

Capacity mechanisms driving dynamic capacity investment decision making with increased renewable energy sources

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(1) Overview

Electricity markets in Europe oppose major challenges in the upcoming years. The reason is mainly driven by the targets set by the EU aiming to limit the human impact on climate change. This goes along with the goal to phase out carbon emitting power plants and the large-scale integration of renewable energy sources (RES). While the generation mix changes, the current design of electricity markets might not sufficiently facilitate this change. Increased generation from intermittent RES leads to changes in the energy market and problems for ensuring the future security of supply including short-term reliability and long-term generation adequacy. The need for flexible generation capacity to balance RES and demand variability has risen and must be addressed sufficiently by the market design.

As for today, the electricity market is organized as an energy-only market. Generators are remunerated for the energy sold to the market. The fixed costs for the generation are covered by the non-scarcity inframarginal rent (base and mid load power plants) and the scarcity rent (peak load power plants). Moreover, price spikes at times of scarcity should be sufficient to trigger enough investment to ensure future security of supply by building adequate power plants.

The expansion of volatile RES leads to a less predictable load factor of conventional power plants and in some cases to too few operating hours to run the power plant profitably. It can also cause the conventional power plants to switch on and off more frequently, or to operate under partial load conditions, both increasing the cost per delivered MWh. Moreover, more volatile market prices reduce the margin for conventional peak and mid power plants and increase the investment risk in new generating units. This situation is described as the missing money problem meaning that prices for electricity are not high enough in time of peak demand to incentivize adequate new investments.

Capacity mechanisms are one way to address the impediment for new investments resulting from the energy-only market outlined above. Capacity mechanisms are additional mechanisms besides the energy-only market to influence the volume of installed generation capacity.

(2) Methods

A general overview and categorization of capacity mechanisms are the baseline for this research. The capacity mechanisms, limited to the four most discussed mechanisms, are categorized as price-based and quantity-based mechanisms. Figure 1 shows the four researched capacity mechanisms. The capacity mechanisms are reviewed with respect to operating principle, involved actors, time horizon and practical application. Their similarities as well as distinguishing differences are compared with each other.

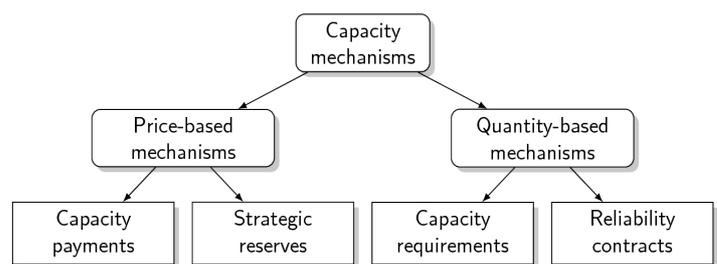


Figure 1: Categorization of capacity mechanisms

Based on the outline, the effects of capacity mechanisms on the investment behavior are examined in a model. It is based on future scenarios of demand growth and the expansion of renewable energy sources. The model calculates the equilibrium of demand and supply on a quarter-hourly basis, resulting in revenue streams for the generating units. Periodic investment decisions are executed. These decisions are based on the long-run average of revenue streams, estimations about future revenue streams and costs for investment and operating the generating unit. Three possible options are considered: mothballing or closing down existing capacity, investments in new capacity or no investments. The newly installed capacity is added to the existing generation after a delay representing the construction of new generation units.

The model simulates an electricity system which is based on the current situation in Belgium, including the installed generation mix, load-duration curves and estimations about demand growth and RES (source: Belgian TSO ELIA).

(3) Results

First, the goals and operation principle of price-based mechanism and quantity-based mechanisms are clarified. The outline emphasizes on the difference of these two approaches based on the researched examples.

Second, the application of the model reveals the influence of market design on the investment decision making process. As a result, the model shows the development of the generation mix under a certain market design (see Figure 2). Market designs leading to underinvestment that threaten the security of supply are revealed. The comparison of different capacity mechanisms and analysis of investment behavior gives insights in the energy-only markets and the possible necessity of capacity mechanisms. The stability and adequacy of investment decisions clarify the ability of a market design to trigger adequate investments and reduce boom and bust cycles (see Figure 3).

Based on the adequacy of the installed capacity and the stability of investment behavior a first comparison of capacity mechanisms is done. The creation of new investments to cover demand growth and support expansion of RES is used to evaluate each of the capacity mechanisms.

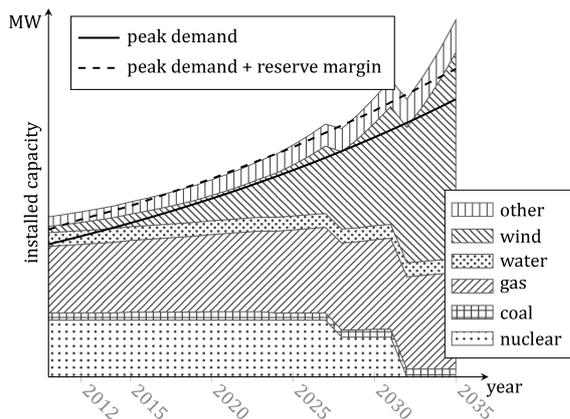


Figure 2: Development of installed capacity as result of a market design

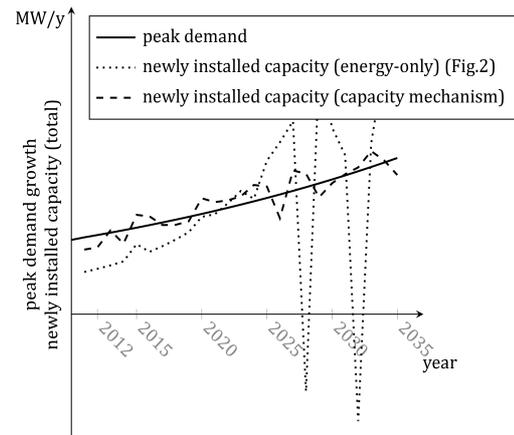


Figure 3: Investment behavior based on market design and demand growth

(4) Conclusions

This paper introduces a model for simulating capacity mechanisms in different future scenarios. A comparison of capacity mechanisms with a energy-only market reveals the behavior of investment decisions based on market design. An analysis of additionally installed volume and technology is examined. Because of the quarter-hourly temporal resolution of demand and supply, not only long-term generation adequacy but also operational short-term security of supply is taken into account. On the basis of the different scenarios and market designs a sensitivity study on the generation mix is done which gives insights on the capability of the generation mix to backup volatile RES.

Energy-only markets might lead to an unsure security of supply caused by too few and not adequate investments in new generation capacity. This undesirable development is based on the missing money problem. The current market design of energy-only markets can be adjusted by capacity mechanisms. These capacity mechanisms ensure an additional and steadier revenue stream for generating units. They address the increased but volatile generation from RES that goes along with an unpredictable load factor for conventional power plants and more volatile prices.

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