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Capacity Mechanisms in Interconnected Markets

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Highlights¹

- Strategic reserves and capacity markets can improve the security of supply and contribute positively to consumer benefits if they are carefully conceived and managed.
- The presence of an interconnector may negatively affect the effectiveness of a capacity market, depending on the relative size of the interconnection and the degree to which the consumption peaks coincide. The capacity 'leakage' benefits the neighbouring market in terms of lower prices and higher reliability, but it may also lead to import dependency.
- A capacity market can crowd out generators in an interconnected energy-only zone. Hence, it may put pressure on neighbouring markets to implement a capacity mechanism as well.
- In case the neighbouring zone decides not to implement a capacity market, a strategic reserve can also offset this crowding-out effect and thus lower the risk of investment cycles in generation capacity.

1. This policy brief summarises the results of the publication "Cross-border effects of capacity mechanisms in interconnected power systems" (2017) in Utilities Policy <http://doi.org/10.1016/j.jup.2017.03.005>



1. Introduction

The growing penetration of intermittent renewable resources is leading to concerns regarding the security of supply and generation adequacy in the European Union (EU). These concerns revive and add to the debate about the security of supply in electricity markets. Consequently, the debate is reopened in the remaining energy-only markets in Europe as to whether to implement a capacity (remuneration) mechanism, especially in the presence of variable renewable energy resources.

In the EU, the decision of whether to implement a capacity mechanism and its design and implementation are left to the discretion of the member states. In a highly interconnected system, such as the continental European electricity system, an apparent risk is that the uncoordinated implementation of capacity mechanisms could reduce economic efficiency and even negatively affect the security of supply in neighbouring systems as has been discussed at length in literature.

In our research, an agent-based model is utilised to analyse the effectiveness of capacity mechanisms in interconnected systems. The cross-border effects on prices, investment and security of supply that they may cause in the long term are studied. We expand EMLab-Generation¹, an existing agent-based model of interconnected electricity markets, by modelling a strategic reserve and a capacity market.

A strategic reserve can be implemented in diverse ways. In its simplest form, when a system operator implements a strategic reserve, he/she contracts and dispatches a certain volume of generation capacity, usually the generation units with the highest variable costs. This contracted capacity is then deployed when the electricity price exceeds an administratively set 'reserve price' that is greater than the power plant's marginal cost of generation but below the value of lost load.

1. www.emlab.tudelft.nl

In theory, the artificial tightening of the supply due to the presence of a strategic reserve would attract investment in generation capacity before a physical shortage occurs. Consequently, the high price spikes that occur in periods of scarcity would be replaced by more frequent but also lower price spikes, capped at the reserve dispatch price.

In a capacity market, consumers, or an agent on their behalf, are obligated to purchase capacity credits equivalent to the sum of their expected peak consumption plus a reserve margin that is determined by the system operator or the regulator through a process of auctions.

The additional revenues from the capacity market are intended to ensure that (peaking) power plants recover their fixed costs and thus discourage any untimely decommissioning. A capacity requirement is also expected to provide an earlier and stronger investment signal than wholesale electricity prices and improve supply adequacy. It should be noted that a variety of capacity market designs have been implemented across the different electricity markets.

2. Scenarios and indicators

The scenarios used in our analysis consists of two identical markets (Zone A and Zone B) that are connected by an interconnector. The reference scenario (BL) consists of energy-only markets in both zones. The remaining scenarios are permutations of capacity mechanism implementation as illustrated in Table 1.

Table 1: List of scenarios

Scenario	Zone A	Zone B
BL	Energy-only	Energy-only
SR-EO	Strategic Reserve	Energy-only
CM-EO	Capacity Market	Energy-only
CM-SR	Capacity Market	Strategic Reserve



The indicators that were used in the analysis of the results are:

1. The **shortage hours** (hours/year): the number of hours per year with scarcity prices.
2. The **average electricity price** (€/MWh).
3. The **cost of the capacity mechanism** (€/MWh): the cost incurred by the consumers for contracting the mandated capacity credits from the capacity market or for contracting generating units into the strategic reserve.
4. The **cost to consumers** (€/MWh): the sum of the electricity price, the cost of the capacity market, and the cost of the renewable policy (if applicable) per unit of electricity consumed.
5. The **supply ratio** (MW/MW): the ratio of available supply at peak (MW) and peak demand (MW).

The quantitative results are presented in Figure 1.

