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Rationales for capacity remuneration mechanisms: Security of supply externalities and asymmetric investment incentives

Jan Horst Keppler

Université Paris-Dauphine, Place du Maréchal de Lattre de Tassigny, 75775 Paris Cedex 16, France

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ABSTRACT

Economics so far provides little conceptual guidance on capacity remuneration mechanisms (CRM) in deregulated electricity markets. Ubiquitous in real-world electricity markets, CRMs are introduced country by country in an ad hoc manner, lacking the theoretical legitimacy and the conceptual coherence enabling comparability and coordination. They are eyed with suspicion by a profession wedded to a theoretical benchmark model that argues that competitive energy-only markets with VOLL pricing provide adequate levels of capacity. While the benchmark model is a consistent starting point for discussions about electricity market design, it ignores the two market failures that make CRMs the practically appropriate and theoretically justified policy response to capacity issues. First, energy-only markets fail to internalize security-of-supply externalities as involuntary curbs on demand under scarcity pricing generate social costs beyond the private non-consumption of electricity. Second, when demand is inelastic and the potential capacity additions are discretely sized, investors face asymmetric incentives and will underinvest at the margin rather than overinvest. After presenting the key features of the theoretical benchmark model, this paper conceptualizes security of supply externalities and asymmetric investment incentives and concludes with some consideration regarding design of CRMs.

1. Introduction: the market failures at the heart of the capacity issues

This paper aims at providing coherent theoretical rationales for the introduction of capacity remuneration mechanisms (CRMs) in deregulated electricity markets. In other words, at current levels of demand elasticity there exist clearly identifiable market failures in the great majority of energy-only electricity markets that, if unaddressed, will lead to socially sub-optimal levels of capacity. In these cases, attaining optimal capacity requires regulatory intervention providing added incentives for capacity provision either through price or quantity instruments or a combination of the two, as, for instance, in capacity markets operating under a system-wide cap set by the regulator.

The standard argument that marginal cost pricing in combination with scarcity pricing at VOLL will provide optimal levels of capacity remains a conceptually coherent benchmark. However, the theoretical benchmark model neglects the two market failures that will be analysed below: security-of-supply externalities and asymmetric investment incentives in markets for non-storable goods with discretely sized equipment. Real-world CRMs have thus been obliged to develop with scant help from the theoretical literature. This has created a wide divergence of views at a time when the introduction of large amounts of variable renewables lends new urgency to the capacity issue, in particular in European electricity markets. The present paper thus aims at filling the gap between theory and practice in the area of optimal capacity provision.

There exist a number of previous attempts to come to terms with this contradiction between theory and practice. They broadly fall into three categories. Authors such as Oren (2003), De Vries and Hakvoort (2004) or Salies et al. (2007) identify potential shortcomings in energy-only markets and define security of electricity supply as a public good. However, these shortcomings relate either to indelicate behaviour by market participants ("under-reporting of true preferences") or transaction costs in energy-only markets. Neither argument upholds closer scrutiny as a general case for CRMs.

The second strand of literature is organised around the notion of incomplete markets, see, for instance, Vázquez et al. (2001, 2002), Battle et al. (2006) or López-Peña et al. (2009). These authors correctly

E-mail address: jan-horst.keppler@dauphine.fr.

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identifying the capacity issue as due to a "missing market". The capacity issue does indeed arise due to the fact that no market exists to internalise security of supply externalities. However, they spend little time on the identification of the market failure as such, but concentrate on the design of the additional market that will internalise the failure.[1] Thus also the second strand fails to deliver a justification for the need of the decisive regulatory intervention that precedes the creation and operation of forward capacity markets.

A third strand of literature is constituted by economists and electricity market experts with backgrounds in industrial and institutional economics, concentrating on the failure of electricity markets to fully remunerate the provision of optimal amounts of capacity, the "missing money" problem. "The fundamental source of the missing money problem is the failure of spot energy and operating reserve markets to perform in practice the way they are supposed to perform in theory," writes Joskow (2008, 166). A particular issue in this context is constituted by the price caps imposed by regulators during scarcity hours, often seen at the origin of less than sufficient capacity remuneration (Cramton and Stoft, 2006, 8; Joskow, 2008, 164; Finon and Pignon, 2008, 145; Finon and Roques, 2013, 112). However, Joskow also points out that empirically price caps are rarely the binding constraint (Joskow, 2008, p. 166) and cites several additional market imperfections related to institutional or informational shortcomings.

The present paper has benefitted from all three approaches cited, in particular the first and the third. In contrast to the first it provides a more complete notion of what constitutes an externality and hence a public good. In contrast to the third, it makes a general case for CRMs, in particular due to security of supply externalities, that is independent of the specific institutional failures of a given market or regulator that could be righted by an expert with superior knowledge.

