How Traditional Regulation of Distribution System Operators Can Be Improved to Accommodate Higher Levels of Distributed Generation

a report by

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The EU's energy policy has three main objectives: environmental sustainability, security of energy supply and economic development. These objectives are the main drivers for the huge development of renewables-based electricity generation (renewable energy sources [RES]) and co-generation of electricity and heat (combined heat and power [CHP]) in Europe.[1] Due to their size and location, these power plants are mainly connected to distribution networks and are known as distributed generation (DG).[2]

The integration of DG into power systems has become a real challenge,[3] particularly for distribution system operators (DSOs), due to their impact on the operation of distribution networks and also on the costs and revenues of the DSOs. Electricity distribution is considered a natural monopoly and as such it is regulated in terms of price, entry and other specific aspects (e.g. quality of service).[4] Therefore, regulators ought to realise the impacts of DG and adapt existing regulatory arrangements accordingly.

The EU has promoted several research projects with research institutes and industrial partners to investigate the regulatory improvements needed to accommodate DG in power systems, such as the Enhancement of Sustainable Electricity Supply through Improvements of the Regulatory Framework of the Distribution Network for Distributed Generation (DG-GRID) and Coordination Action to Consolidate RTD Activities for Large-Scale Integration of DER into the European Electricity Market (SOLID-DER) projects, among others.[5,6]

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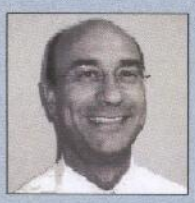

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The impact of DG on DSOs clearly differs depending on the country considered, as each country has different characteristics, for instance DG's share of the market (see *Figure 1*), DG technology (which depends on the RES potential) and energy and support policies. Below, four key areas affecting the impact of DG on DSOs are presented, and some regulatory recommendations from a European perspective are given. As regulation of electricity distribution is very complex and may differ significantly on a country-by-country basis, these recommendations are given on a very wide regulatory framework.

Compensate Distribution System Operators for the Negative Impact of Distributed Generation on Network System Costs

The connection of DG to distribution networks may bring about extra costs or reduced costs (benefit) for the DSO.[7] The DG integration costs, either positive or negative, are mainly related to new reinforcements in the network and variation of the energy losses. DG integration may require the upgrading of circuits and substations in rural networks and replacement of switchboards in urban networks. On the other hand, investment deferral could be achieved by integrating DG into the planning process.[8,9] Additionally, energy losses generally decrease with low DG penetration and increase with higher penetration levels. However, current regulatory frameworks tend to neglect these effects of DG.

In order to mitigate the possible negative impact on DG penetration, it is recommended that DSOs be compensated for these incremental costs. For instance, in the UK, a revenue increment per each kW of connected DG has been included in the remuneration for DSOs. A more developed remuneration alternative is to include two compensatory measures, one based on the DG capacity connected and one considering the energy fed into the distribution network by DG. These compensations should be calculated for each distribution area, since the impact of DG depends on the specific network area in which it is connected.[10]

On the one hand, DSOs are usually incentivised to reduce energy losses. If actual losses exceed certain reference values defined by the regulator, DSOs are penalised. On the other hand, DSOs will receive an incentive if they manage to reduce losses below the reference values. The connection of DG may significantly affect energy losses,[11] which should be taken into account when setting the reference values. It is recommended that the impact of DG on energy losses be taken into account through both use-of-system (UoS) charges and DG support schemes.

Incentivise Distribution System Operators to Consider Distributed Generation for Efficient Network Planning

According to article 25/7 of the EU Electricity Directive 2009/72/EC,[12] DSOs should consider DG as an alternative to network expansion. However, in most countries, under the existing unbundling provisions

DSOs cannot currently own or operate any generation asset. Hence, DSOs have no direct control over decisions on the location, size or operation of DG units.

In order to achieve the objective of the EU Directive, a regulatory framework of DSO remuneration should be able to provide specific incentives to DSOs for efficient network expansions taking advantage of the potential DG benefits. This is the case with incentive regulation based on price or revenue caps. Under this scheme, DSOs should be allowed to keep efficiency gains due to efficient integration of DG. Moreover, DSOs should make an effort to change their planning strategies to incorporate DG.

However, DG nowadays plays a passive role with regard to distribution networks. Consequently, DSOs are reluctant to rely on DG to defer or avoid new network investments. Therefore, this paradigm must be changed by increasing the visibility of DG and providing DG with appropriate incentives to behave more in line with system and network needs. In order to improve the use of current network assets and decrease the need for additional network investments, some recommendations are suggested: UoS charges differentiated on time and voltage level, as discussed below, and economic incentives for DG to assist (through ancillary or system services provision) the DSO in network operation.[13]

Distribution System Operators and Distributed Generation Agreements to Improve Network Performance

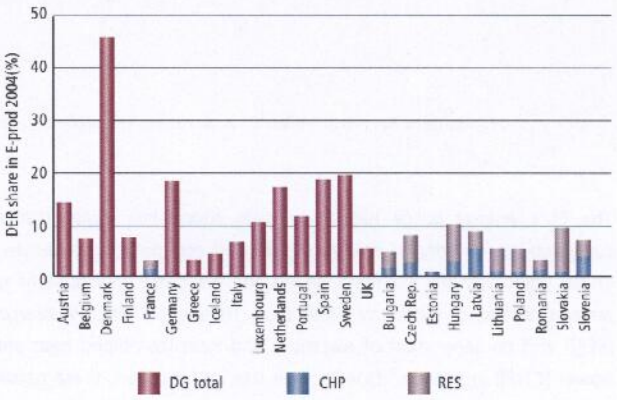
Currently, in most countries DSOs consider DG as a potential source of problems rather than an aid for network operation and quality improvement. This point of view is the result of the lack of control and observability that DSOs have on DG, together with the current frequent DG disconnections in case of network disturbances. However, the higher DG penetration levels expected in the near future will give DSOs the opportunity to use DG as a new control source. For instance, DG can help to improve reliability indices, working in islanding mode in case of network outages. DG can also improve power quality by the procurement of ancillary services such as voltage control, frequency reserve or black start.[10]