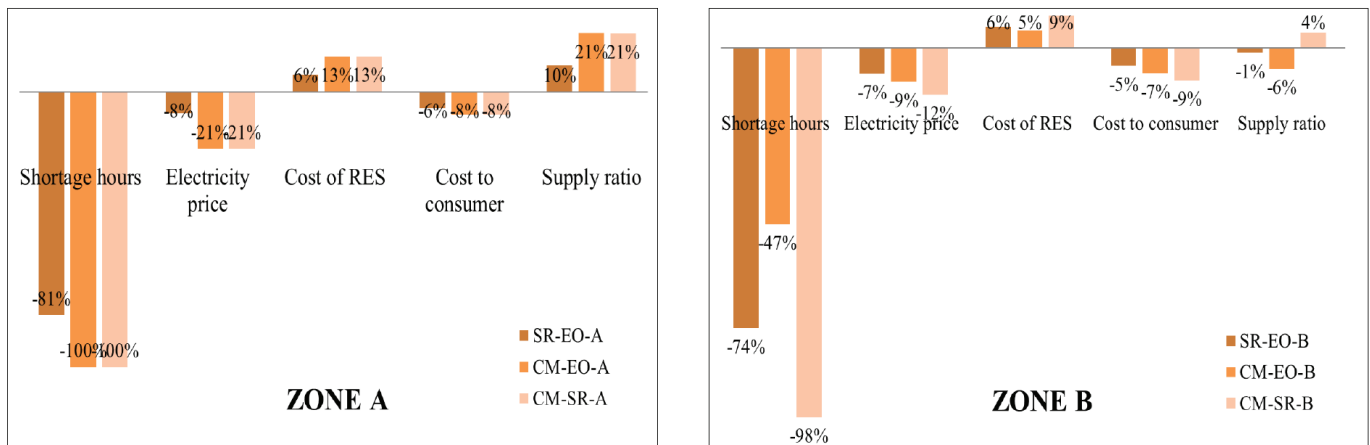
6. Cross-border effects of a strategic reserve

In our research, implementation of a strategic reserve in one zone (Zone A) of an interconnected system improves the security of supply and net con-

sumer benefits in that zone. The benefits also spill-over to the neighbouring interconnected zone, both regarding reduction in shortage hours and reduction in costs to consumers. In the other zone (with an energy-only market - Zone B), no significant effect on investment is observed – at least, in our experimental setup with two equally-sized markets and a fixed interconnector size.

We also compare these results to an isolated system (no interconnections) with a similarly sized strategic reserve. Part of the capacity from the zone with a strategic reserve is exported to the neighbouring market, as there is no restriction on exports. Consequently, there are more shortage hours in the zone with the strategic reserve than in the isolated case, while the shortage hours in the neighbouring energy-only region are reduced. Hence, a strategic reserve has a similar positive external effect upon neighbouring countries as a capacity market, but its investment dynamics are different. Again, the consumers in Zone B may be considered to be free riding on the consumers in Zone A, and less interconnection would limit the effect. A TSO that implements a strategic reserve would, therefore, experience an incentive to restrict exports, for example by limiting the volume of interconnector capacity that is made available to the market, during simultaneous power shortages in both zones.

Figure 1: The percentage change in values of various indicators in Zone A (left) and Zone B (right) on implementation of capacity mechanisms as compared to the baseline scenario (BL)





7. Cross-border effects of a capacity market

In our research, if a capacity market is introduced in a zone that is interconnected with an energy-only market, the capacity market still achieves the adequacy goals in the zone (Zone A) that implements it, at least in our experimental set-up with two equally-sized markets. If the capacity market is small in comparison to its neighbour(s), we cannot exclude the possibility that the exports will reduce its effectiveness. The supply ratio in the capacity market remains adequate, while the consumers in the interconnected market benefit from the additional capacity with lower prices and fewer shortages. The free riding of the consumers in the interconnected energy-only market (Zone B) leads to a marginal increase in the cost to consumers of the region implementing a capacity market, but the overall consumer benefit improves. The fact that the consumers in the zone without a capacity mechanism may be free riding on the consumers in the zone with a capacity mechanism may create acceptability issues in the country with the capacity mechanism, where the consumers are paying more.

