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THINK

From Distribution Networks to Smart Distribution Systems: Rethinking the Regulation of European electricity DSOs

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Highlights

- An emerging broad range of technologies for distributed energy resources (DER) is causing significant changes in the planning and operation of power systems. These changes cause challenges for power systems and regulators alike. However, DER – with the right regulation and market design – can at the same time be exploited to establish a more efficient and cleaner electricity system than our current one. To this end this THINK report discusses how adjustments to the regulation of European DSOs can incentivize the latter to effectively integrate DER into electricity markets and system management.
- A sound regulation that incentivizes DSOs to exploit DER for a more active system management has to take account of changing OPEX and CAPEX structures, the optimal choice among both, and of how to incentivize DSOs to favor innovative solutions. Furthermore, as grid users are becoming more complex and sophisticated agents, distribution cost should be recovered

via grid tariffs that reflect the true costs (or benefits) of different types of load and generation for the system.

- As the complexity of the system increases with an increasing DER penetration, an insufficiently unbundled DSO could either stay with a restricted set of traditional system tasks, or the DSO could expand its portfolio of activities, but be accompanied with stricter requirements for unbundling.
- The general responsibilities of network operators with respect to grid management do not change, but the set of tools available to perform their tasks is enriched by DER. Products that system operators use to ensure reliable grids should be clearly defined in terms of geography and timing. Procedures of coordination between DSOs and TSOs have to be updated.
- In the European context, regulation should be kept at minimum level. We see neither the justification nor even the convenience for an EU-wide harmonization of the regulation of DSOs. However, we recommend setting clear minimum requirements in a few key regulatory aspects, as well as the publication of EU guidelines to spread, encourage, and monitor good regulatory practices in some of the critical areas identified.

Background

Technological advances are reshaping today's electricity markets. More mature technologies for local renewable generation and decreased investment costs thereof, joint with national support schemes, led to a significant market penetration of distributed generation in many EU countries. Not only distributed generation but a newly emerging broad range of distributed energy resources (DER), including also local storage, electric vehicles or demand response, are driving or at least allowing for potentially significant changes in the operation of power systems. Today, some challenges are only a possibility, and might arise once technologies mature and are more widely deployed. Other challenges, foremost related to distributed generation and, for example, resulting volatile power flows, are already established facts observable in many EU distribution systems. However, the same technologies that are causing substantial challenges for power systems and regulators can – with the right regulation and market design – be exploited to establish a more efficient and also cleaner electricity system than our current one.

In the light of these changes, this THINK report discusses regulatory implications of changing local electricity markets. To this end this report sets the focal point on electricity distribution system operators (DSOs) as regulated local entities and local market facilitators. First, we shed light on where the current regulation of DSOs needs updates to allow for welfare-enhancing DER technologies to be adapted efficiently and in a timely fashion. A major challenge is to revisit regulation such that distribution companies are not negatively affected by the development of DER and are incentivized to foster the integration of viable new technologies into the market. Moreover, updates are needed to provide the right regulatory tools to DSOs such that they can benefit from the services DER can offer for system operation and planning. Ultimately, the priority task of regulation is not to try to predict what the future will be, but to design incentives that make possible all welfare-enhancing business models under any future market development.

