Investment vs refurbishment: examining capacity payment mechanisms using stochastic mixed complementarity problems

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Executive Summary

Electricity markets are increasingly moving from a design wherein firms are compensated solely for the energy they provide to one where firms are also compensated separately for other costs incurred. One example of this is a capacity remuneration mechanism (CRM). CRMs are designed to compensate firms for their fixed costs of capacity, thereby ensuring that sufficient electricity generation capacity exists to provide sufficient generation during peak demand hours, ensuring reliable supply.

Electricity generators also do not exhibit complete reliability, in that they may not be available to generate at every point in time. Generators may need to be on scheduled outage for routine repairs, or may also be on forced outage due to a technical fault. The availability of variable renewable generation, such as wind and solar, depends on the weather. The reliability of the total electricity generation fleet will depend thus not only on the amount of generation capacity installed, but also on the reliability of each unit, and therefore on how likely it is that a particular unit will not be available to generate in any given time period. Firms may choose to refurbish units in order to improve their reliability and reduce the probability of being unavailable in any given time period.

This paper examines the potential for different CRMs to incentivise investment in new generation capacity and also to refurbish existing generation capacity, thereby increasing the reliability of existing units. Two capacity mechanisms are considered. The first is a price-based mechanism, in which a policy-maker, regulator or Transmission System Operator (TSO) determines a fixed amount of remuneration for capacity each year, and this total sum is spread over all units on the basis of their capacity. Thus, a higher amount of installed generation leads to lower payment per unit, and vice versa. The second mechanism is a quantity-based mechanism, in which the policy-maker decides on a target level of capacity for the period in question, and provides a capacity payment to all firms that hold capacity up to this target level. Firms compete in an auction to receive a capacity payment. A firm that is in receipt of a capacity payment must repay the difference between the energy price and a predetermined strike price to the TSO whenever the energy price rises above the strike price. This provides the firms with an incentive to be available to generate in all possible time periods.

We solve the model under various input scenarios once without allowing firms to refurbish their units and once allowing them to make refurbishment decisions. We find that when refurbishment is not allowed, the quantity-based mechanism lowers final costs to consumers, while the price-based mechanism incentivises higher levels of investment and therefore higher levels of reliability. There is thus a trade-off between the cost and the reliability of electricity supply from the consumer's point of view.

When refurbishment is allowed, the cost to the consumers is the same under both mechanisms, with the exception of a sensitivity performed in which there were high levels of initial capacity. Under this sensitivity, the reliability options mechanism led to lower consumer costs. All firms refurbished their units to the maximum extent possible, which brought about the maximum possible level of reliability for the system as a whole. The total amount of electricity generation and investment was equal under both mechanisms, as were prices.

In both cases, there was no market exit under initial levels of over-capacity. Therefore a quantity-based mechanism, which limits capacity revenues to a target level of capacity only, did not reduce total capacity to the target level.

This work shows that the differences between capacity remuneration mechanisms may be driven to some extent by the extent to which firms can refurbish their units to improve their reliability. There

may be technical and/or economic limitations on the extent to which reliability can be improved, which could see differences between the mechanisms emerging. In this case, policy-makers may have to determine the socially acceptable trade-off between cost and reliability of supply.

This work also questions whether overcapacity will arise due to the design of the capacity remuneration mechanism, and whether a quantity-based mechanism is likely to induce exit over and above a price-based mechanism. Policy-makers who are concerned about excess capacity on a particular system should ensure that such overcapacity is not arising due to excess rents being earned through other market mechanisms before attempting to reduce over-capacity through the design of the capacity remuneration mechanism.