Energy Policy 103 (2017) 30–46

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Capacity adequacy in power markets facing energy transition: A comparison of scarcity pricing and capacity mechanism

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ARTICLE INFO

Keywords:
Capacity mechanism
Security of supply
Energy transition
Mature market
System dynamics

ABSTRACT

This article analyses how a capacity mechanism can address security of supply objectives in a power market undergoing an energy transition that combines energy efficiency efforts to stabilise demand and a rapid increase in the proportion of renewables. To analyse this situation, power markets are simulated over the long term with a System Dynamics model integrating new investment and closure decisions. This last trait is relevant to studying investment in power generation in mature markets undergoing policy shocks. The energy-only market design with a price cap, with and without a capacity mechanism, is compared to scarcity pricing in two investment behaviour scenarios with and without risk aversion. The results show that the three market designs lead to different levels of risk for peaking unit investment and results thus differ according to which risk aversion hypothesis is adopted. Assuming a risk-neutral investor, the results indicate that compared to an energy-only market with a price cap at 3 000 €/MWh, an energy-only market with scarcity pricing and the market design with a capacity mechanism are two efficient options to reach similar levels of load loss. But under the hypothesis of risk aversion, the results highlight the advantage of the capacity mechanism over scarcity pricing.

1. Introduction

In the European Union, an important debate has emerged around the issue of capacity adequacy in power markets. Concerns about short and long term functioning of power markets are reinforced by the significant deployment of variable renewable electricity sources (RES) supported by long term production subsidies (feed-in tariffs, etc.). According to the electricity market textbooks, in the energy-only market design, energy prices are supposed to drive power generation investment choices in order to ensure long-term generation capacity adequacy in parallel with optimal mix development. Essential conditions for ensuring that electricity markets send the right price signals to reach adequate levels of capacity are (i) allowing prices to reflect scarcity during demand peaks and (ii) making sure that investors trust the long-term price signals from the day-ahead market.

However, for many reasons, ranging from system operator rules during critical periods and operational price caps to the political unacceptability of very high prices, power prices rarely reach the theoretical value of lost load (VOLL) in practice, leading to a chronic shortage of revenue for plant operators. This so called "missing money" issue is widely dealt with in the academic literature (Jaffe and Felder, 1996; Hogan, 2005; Joskow and Tirole, 2007; Joskow, 2008, Cramton and Soft, 2008, Fabra et al., 2011). Proponents of the unfettered energy-only market denounce system operators' procedures and the introduction of price caps as the most important barriers to efficient scarcity pricing, which should in fact be an important element in future market design. To those who say that more volatile prices could lead to a risk of political acceptance issues or abuse of market power, the authors reply that these risks can be avoided by hedging against volatility while assuming complete markets. The 2015 European Commission Communication on market design reforms (EC, 2015) develops this position:

> "Allowing wholesale prices to rise when demand peaks or generation is scarce does not necessarily mean that customers are exposed to higher or more volatile prices. Well-functioning longer-term markets will allow suppliers and producers to manage price swings on spot markets – where generators effectively can sell insurance to suppliers and consumers against the impact of price swings and also improve the long term investment signals. [...] This is why it is

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http://dx.doi.org/10.1016/j.enpol.2016.12.032
Received 13 May 2016; Received in revised form 14 December 2016; Accepted 17 December 2016

critical both to allow for price fluctuations in short-term markets and link them to long-term markets".

Given the specific characteristics of power markets, such hedging products are unlikely to emerge due to the misalignment of investors' and suppliers' interests (Chao et al., 2008). Thus, the focus should be placed on market failures in an energy-only market without a price cap. Whereas price peaks constitute a significant percentage of generators' revenues and are thus an important signal for any decision, the frequency and the level of these price peaks are hardly predictable. Under such conditions, it is difficult to anticipate the level of capacity – including peak capacity – that will emerge spontaneously from stakeholders in the market and therefore to predict the occurrence of load shedding and outage situations. In other words, scarcity prices are highly uncertain and intrinsically volatile and, most importantly, there is no guarantee that adequacy standards set at a political level will be achieved. The missing money problem becomes even worse if investors are risk averse, which they could be given the uncertainty of revenues during peak periods. The inclusion of a capacity mechanism thus contributes to improving the social efficiency of the electricity markets (Oren, 2003; Joskow, 2008, Cramton and Soft, 2008, De Vries and Heijnen, 2008, Cramton et al., 2013).

In an original analysis of market failures in terms of capacity adequacy, Keppler (2014) highlights two imperfections of the energy-only market which justify the transitory adoption of a capacity mechanism: (i) the high social cost of unreliable supply – in particular the cost of unannounced and involuntary supply interruptions, and (ii) the asymmetric incentives for agents to invest in peaking units – as opposed to baseload technologies – in a situation of inelastic demand and fixed-unit-size generation units. More precisely, the discrete nature of the long term supply function due to the nominal power capacity of each technology, combined with the inelasticity of demand, prevents correct anticipation of rents which could cover the fixed costs of new peaking units in the absence of appropriate hedging products to trigger investment decisions. This invites an analysis of the issue of investment in generation with fixed-unit-size representation of plant capacities and a hypothesis of risk-averse behaviour.