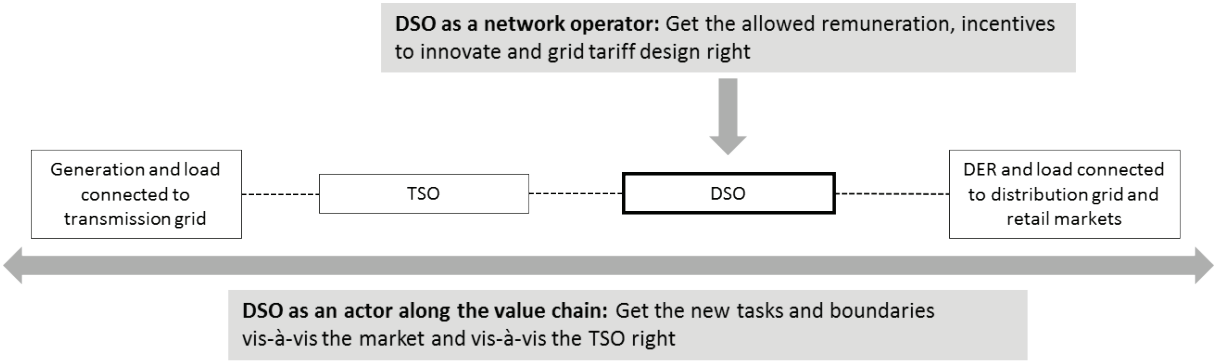


Figure 1: Relevant areas of regulation

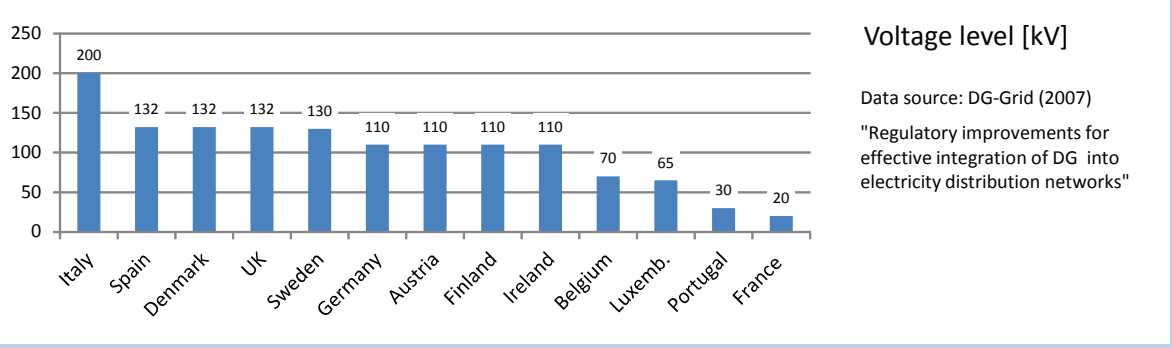
Existing regulation of DSOs needs to be reviewed in its full spectrum

The market penetration of DER opens possibilities for decentralized trade of energy. These trade opportunities allow for new business models, mainly related to the aggregation and marketing of DER. Also DSOs can profit from employing DER resources in their daily tasks of ensuring system functioning and grid investments. However, to exploit the full range of potentials that DER offer, DSOs have to undertake significant upfront investments in grid (and

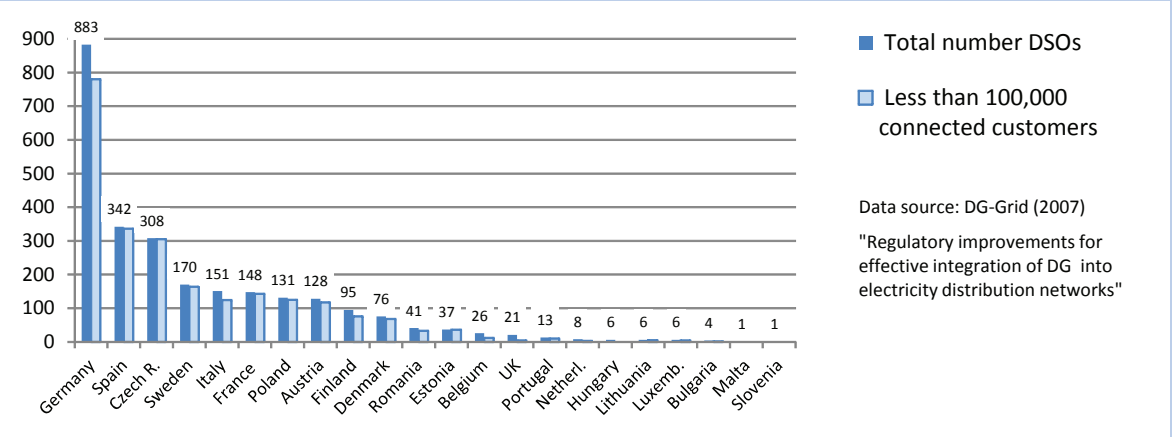
Box 1: Electricity distribution in the EU – A patchwork of national systems

Today's DSO landscape resembles a patchwork with diverse national implementations of relevant pieces of EU legislation and resulting heterogeneous end-user market structures in different Member States. Substantial differences regard, amongst others, operated voltage levels, designation procedures, the scope of activities, the size and number of DSOs in a country, the level of unbundling, and applied regulatory schemes. Also the degree of retail market liberalization and competition still varies significantly across the EU, even though full eligibility of customers is mandatory, and the choice of suppliers and tariffs generally increased over the recent years.

Boundary between transmission and distribution in terms of operated voltage levels:



Total number of DSOs in selected Member States:



related) infrastructures. For DER to flourish and to enable them to compete with resources connected to the transmission grid, DSOs also have to provide adequate conditions for network access and usage. The latter also includes adequate conditions for new business models related to the aggregation of DER. Successful integration of these new business models may potentially even lead to a paradigm shift that might shake up the traditional value chain and cause a radical change of the power market architecture as we know it today, replacing traditional downstream marketing of power by increasing reliance on local sources.

