predetermined category, but only by their ability and willingness to react to dynamic prices (their flexibility-profile).

IX.54.3.3 Transactions

Transactions at distribution system level currently take place between producers/suppliers and consumers, and between consumers and DSOs. Typically, consumers require services (*i.e.* electricity supply and delivery), and producers and the DSOs provide these services. The electricity flows are predominantly unidirectional, moving from the transmission system, via the distribution system, to the final consumers. This technical setting is also reflected in the tariff (or pricing) structures for supply and transport (network). Typically, supply tariffs entail a fixed charge per kilowatt hour, with potential variations between day and night-time usage, and with respect to the volume of electricity

³⁵ 2019 Electricity Directive art 2(8). See also Chapter 61 of this book.

³⁶ 2019 Electricity Directive art 15(1)(f).

³⁷ *ibid* arts 10, 15(1).

distributed (volumetric charges).³⁸ The main component determining the price is thus related to the electricity consumed. This changes in the smart grids where flexibility is the main factor determining the price. Incentivising demand flexibility requires dynamic tariffs for supply and network use, signalling to the consumers when it is cheaper or more expensive to consume electricity, according to the available production and network capacities.³⁹ This changes the unidirectional structure of transactions, as consumers not only consume, but may potentially offer a service – demand flexibility. This poses regulatory questions of the organisation of new transactions, specifically pertaining to the contractual rights of consumers engaging in demand flexibility, and the potential roles of new service providers.

Access to real-time information regarding the price of electricity supply and network use enables new forms of transactions. Ideally, smart grids facilitate non-discriminatory and transparent access to this information, empowering system users to engage in self-determined market transactions. Smart meters are essential for this. Smart meters are installed at the premises of the consumer and, as general meters, measure electricity consumption for billing. However, whereas traditional meters are analogue, and work in one direction (measuring consumption), digital smart meters are ‘equipped with two-way communication technologies’, enabling the real-time communication of data relating to generation, loads, and flexibilities.⁴⁰ Consumers may not only engage individually in new transactions, but also through third-parties (intermediaries). One example of a new business model is aggregation. Aggregation is the concept of a pooling service for consumers, not for the purpose of supplying them with electricity, but for maximising their demand flexibility or possibly managing their generation surplus.⁴¹ Generally, access to information amplifies the number and type of transactions and actors and diversifies the services on offer.⁴²

The 2019 Electricity Directive introduces a couple of new elements to enable new forms of transactions. Under the chapter of ‘consumer empowerment and protection’, the directive, *inter alia*, introduces the right for consumers to conclude a dynamic electricity price contract; the right to purchase and sell electricity services, such as aggregation, independently from their electricity supply contract; and the entitlement to smart meters. Furthermore, MSs are required to allow and foster demand response through aggregation.⁴³ These elements potentially expand the type of transactions and actors in the electricity sector. However, it also links to the preceding section on the changing role of system users, *i.e.* consumers, in the smart grid scenario. While some consumers may be better equipped than others to engage in dynamic market transactions and reap the benefits, others may require a great deal of protection in the smart grid scenario.

³⁸ REF-E and AF-Mercados and Indra (2015) 2. See also Chapter 61 of this book.

³⁹ Khan and others (2016) 1312.

⁴⁰ Erlinghagen, Lichtensteiger and Markard (2015) 1250.

⁴¹ Moura and Centeno Brito (2019) 821.

⁴² Eisen and Mormann (2018) 71.

⁴³ 2019 Electricity Directive arts 11, 13, 17, 21.

IX.54.4 Conclusion

Smart grids have the potential to accelerate the energy transition by enabling efficient integration of DG from RES. However, as argued in this chapter, smart grids are multifaceted systems, combining a variety of objectives and functionalities. In order for smart grids to become functionally effective, the legal framework of the electricity sector needs to address several issues, including the operation of smart grids, the role of system users, and the variety of transactions. This also suggests that smart grids cannot only be considered as a technical tool, but their implementation also needs to consider potential economic and social impacts. The legal framework should seek to align these effects and enable a secure, affordable, and sustainable electricity sector.

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