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Improvements in current European network regulation to facilitate the integration of distributed generation

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ABSTRACT

This paper analyzes how traditional regulation of distribution system operators (DSO) has to be improved to accommodate higher levels of distributed generation (DG). In addition, new economic signals to be given to DG operators for system efficient integration are proposed. Regulatory improvements at the European level are recommended. Recommendations are centered on schemes for DSO revenue compensation to consider incremental network costs due to DG, distribution network planning integrating DG, and DSO incentives for improving network performance with active integration of DG. Regarding DG economic signals, recommendations are focused on the design of DG connection and use-of-system charges, the revision of current DG support mechanisms based on flat feed-in tariffs, and the provision of ancillary services by DG for network voltage management, power flow controls and islanding.

1. Introduction

In European member states, the public goal of a sustainable electricity system is strived for through a number of technology-specific member state support schemes for renewable-based electricity generation (RES-E) and co-generation of electricity and heat (CHP). This objective is a main driver of the growth of distributed generation (DG) – generators connected to the distribution network – to significant levels.

The DG-GRID and SOLID-DER projects[1], which have been carried out by different research institutes and industrial partners, have surveyed and investigated different issues regarding regulatory improvements to accommodate DG in distribution networks, such as:

- current regulation and main barriers for DG integration across Europe,
- the impact of DG on costs and benefits of distribution system operators (DSOs), and
- new business models and regulatory improvements to enhance DG network integration.

According to the EU electricity directive distributed generation are all power plants connected to the distribution system [1]. Each different type of distributed generation has, however, its own technical and commercial characteristics. Table 1 makes a distinction between large and medium/small-scale RES and CHP supply technologies. The medium and small-scale units of both RES and CHP sources are considered as distributed generation.

The situation of DG shares in power systems of EU-27 European member states in 2004 is shown in Figure 1. The figure shows that eight countries have a DG share over total electricity production above 10%, and half of them are over 20%. Differences between member states can be explained by different potentials for RES and CHP and from different energy policies in the past [2]. The DG share in electricity supply has the potential to increase rapidly. This can be derived from the policy objectives for renewable energy (20% in 2020 [4]) and energy efficiency improvement, and also from the support mechanisms for RES and CHP EU member states have implemented.

In this paper, several policy recommendations – partly at the EU level and partly for implementation by national regulators – that were developed under the DG-GRID and SOLID-DER projects to ease the efficient integration of higher expected levels of DG penetration [5] are presented. This paper first analyzes in Section 2 the impact of DG on DSO costs, and proposes different schemes for

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Table 1
Categorization of sustainable electricity supply technologies [2].

	Combined heat and power (CHP)	Renewable energy sources (RES)
Large-scale integration	Large district heating*	Large hydro**
	Large industrial CHP*	Off-shore wind
		Co-firing biomass in coal power plants
		Geothermal energy
Medium and small-scale generation	Medium district heating	Medium and small hydro
	Medium industrial CHP	On-shore wind
	Commercial CHP	Tidal energy
	Micro CHP	Biomass and waste incineration and gasification
		Solar energy (PV)

* >50 MW.
** >10 MW.

DSO revenue compensation to consider these incremental network costs. The planning of distribution networks integrating DG and DSO incentives for improving network performance with active integration of DG are discussed in Sections 3 and 4, respectively. In the second part of this paper, comprising Sections 5–7, the efficient economic signals to be sent to the DG are identified. Section 5 analyzes the design of DG connection and use-of-system charges. In Section 6, a revision of current DG support mechanisms based on flat feed-in tariffs is proposed. Finally, Section 7 examines the provision of ancillary services by DG for network voltage and flow controls and islanding.

2. Impact of DG on DSO costs

2.1. Impact of DG on network system costs

An increase of DG can have an impact on distribution networks system costs that can turn out into extra costs or reduced costs (benefit) for the DSO. Considering the main technical issues, the DG integration costs are related to upgrading of circuits and substations in rural networks and replacement of switchboards in urban networks. With a strong growth of DG connections a large amount of investment is needed to upgrade current network assets when network operators use the traditional 'fit and forget' approach, i.e. passive network operation philosophy. If an active network management philosophy is adopted, the amounts of DG that can be accommodated with limited investments will be larger. Instead of increasing the capacity of the network, the operational management is then changed: voltage and fault level control is applied as well as active involvement of distributed generators (and consumers) in optimising the economic operation of the system.

DG influences three kinds of DSO costs [6]:

- Reinforcement costs: the incremental costs related to network reinforcements necessary to integrate DG into the network. The incremental costs are zero for low DG penetration levels. Once investment is required the incremental cost increases progressively, both in rural and urban networks. If DG is more densely connected (i.e. more concentrated), this cost increase will be larger. If active network management is applied, in most cases the reinforcement costs will be lower compared to a passive network management approach.
- Energy losses: with low DG penetration energy losses decrease and the costs for compensating these losses will become smaller. However, if more DG penetrates the network energy losses will increase resulting in higher operational costs. With active network management the increase of energy losses will start at lower DG penetration levels and the increase will be larger [7].
- Capacity replacement value: DG may result in smaller electricity flows from higher to lower voltage levels postponing the need to reinforce the system in case of load growth or to reduce the investment required in case of equipment replacement [8].

The type of DG (non-intermittent and intermittent) influences network capacity and energy losses [9]. The effects are different for rural and urban networks, also because of the different types of DG connected.

A quantitative analysis was carried out in [10]. White bars in Fig. 2 show the impact of DG under current business model, measured as the DSO net incremental profit due to DG penetration and quantified in percentage over total regular profit. DSOs generally

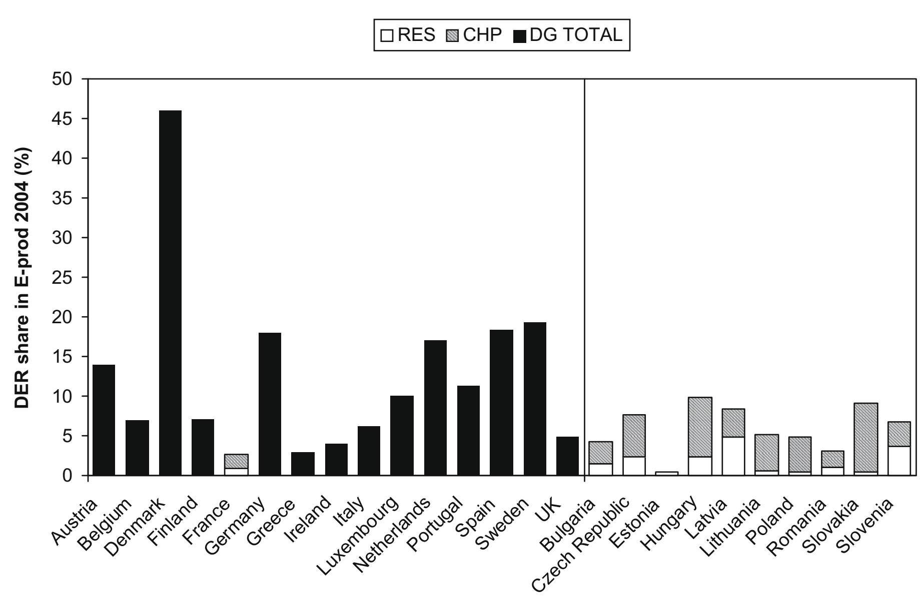

Fig. 1. DG shares in EU-27 of electricity production in 2004 [3].