As a consequence, existing regulation needs to be reviewed in its full spectrum. This full spectrum of DSO activities can be distinguished according to, first, the DSO's function as a network operator and, second, its function as a market facilitator along the value chain (see Figure 1). Reviewing DSO incentives as a network operator implies revisiting regulatory schemes for allowed remuneration and resulting incentives to invest and to innovate, as well as revisiting network tariff design. DSOs are a natural monopoly for which allowed remuneration has to be regulated. This allowed revenue will be collected via grid charges and the structure and format of these charges will have an important impact on grid users' behavior. In contrast, reviewing DSO incentives as a key player along the value chain implies revisiting the regulatory base of DSOs both vis-à-vis the transmission system operator (TSO) and vis-à-vis energy and power markets.

However, a common European approach to DSO regulation is hampered by substantially heterogeneous existing regulation and distribution system structures throughout the EU. Box 1 illustrates the patchwork of different national distribution systems. Therefore, the advent of DER will have a different impact on different European distribution systems, and hence, also regulatory responses should differ, and when implemented on the European level, leave room for diverse national implementation.

System-specific regulatory responses are needed because it will make a difference whether adequate DSO remuneration and distribution tariff design, or infrastructure tasks of DSOs (that is, their regulated asset base) are discussed within a simpler system architecture, or whether in contrast system complexities increase with the massive penetration of DER. At one extreme are areas without a noteworthy penetration of DER and where investments in distribution grids are solely motivated by a renewal of aging infrastructure and the connection of new consumers. At the other extreme, there are systems with a substantial penetration of DER and small-scale consumers behaving as active prosumers. In such systems power flows will become much more volatile and the approach to system management changes, with DSOs jointly coordinating local DER power flows and those coming from the transmission grid, and hence managing the system closer to real-time.

It also will make a difference for adequate future regulation whether the respective DSO is subject to (voluntary) ownership unbundling as is the case in the Netherlands, or whether in contrast it is a small integrated operator being exempted from strict unbundling provisions. This for instance often is the case for small German ("Stadtwerke") or Spanish ("Cooperativas") utilities, which also engage in other-than-energy social activities within their territory. Insufficient unbundling biases the level-playing field against DER and in favor of conventional

technologies especially when the incumbent retailer (that shares the parent firm with the DSO) mostly markets electricity from upstream sources, and, thus, poses one of the most serious obstacles to retail competition.

Key areas of DSO regulation and needed changes for DER integration

As demonstrated above, four key areas of DSO regulation have to be assessed on whether they – with massive DER penetration – still deliver the desired regulatory goals.

#1 – *Adequate regulated DSO remuneration*

For high amounts of DER connected to distribution systems, the total costs of business-as-usual management of distribution networks (that is, a continued "fit-and-forget" grid management) will likely increase in most systems. Yet, increasing amounts of DER have a twofold impact on DSOs' cost structures: On the one hand, substantial future investments are required to connect all new resources, to enable the system to deal with increased volatility of net demand and peak demand fluctuations, and to set up ICT infrastructure that empowers DSOs to employ DER for their daily grid operations. On the other hand, DER at the same time offer a new set of instruments for grid operation and thereby a tool for DSOs to perform their tasks of ensuring a reliable, secure and efficient electricity distribution. Distributed energy resources allow for an active distribution system management and have the potential to decrease the total costs of DSOs compared to not relying on DER in local system management.

Therefore, incentive regulation for DSOs has to allow for overall higher compensation of DSOs, but at the same time set sufficient incentives to invest in ICT and grid infrastructure in order to exploit the full potentials that DER offer for system services and hence for active system management. Future regulation hence has to take account of i) changing OPEX and CAPEX structures of DSOs, ii) the optimal choice among both, and of iii) how to incentivize DSOs to deploy innovative solutions.

#2 – *Adequate distribution network tarification*

The present design of network tariffs does not provide a level-playing field among all agents that use the distribution network. With an increasing penetration of DER, ill-designed distribution network charges, such as volumetric network charges combined with net-metering, will become even more problematic. Business models exploiting, for instance, inefficient arbitrage possibilities caused by differentiated treatments of different DER technologies, or of certain types of producers and consumers, might flourish in the absence of sound tarification procedures.