The issue of capacity adequacy is reinforced by the growing proportion of RES generation that is directly dependent on weather conditions. Indeed, mature electricity markets, such as those in the EU, combined with very active promotion of renewables offer a radically different economic context for existing generators and investors who were used to investing in a world of demand growth. The appearance of RES supported by out-of-market mechanisms further complicates the situation for at least three reasons: (i) in the short-term, generation by RES tends to alter the pricing on the day-ahead markets and to decrease the revenues of existing and new conventional plants by the so-called "merit order effects" (Sensfuß et al., 2008); (ii) energy prices become more variable hour-by-hour and price risk increases for investors; and (iii) future development of RES capacity and its influence on prices compared to the contribution of RES to overall production is unpredictable (Nicolosi and Fürsch, 2009). In consequence, energy spot prices no longer perform their theoretical long-term coordination function of guaranteeing capacity adequacy of the system in parallel with the development of an optimal mix. This situation affects both new projects for conventional units – because of huge uncertainty over the possibility of recovering their fixed costs – and existing power plants because of the difficulties of recovering operating costs in the short term, as evidenced by the wave of mothballing or closure of recently built gas power plants announced by a number of European electricity producers. At the same time, electricity systems need greater reserve capacities to deal with the increasing proportion of renewables with variable production. Thus, the debate about missing money has evolved to address a new issue: recovery of existing plants' operating costs besides the traditional issue of recovering fixed costs of new units to trigger investment decisions, the latter being amplified by the price variability resulting from the high proportion of variable production. In this respect, the motives for introducing a capacity mechanism are reinforced as a solution to complement the market design so that generation adequacy is preserved and enhanced. Thus, in 2015–2016, several European countries are setting up specific capacity mechanisms and others are considering implementing them, despite the reluctance of the European Commission for which the scarcity pricing approach remains the theoretical benchmark solution to trigger new investments.[1]

To inform this debate, this article focuses on a capacity mechanism which can be a decentralised obligation imposed upon electricity suppliers, similar to the mechanism proposed in France, or a forward capacity market with auctioning by the system operator as in some US mechanisms such as those used by PJM or in New England (Finon and Pignon, 2008). The objective is to analyse how the introduction of this capacity mechanism enhances long-term generation adequacy compared to the energy-only market, with or without a price cap in the case of mature markets characterized by a stable electricity demand and an increasing proportion of RES, as is the case in a number of European member states. To carry out this analysis, changes in the electricity market are simulated over several years with a System Dynamics model. By focusing on change over time, this approach is particularly well-adapted to studying mature markets in which a distinction is made between the economic rationale for retiring existing plants and economic decisions for new investment. Moreover, the model includes both new investment and closure decisions, an originality that is relevant to the study of mature markets prone to RES policy shocks. The second originality of the approach is that it compares scarcity pricing to capacity mechanisms under different hypotheses of investment behaviour in terms of risk aversion.

The simulations underline how investment and retirement decisions are affected under three different market designs: (i) energy-only market with a price cap, (ii) energy-only market with scarcity pricing and (iii) the addition of a capacity mechanism to an energy-only market with a price cap. These three market designs are simulated with two different hypotheses of investor behaviour: risk neutrality and risk aversion. As a consequence of assumptions on electricity demand and renewables development, some thermal electricity generation units are expected to be decommissioned endogenously.

The following Section (2) details the System Dynamics model that was used in the simulations with a focus on the modelling of the capacity market. The case study and data are described in Section 3. Section 4 presents and discusses the results. Finally, Section 5 concludes and highlights policy implications.

2. Specifications of the SIDES model

Traditional power market equilibrium approaches, such as dispatching programming and long-term optimisation, present two major limitations: (i) they do not provide any information about transition phases from one equilibrium state to the next and (ii) they do not indicate whether the real initial electricity system could move towards this equilibrium. On the other hand our approach, based on System Dynamics (SD) modelling, focuses on dynamic changes in electricity systems based on the representation of decision rules and sheds additional light on the functioning of electricity systems. Sterman

[1] The position of the European Commission is hinted at in its Communication on New Energy Market Design (EC, 2015): "Closer integration of markets across national borders and the development of short- and long-term markets with effective price formation – notably reflecting the need for new capacity – should deliver the right investment signals to allow new generation sources to come onto the market and, where overcapacity exists, signals for decommissioning." … "While capacity mechanisms might be warranted under certain circumstances, they may be costly and distort the market. Furthermore, they may contradict the objective of phasing out environmentally harmful subsidies including for fossil fuels."