How Renewable Energy is Reshaping Europe's Electricity Market Design

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Executive summary

One of the main challenges for the electricity industry is how to adjust to a large share of variable renewable energy sources (RES). Power system flexibility is widely recognized as the key to dealing with the variability and uncertainty of RES. Because the implementation of flexibility affects all system levels, from the household connection to cross-continental energy flows, the regulation of the electricity system likewise needs to be integrated. A second reason for energy system integration, aside from the introduction of variable renewable energy, is the fact that different policy instruments interact with each other.

We present an analytic framework, based on the identification of three dimensions by which we categorize system integration issues within the electricity sector. The underlying premise is that technical relations need to be reflected in the regulatory framework and that when current developments create changes along one of the physical dimensions that we identified - geography, system level and time scales - attention needs to be given that the regulation is adjusted accordingly. The framework therefore helps identify regulatory challenges - potential inefficiencies due to a lack of coordination - and to place them into context. Figure 1 schematically depicts the framework.

Geographically, the key issues are the integration of national and cross-border congestion management methods with each other and with power exchanges where this is not the case yet; the improvement of the granularity of congestion management methods (allowing multiple price zones per country); and the coordination with capacity remuneration mechanisms (which may also require different price zones). Along the system level dimension, the operation of the wholesale and small prosumer levels (the transmission and distribution levels) needs to become more integrated but a single congestion management method does not appear necessary at this point. The third dimension concerns the time scales at which electricity is traded: the design of short-term markets needs to be adjusted in order to optimize the short-term behavior of variable renewable energy sources, storage and demand response. We apply this framework to four areas that are particularly affected by the introduction of variable renewable energy sources: 1) system adequacy, 2) coordinating network investment with the market, 3) short-term market design and 4) congestion management.

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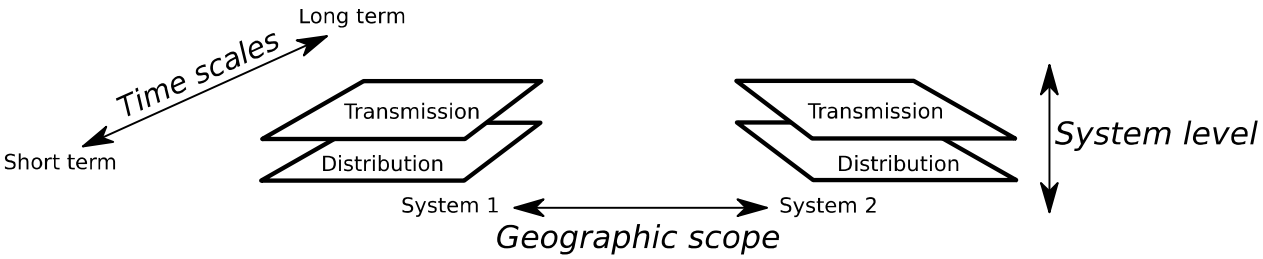

Figure 1: Elements of institutional challenges and the interfaces between them

Source: Own illustration.

The overall picture that emerges from this approach is that the institutional fragmentation of the European electricity sector will become increasingly burdensome as the development variable renewable energy requires ever closer coordination between countries, between the different levels of the electricity system and between markets that serve different time scales. Along the geographic dimension, the main issues appear to be the improvement (and integration) of cross-border and national congestion management, the cross-border coordination of transmission investment, and the alignment of capacity mechanisms, including cross-border trade in capacity rights. Along the system dimension, the challenges to integrating local markets (with demand response, flexible EV charging and rooftop solar) with the wholesale market can be divided in aligning local energy prices with wholesale prices and managing distribution grid congestion. A novel challenge to market design is the need for intertemporal arbitrage, as in the presence of enough local flexibility, distribution grids no longer need to be dimensioned to accommodate all peak flows. Finally, electricity needs to be traded closer to real time, in order to reduce the impact of forecast errors of variable renewable energy sources. This not only means a better integration of markets with different time horizons, but also a better integration of congestion management with market clearing.

The implication for research is that a shift is required from single issue, single country studies to studies with a larger scope with respect to the system levels, the geographic scope and/or the time scales that are included. This will pose a significant challenge to quantitative (modeling) studies, but not taking up this challenge would result in increasingly irrelevant research results.