Moreover, grid users are becoming complex, sophisticated agents, which can have very diverse consumption and production patterns, being able (and willing) to react to price signals. The current paradigm, exclusively designed for pure consuming agents and where distributed generation was considered a minor exception, does not hold anymore. The power system of the future (of the present already in many countries) will be much more complex and the tariff design paradigm has to be changed before much efficiency distortion is created and many agents will ac-

quire rights to ill-designed subsidies. A continuation of traditional tarification methodologies applying widely uniform charges over the whole distribution system and, thus, socializing network cost among all "consumers", would imply an increasing cross-subsidization. Such practice clearly is against the principles of cost-causality and economic efficiency.

Instead, grid tariffs, on top of guaranteeing full cost recovery, should be able to convey efficient economic signals to the entire diversity of agents that may connect to the distribution grid. Tariffs should reflect the true costs (or benefits) of different types of load and generation for the distribution system, which will depend on an agent's geographic location in the system as well as on the profile of injection/withdrawal from the connection point. A network reference model, as for example already applied in Spain or Sweden, can be very useful to evaluate the different components of distribution network charges. When distribution costs are allocated to those who cause them – admittedly not a simple task – distribution tariffs will induce a more efficient behavior of grid users. Network congestions and other operational problems should be dealt with separately. Any hidden subsidies should be removed and replaced by sufficient but direct subsidies that do not turn into inefficient signals. Guidelines for a fresh approach to network tariff design are proposed in the report.

#3 – DSO activities vis-à-vis the market

There are a number of areas in the newly emerging market environment where there is no consensus about whether the respective tasks should be under the responsibility of the DSO or not. Such tasks in theory may be fulfilled by regulated agents (which could be the DSO or also a third regulated party) or by non-regulated ones. The regulatory challenge is to clearly define the roles, boundaries and responsibilities of DSOs, so that there is a stable level-playing field for all potential and valuable business models.

Different proposed (regulated as well as liberalized) models for (1) the ownership and management of metering equipment, (2) data handling and (3) EV charging infrastructure all have their advantages and disadvantages. These tasks may or may not be offered at lowest cost (due to sufficient synergies with grid operation) and/or in a more qualitative way by the DSOs as compared to other third regulated agents or commercial actors. The suitability of a certain model will depend on system-specific conditions. If a full rollout of advanced meters (including data management), and also EV charging infrastructure must be provided in a timely fashion, advantages lie in the domain of the DSO. Regulators, however, have to take care not to foreclose market structures through DSOs becoming incumbents once new technologies are deployed at scale and commercial actors want to enter the market.

For all new infrastructure services it holds that when regulators opt for implementing these new tasks via DSOs, possible repercussions on energy and power markets have to be ruled out. Retail market competition and, in particular, the current levels of unbundling are not fully satisfactory. With an increasing penetration of DER and the accompanying advent of new market actors and business relations, the negative effects of limited unbundling might become aggravated. When mandatory ownership unbundling is politically not enforceable, or is economically counterproductive for the customers' choice (through a drastic reduction of suppliers on the market) or for the customers' bill (through duplication

of costs in separated entities or loss of synergy with other local utility functions), stricter implementation of unbundling requirements and market transparency measures should be mandated as more responsibilities are given to DSOs. At the same time it has to be noted that before investigating new forms of "Chinese walls", the implementation of, and the compliance with, existing unbundling requirements have to be reinforced.

Hence the existing unbundling rules place minimum requirements on DSOs, on top of which additional requirements can gradually be added as the role of respective DSOs changes with increasing penetration of DER. These additional requirements could mostly center around the use of customer data and transparency in procurement of services for DSO system operation. For instance, switching procedures should include clear mechanisms for accessing commercial information. An appropriate data management procedure should guarantee the availability of information for all interested market players (and especially retailers), to the extent allowed under data protection legislation. Strict supervision by regulatory agencies is necessary to prevent potential irregular practices and furnish advice on the appropriate package of measures to be finally adopted.

It has to be discussed if **small DSOs** that want to engage in additional tasks as introduced above, but which currently might be exempted from strict unbundling requirements, should also be exempted from additional "Chinese walls" that come with these new tasks. On this level, EU and national regulation will have a very high impact on local governance and municipal structures, in which often a part of the profits from distribution activities are also used for municipal social activities. Nonetheless, all problems arising from unbundling likewise apply to small DSOs. If general exemptions from unbundling for small DSOs prevail, other regulatory means gain in importance. Therefore, especially for small exempted DSOs, new ICT or EV infrastructure needs to be sufficiently standardized such that third party market entry is facilitated as far as possible despite the lack of unbundling. Furthermore, it should also hold for small DSOs that market data relevant to accessing ICT infrastructure and finally relevant for trading and retailing has to be made available such that barriers to market entry are further reduced.