However, to achieve these advantages from DG, an important change in the relationship between DG and DSOs is needed. For instance, DSOs should be entitled to make agreements with DG to regulate under certain transparent conditions the purchase of ancillary services. Moreover, a deep DSO transformation from traditional passive network management to more active network control is required for the adequate participation of DG. It seems that current regulatory schemes do not provide DSOs with sufficient incentives to innovate. Therefore, regulators should incentivise DSOs for specific innovation actions to evolve to active network management. This recommendation is even more important in light of the future development of the so-called smart grids.

Define Efficient Network Charging Schemes for Distributed Generation

The network charges paid by DG when accessing the network can be classified into connection charges (paid just once when DG requires network access) and UoS charges, which are periodically paid by DG operators in some European countries. Depending on the regulatory framework in each country, connection charges can be shallow, deep

Figure 1: Distributed Generation Shares of Total Electricity Production in the EU-25 Countries, 2004



DG = distributed generation; CHP = combined heat and power; RES = renewable energy sources; DER = distributed energy resources.
Source: SOLID-DER Project.

or shallowish. Shallow connection charges encompass only the direct costs of connecting the DG producer to the nearest point in the distribution network. By contrast, deep connection charges imply that all the costs for network reinforcements at both the transmission and distribution levels have to be borne by the DG producer. Shallowish charges constitute an intermediate approach.

The connection charging scheme is of great relevance for DSOs and DG, particularly small DG units. There is a trade-off between providing incentives for the optimal and cost-effective location of new generation capacity (deep connection charges) and facilitating entry for small-sized DG operators (shallow connection charges). Shallow connection charges seem to be the best economic signal for DG integration in order to:

- keep entry barriers as low as possible;
- keep the calculation simple and transparent; and
- lower transaction costs for DG promoters.

However, shallow connection charges may seem less attractive for DSOs, especially if there is no clear mechanism to recover network reinforcements associated with DG connections. In this situation, the cost of network reinforcements should be recovered by DSOs through UoS charges.[13] On the other hand, UoS charges should, as far as possible:

- reflect the cost incurred for providing the network user with the network transport and system service; and
- ensure full recovery of the DSO's total acknowledged revenues.

Consequently, DG could pay either positive or negative UoS charges depending on its impact on the network.[14,15] For this purpose it is proposed that DG UoS charges should be differentiated by time of use and voltage levels. For instance, DG connections at lower voltage levels should be incentivised, as it is clear that the connection of DG to lower voltage levels would reduce energy losses and delay system reinforcements. Time-of-use differentiation should promote higher production at local peak demand hours in order to match local generation and demand. Time-variable UoS charges could encourage

more focus on bringing down network utilisation and losses at peak load times, i.e. when the network is used most intensively and therefore would have a tendency to increase line losses.

Conclusions

The European Electricity Directive mandates legal and functional unbundling of distribution from generation and supply. Therefore, location and operation of DG cannot be decided by DSOs. As a consequence, regulation should provide both DG and DSOs with the adequate price signals and incentives.

To improve network integration of DG into the network, two main questions must be addressed:

- how can regulation of DSOs ease the integration of DG into electricity networks? and
- what economic signals should be given to DG companies to achieve their active integration in distribution networks?

Current network regulation should be updated to ease the integration of DG, and new regulatory improvements in DSO remuneration are required that consider the incremental costs resulting from the connection of DG. Additionally, new schemes are needed to integrate DG for an efficient expansion of the distribution network and to take advantage of DG in order to improve network quality performance. In addition, specific incentives for innovation are deemed necessary so as to achieve a long-term and deeper transformation of distribution networks. The aim is to evolve from current passive networks to active networks, where DG can play an active role thanks to its effective and efficient integration. Finally, some new proposals should be designed to define DG shallow connection charges and DG use-of-system charges with location and time differentiation. ■

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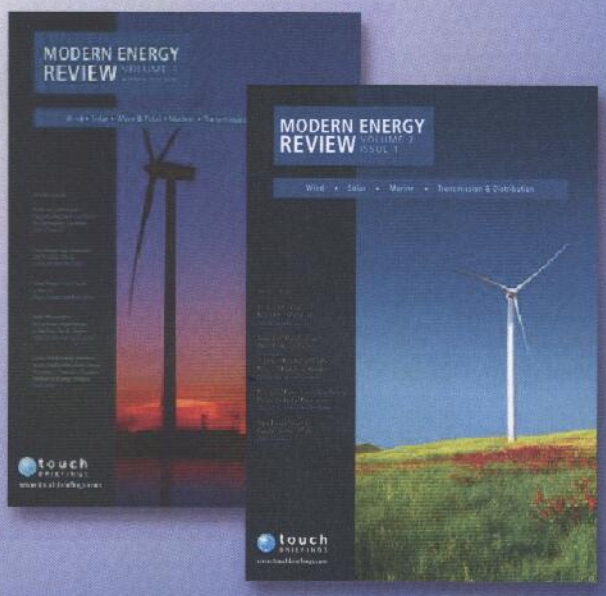

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