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Capacity mechanisms and the technology mix in competitive electricity markets

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Capacity mechanisms are playing a growing role in electricity market design. In a nutshell, they award generators a capacity payment in exchange for being available to supply at a specified date. Capacity markets, in which this payment is determined by auction, are long-standing feature in US power systems (such as ISO New England and PJM) and have been introduced in Great Britain, France, and Ireland. In 2018, the European Commission approved new market-wide capacity auctions in Italy and Poland as well as strategic reserves in Belgium and Germany.

There are a variety of justifications for a capacity mechanism. Its rationale is often said to arise from the presence of a price cap in the wholesale market. On one hand, a price cap protects electricity consumers from “too high” prices (perhaps resulting from the exercise of market power). On the other hand, setting it too low leads to underinvestment—known as the “missing money problem”. To this is added that greater renewables penetration reduces the running hours of conventional plant via the much- discussed “merit-order effect”. A capacity mechanism, by providing generators with an additional revenue stream, has the potential to resolve the missing-money problem.

At the same time, the use and design of capacity mechanisms remains hotly debated. Some jurisdictions, such as Texas, rely on an “energy-only” market design without apparent need for capacity payments, some jurisdictions rely on a capacity auction and yet others use a strategic reserve to guarantee security of supply. Despite the recent proliferation of national capacity mechanisms, the European Commission has arguably taken a sceptical view due to concerns about market fragmentation and potential distortions of competition. By contrast, some analysts speculate that the wholesale market will over time be eroded by zero marginal-cost renewables, with virtually all “action” shifting to the capacity market. In short, the debate around capacity mechanisms is one of the biggest policy issues for the future design of electricity markets.

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In this paper, we introduce a new benchmark model of long-run investment with a capacity mechanism. Our main interest lies in understanding the optimal policy design when the regulator can use multiple instruments: a wholesale price cap and a capacity mechanism. We study three types of capacity mechanism: a capacity payment and capacity auction, both market-wide, and a targeted strategic reserve.

The key features of the model are as follows. First, we consider a wide range of generation technologies, with the standard trade-off that a lower production cost comes with a higher investment cost. This enables us to study how capacity mechanisms affect base-load, mid-merit and peak generation units in potentially different ways. Second, we assume that demand is stochastic but price-inelastic. Third, if demand exceeds generation capacity, there is forced rationing (rolling black-outs). Moreover, we consider a system-cost externality which represents lost welfare due to accidental system-wide black-outs or that it is costly for the SO to conduct rolling black-outs. Fourth, our interest lies in the optimal design of capacity mechanisms for the case of perfect competition among producers.

We begin with the first-best benchmark for optimal investment. Social welfare consists of the gross consumer value from electricity minus production costs, investment costs and the system cost. A social planner keeps on investing until the marginal benefits of higher consumer value and a lower system cost are equal to the investment cost. A higher consumer value of lost load (VOLL) and a greater system-cost saving both lead to more investment into peaking plant.

We then study market-based investment under perfect competition. We show that there is a family of combinations of the price cap and capacity payment which achieves the social optimum via the market. This makes precise how much “uplift” in a capacity payment is needed to correct for different degrees of missing money. One member of the family is setting the price cap at the VOLL and the capacity payment to internalize the system-cost externality. For baseload and mid-merit plant, the extra revenue from a higher capacity payment is exactly offset by the reduction in scarcity rent. The additional revenues go solely to financing new investment into peak plant. In our model, a capacity payment that leads to a market-based capacity volume is equivalent to a capacity auction.

We present two extensions. First, we study how intermittent renewables enhance the need for a capacity mechanism. Renewables crowd out conventional generation via a merit-order effect; all else equal, this exacerbates the system-cost externality by making it more difficult to control the power system. When “firm capacity” from conventional generation acts as a complement to intermittency, this raises the social value of investment in peaking plant—which is incentivized by a higher capacity payment. Second, we outline a new socially-optimal design of a strategic reserve. A capacity payment that discriminates between plants inside and outside the reserve can easily lead to market distortions in investment. The key idea of our design is to avoid such inefficiencies by paying an extra-high price to non-reserve plants whenever the reserve is used.