#4 – *DSO activities vis-à-vis the TSO*

When moving from "passive distribution networks" towards "active distribution system management", DSOs become more active system operators and the existing hosting capacity of the distribution network can be used more efficiently if an optimal use of DER is considered. Thus, DSOs become agents that manage local markets for network services or directly purchase services with commercial value from other agents, and their role and organization will have an important impact on (retail) market functioning. Thereby, the general responsibilities of network operators with respect to grid management do not change, but the set of tools available to perform their tasks is enriched by DER. DER can offer a range of products to manage short-term problems in the grid, to optimize the cost of maintaining the desired quality of service, to reduce grid losses and to reduce or postpone future grid investment needs.

Some of these products are relevant for either the TSO or the DSO, whereas other types of services might be of interest for both types of network operators. Hence, coordination and information exchange

between TSOs and DSOs, from planning stage to operation, will play a particular role as the amount of DER increases and as DSOs become more active and exploit DER services closer to real-time delivery. Products that DSOs and TSOs use to ensure reliable grids (and often procure for this sake) should be clearly defined in terms of geography and timing. Wherever DSOs and TSOs in principle can procure the same service, a more clear coordination among DSOs and TSOs is needed the more this product relates to real-time trading. Furthermore, protocols have to be installed regarding which resource has sold products already, to whom, and for what timeframe.

Coordination needs will differ among systems. It will make a difference whether a distribution system contains only an insignificant amount of DER, whether in contrast there is a large penetration of distributed generation with installed capacities considerably exceeding peak demand, or whether it contains a whole portfolio of DER including also non-negligible volumes of local storage and demand response potential. Coordination needs will be higher in the latter system. Moreover, regulation or coordination efforts have to take account of which voltage levels are part of the distribution activity. Coordination needs probably will increase when DSOs also operate MV (or even HV) grids.

A role for the EU to encourage good regulatory practice

In the **European context**, regulation has to be in line with the three EU energy policy pillars and be kept at minimum level, respecting the principle of subsidiarity. Accordingly, we see neither the need nor a solid justification for an EU-wide comprehensive harmonization of the regulation of DSOs, although we recommend setting clear minimum requirements in a few key regulatory aspects, as well as the publication of EU guidelines to spread, encourage, and monitor good regulatory practices in some of the critical areas that have been identified in our report.

- National regulators can benefit from sharing experiences on bad and good practices. EU guidelines for a sound regulation and adequate remuneration of DSOs should be formulated, followed by regular monitoring and benchmarking to reveal shortcomings of national regulatory approaches. Similarly, although distribution grid tarification is – and should remain – a national issue, again, it is urgent that research is conducted to develop a set of EU guidelines that should be published, recommended and monitored to reveal shortcomings of national regulatory approaches and to improve tariff design practices.
- The performance of new business models and the functioning of retail market competition rely on comprehensive consumer data. The EU should provide a minimum level of support in that respect, mandating – provided that individual consumers give their authorization for the use of their personal profiles – that consumer data are made available to registered agents. The

definition of the specific format of data provision (i.e. one of the three proposed data models, or a combination thereof) can then be left to the Member States.

- Depending on system complexity and the number of tasks to be accomplished by DSOs – stricter unbundling requirements should be mandated. As system complexity increases, an insufficiently unbundled DSO could either stay with a restricted set of tasks, or the DSO could expand its portfolio of activities, but accompanied with an increasing level of unbundling. Increasing levels of unbundling could be implemented by "higher Chinese walls" between DSOs and their subsidiary retailers that engage in trading of distributed sources. The EU should provide guidelines for measures to reinforce "Chinese walls" between any DSO and the DER-related businesses that may exist under the same holding that owns the DSO.
- If general exemptions from unbundling for small DSOs prevail, additional regulatory means gain in importance. Therefore, especially for small exempted DSOs, new ICT or EV infrastructure needs to be sufficiently standardized such that third party market entry is facilitated as far as possible despite the lack of unbundling. Furthermore, it should also hold for small DSOs that market data relevant to accessing this ICT infrastructure and finally relevant for trading and retailing has to be made available such that barriers to market entry are further reduced.
- Finally, procedures and principles of coordination between DSOs and TSOs also should be defined at a European level in order to avoid distortions in competition and barriers for market entry due to different rules and market designs in different Member States. The possible set of distribution company functions needs to be extended. Also the currently developed EU network codes should take account of the need for coordination and rules among system operators that rely on DER services.

Necessary regulatory actions must be developed in a timely manner in order to minimize regulatory risk and barriers and increase investment activities in distribution and retail market segments as soon as possible.

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