DESIGNING THE MARKET DESIGN FOR THE ELECTRICITY SYSTEM OF THE FUTURE

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Overview

In many countries, the characteristics of the electricity supply system are changing. Important developments that are unfolding in the electricity sector are (i) the growth of generation from renewable sources (PV, wind) that are *less controllable* than traditional power plants and that for a large part feed in into the *distribution* grids, and (ii) the increase in the use of ‘controllable loads’ such as heat pumps and the batteries of electric vehicles (of which the use can be shifted in time), that are also mostly connected to distribution grids (IEA 2013). Other developments may lie ahead, such as the feasibility of decentralised *controllable* generation, e.g. from the fuel cells of future fuel cell cars, or low cost options of electricity storage.

These developments will have an impact on how the entire electricity system and distribution grids in particular can (or should) be operated, as they will certainly change the technical characteristics (and possibilities) of the system and system operation. As a consequence, the roles, rules and relations between actors in the electricity industry need to be reconsidered as they need to adapt to the changing system (cf. RUESTER *et al*., 2013). For example, the tasks of distribution grid operators will become more complex, while small system users may start contributing to (the provision of) ancillary services. However, the current organization of the electricity industry (the ‘market design’) is in most countries still based on the ‘old paradigm’ for the power sector: centralised, dispatchable generation that is top-down transported to the end users over a network with more than sufficient capacity: power supply follows power demand.

The developments considered in this paper may deviate from this paradigm as these concern, for example, controllable *demand* and non-controllable *supply*. In the electricity industry it is a legitimate question how such a technological change interacts with the existing legal and institutional arrangements (KÜNNEKE *et al.* 2010). In other words, what should be the appropriate ‘market design’ for such a different technical system? To make it more complicated we need to take into account that there is *uncertainty* about the future (technical) developments. This leads to the central topic of this paper: how can we design the “organization” (roles, rules and relations) of the electricity industry in such a way that there is room for innovations and new developments (and that they are not impeded by *lock-in* regulation), and that the legal framework is sufficiently robust or flexible in order to cope with changes in the functioning of the electricity system, while securing the system’s performance.

We use the following approach. First, we analyse the impact of technical changes upon how the sector can (or should) be organised, by developing a number of (technical) scenarios for the electricity system. These scenarios cover a wide range of technological changes. Second, we analyse how well a couple of “organization models” for the electricity sector match with each of the scenarios, assessing them for several criteria that relate to the relevant objectives and constraints. Third, we analyse these results in order to find a best solution or the best *strategy* to keep the sector’s organization fit for the future developments. Finally, we conclude as to what our results mean for energy policy and legislation. Although our approach is as generic as possible, we shall, if necessary, focus on the situation in the European Union, in which context the research has been carried out.

Methods

To select the most relevant scenarios for the technical development of the electricity system a literature review is used.

For the exploration of the possible “organizational models” (the roles, rules and relations) we applied a combination of methods. First, in an expert meeting experts were asked to design (from a greenfield situation) the organization of the sector *given* their technical scenario. The experts had to develop at least one feasible ensemble of roles, rules and relations (“market design”) for each scenario. Second, a project team of academic and industry researchers developed four different “organizational models” that are supposed to cover most of the possible designs. Third, in a MSc student project the possible designs were generated by using the ‘function-based legal design & analysis' (FULDA) method, elaborated in KNOPS (2008). This method helps to design in a systematic way the organization of the power sector taking into account the technical, economic, legal and policy context

For the assessment of how well the different organizational models would perform, we applied a multi criteria analysis.

Results

The first result of this research is that it provides insight in how different technical characteristics of the power system could (or would) change the options for the organization of the sector. Do roles change, are new roles needed, how will rules change and what would al that mean for the relations (e.g. contracts) between the actors?

The second result is that the research will provide an overview of alternative ways to organize the sector and how they relate to changing technology (and/or changing expectations by system users). What are potential market designs: which activities should be (regulated) monopolies, which ones can be left to the market? How are prices and tariffs set, and how are crucial functions, such as congestion management, organized?

The third result is an assessment as to the expected performance of these different organizational models: do they lead to economically efficient system use, do they secure public policy goals such as reliability and sustainability, and do they fit in the larger legal framework? (For the last issue, we focus on the EU.)

Conclusions

We do not know the future, but the position of distribution grid operators is likely to become more complex. Besides that, more system users may start playing a role in system operation (in the context of, e.g., balance management, reactive power, or congestion management). These are issues that are generally not provided for in the current organization (market design) of the power sector, which is based upon the 'old paradigm'. We therefore conclude that the current legal framework may not be optimal for a different technical future.

How should that legal framework change? That is difficult to prescribe, given the uncertainty about which developments are really going to happen and will make an impact. Therefore, one needs to design for uncertainty, that is to build in sufficient flexibility so that the "organization" of the sector can be adapted depending on the actual changes in the context. This means, *inter alia*:

- allow for the fact that the expectations concerning power supply can change (more or less weight could, for example, be given to reliability or to the environmental sustainability of power production),
- think about *who* is going to make the trade-offs between the different objectives, e.g. in relation to investments, (a central regulator, a poltical body, or the grid operator/owner itself, or some body made up of stakeholders) so that "legitimate" decisions can be made; this concerns the *governance* issue;
- create a meta structure in the legislation/regulation that allows several options/directions which can be implemented when necessary given the changing circumstances.

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