In our research, a capacity market suppresses investment in the interconnected zone (with an energy-only market), which may make the neighbouring zone import dependent and may lead to an investment cycle there. The leadership in the zone with an energy-only market may become concerned about the availability of electricity during power shortages and strive for sufficient domestic generation capacity to be able to meet demand without imports if necessary. This may be a reason for implementing a capacity mechanism in the energy-only market zone as well. However, allowing (and facilitating) the cross-border trade of capacity credits might counteract the crowding-out of generation capacity in the neighbouring market.

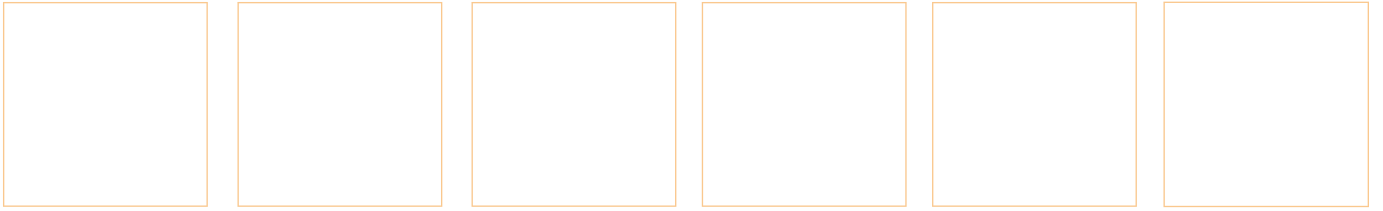
8. Cross-policy effects due to the implementation of dissimilar capacity mechanisms

If a capacity market and a strategic reserve are implemented in neighbouring markets, we find that the effects are generally positive, as the number of shortage hours and the total cost to consumers are reduced in both zones. The performance of the capacity market is hardly affected by the presence of a strategic reserve in the neighbouring zone. Our research results not only indicate that the capacity market is a robust policy mechanism, but also that the strategic reserve in the neighbouring zone does not impact the capacity market negatively. This is not surprising, as both capacity mechanisms were shown to have a positive spillover effect on an energy-only market. The presence of a strategic reserve in the interconnected zone does not impact capacity prices significantly.

In the zone with the strategic reserve, the import of electricity from the capacity market, along with the additional capacity available due to the strategic reserve, leads to a sharp reduction in shortage hours, a reduction of the price volatility and a decrease in the average electricity prices. The exports from the capacity market reduce the need for a (large) strategic reserve. In the presence of the capacity market, the strategic reserve is no longer able to recover its costs. In this case, it appears that a smaller strategic reserve would suffice.

9. Conclusions & policy implications

We present an analysis of the cross-border effects that may arise due to the implementation of capacity mechanisms in interconnected electricity markets with the use of an agent-based model. In the scenarios analysed in our research model, both capacity mechanisms improve the security of supply and contribute positively to consumer benefit in the two zones considered.



Interconnection with a neighbouring zone of equal size did not affect the ability of a capacity market to reach its policy goals in our model, but this may have been due to the implementation of a large capacity reserve margin in our model. When a capacity market is implemented, a neighbouring market may experience a positive spillover and therefore free ride on the capacity market. This may result in greater level of reliability and lower electricity prices in this neighbouring market. Free riding may increase the cost to the consumers in the capacity market, as they are paying for the additional adequacy. The generators in the neighbouring energy-only zone may be crowded out, in some cases to the extent that an investment cycle develops. While this does not necessarily affect generation adequacy and prices in this zone negatively, policy makers may be uncomfortable with the resulting import dependence.

Allowing generation companies in the zone without a capacity market to sell capacity credits in the capacity market may counter this effect, as it will increase the value of generation capacity in the non-capacity market. Another option is to implement a capacity mechanism in the neighbouring zone as well. Hence, the implementation of a capacity mechanism may cause pressure on neighbouring markets to do the same.

A strategic reserve also has a positive spillover effect on a neighbouring energy-only market, both regarding the reduction in shortage hours and cost to consumers. However, the presence of an energy-only market in a neighbouring zone hurts the performance of the strategic reserve with respect to the net cost to consumers and the number of shortage hours when compared to an isolated system with a strategic reserve. A strategic reserve can reduce the crowding-out effect on its electricity market caused by the capacity market and thus lower the risk of investment cycles in generation capacity. However, in our research model, in the presence of the capacity market, a strategic reserve in an interconnected zone was unable to recover its costs. In this case, it appears that a smaller strategic reserve would suffice.

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