Before discussing the fundamental market failures providing a pervasive rationale for CRMs, the present article sets out to reaffirm the conceptual validity of the theoretical benchmark model for energy-only markets with scarcity pricing at VOLL under the assumptions of perfect information and in the absence of externalities, market power and transaction costs. It will then conceptualise the two recurring features of real-world electricity markets, security of supply externalities and asymmetric investment incentives that challenge the conceptual benchmark model, which is ultimately too narrow a representation of electricity markets.

The fact that the case for capacity mechanisms ultimately depend on an externality argument also explains some of the difficulty that energy economics has had in organising a more systematic debate on the origins of the capacity issue. For methodological reasons, theoretical economics will always tend to disregard difficult to codify goods such as the security of electricity supply. However, the empirical pressure for CRMs requires addressing the capacity issue also on a conceptual level in a more definitive manner.

While security of supply externalities and asymmetric investment incentives exist, in principle, in all electricity markets, the magnitude of their impact depends crucially on structural factors such as the elasticity of demand and the size of generation equipment. There might thus exist electricity markets, where the tendency towards socially suboptimal levels of capacity might be too weak as to warrant dedicated regulatory intervention. In a system where storage is ample, the unit size of dispatchable generators is small and the elasticity of demand is high, it is unlikely that a CRM will be required.

The validity of the theoretical benchmark model for energy-only electricity markets thus depends on the presence, degree and precise form of the two market failures mentioned. Furthermore, as discussed in Keppler (2010) externalities always inscribe themselves in a dynamic of progressive internalisation. This is particularly true for capacity issues. In fact, CRMs have a tendency to progressively bring about a form of structural change – more storage, smaller unit sizes and more flexible demand – that will eventually reduce the tendency of energy-only markets to supply sub-optimal levels of capacity. Thus, while required in the majority of electricity systems today, CRMs have a tendency to render themselves obsolete over time.

However, before things might eventually get better, they are currently getting worse. In European electricity markets at least, the capacity issue is magnified by the decrease in average prices following the introduction of large amounts of variable renewable capacity. This has led to the decommissioning or mothballing of gas plants slated to work during periods of high demand. The shift of the load curve towards the right due to the influx of variable renewables (VRE) thus exacerbates the vulnerability of peak-load plants required to recover their capital costs during a small number of hours. Peakers have always been exposed to the stochastic nature of electricity demand. This effect is now doubled by the further increase in price volatility due to the equally stochastic nature of VRE production.

Price caps in energy-only markets contribute further to reducing privately provided capacity below socially optimal levels. While some administrative guidance is required for situations in which an inelastic short-term demand exceeds an inelastic short-term supply, current price caps are often unrealistically low. Even in the absence of the market failures discussed below, current price caps in the European market, for instance, are inconsistent with stated security of supply objectives. This can be easily demonstrated by looking at the French electricity market. The latter has the virtue of stating an explicit security of supply target, which is set at a level of three scarcity hours per year. The corresponding capacity will, at the margin, be provided by gas- or oil-fired combustion turbines. With prices on the French-German day-ahead market EPEX Spot capped at € 3 000 per MWh, VOLL pricing during three hours per year with a French peak demand of circa 100 GW will generate in an average year € 900 million. This however is not nearly enough to recuperate the missing money necessary to finance a peaking unit. The annualised capital cost of € 50 000 per MW for a combustion turbine would require revenues of € 5 billion during scarcity hours. Recuperating this amount would require at least 16 scarcity hours per year, far above the level deemed socially optimal.[2]

While these empirical considerations add urgency to the capacity issue, they do not affect the conceptual arguments of this article. Its structure is as follows. Section 2 will present the theoretical benchmark model according to which competitive energy-only markets in the absence of market or regulatory failures provide privately and socially optimal levels of capacity. It will also discuss its limits, in particular concerning the rarely fully spelled out details of scarcity pricing at VOLL. Section 3 will identify market failures in energy-only markets on the demand side in the form of security-of-supply externalities and the fundamental inability of consumers to properly hedge against system-wide security of supply risks. Section 4 will identify market failures on the supply side on the basis of the fact that discontinuities in electricity price formation will asymmetrically induce producers to underinvest rather than to overinvest in capacity, an effect that is exacerbated by uncertainty about the precise level of demand, risk aversion and the

[1] This approach comes under different headings such as "reliability options", "price risk-hedging contracts", "call options" or "forward reliability auctions". They share the underlying idea that either market participants (decentralised approach) or the TSO (centralised approach) ensure by means of a call option the availability of the total maximum amount of electricity they will need at a fixed price (see Battle et al. (2006)). Since the overall cap is fixed by the regulator or the TSO, the security of supply externality is effectively internalised. The "market" element of this approach is limited to the efficient, least-cost provision of energy and capacity, not the system-wide capacity limit.

[2] In reality, the situation is even less satisfactory. Reaching the cap of € 3 000 per MWh during four hours in 2009 produced a political uproar and a serious questioning of the adequacy of liberalised electricity markets across the political spectrum.