ELECTRIC CAPACITY MARKET PERFORMANCE WITH GENERATION INVESTMENT AND RENEWABLES

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Overview

Competitive markets have become more common for whole electricity transactions. Initially markets developed to improve efficiencies in the operational dispatch of electric energy; however, as systems mature and additional capacity is required to meet load and adequacy requirements, market failures may indicate that energy-only markets are insufficient to motivate the necessary investment in new capacity. Various countries and market operators have implemented investment incentives, such as capacity markets, that may address specific resource adequacy issues that their particular system has experienced. However, many of these mechanisms have required significant revisions to address unanticipated issues. Additional work is necessary to determine long-term strategies that motivate optimal amounts and types of capacity investments while responding to policies mandating expansion of renewable energy and upgrades of existing facilities to meet clean energy standards.

Several jurisdictions are reviewing capacity mechanisms to determine best methods to motivate investment in appropriate future generation technologies. This paper explores the ability of different capacity mechanisms, including those now implemented or under review by several countries and regions, to motivate efficient investment in different generation resources, new and refurbished, and compares investment incentives and equilibrium capacity mixes with a theoretically optimal system. Interactions with alternative reliability criteria and renewable incentives are examined using models of capacity adequacy that simulate some European and U.S. markets. Specific market design issues, such as distortions introduced by remunerating capacity based on average rather than marginal capacity contributions, are considered as well, since they can significantly impact the effectiveness and efficiency of capacity mechanisms. Recommendations will be made regarding implementation of capacity mechanisms and overcoming challenges introduced by renewable generators.

Methods

Using optimization techniques and energy and capacity market equilibrium models, two alternative regional power systems have been modelled based on actual normalized historical load, wind and solar data. One system is winter-peaking with a moderately high load factor, typical of European systems. The second system is summer-peaking with a significantly lower load factor typical of U.S. systems with high air conditioning load. New generation technologies were modelled using the most recent U.S. Energy Information Administration (EIA) cost information and best-in-class resources for peaking, intermediate and baseload operation. Renewable technologies are initially modelled without subsidies. The models aggregate coal, natural gas combined cycle, natural gas combustion turbine, wind and solar generation into technology clusters. Ramping constraints were placed on each technology cluster to allow consideration of capacity markets that differentiate between flexible and inflexible capacity (such as in California). Natural gas prices were modelled at the current lower prices reflected in the United States natural gas market and the current higher prices of the European gas market. The capacity amounts and annual hourly dispatch of each generation technology have been optimized to meet load requirements. For cases in which wind and solar technologies would not be competitive in the optimal generation mix, varying amounts representing Renewable Portfolio Standard (RPS) compliance have been added to the model and the dispatch of the remaining generation technologies have been re-optimized. Scenarios have been developed to include existing, significantly depreciated baseload coal plants.

This paper focusses on several volume-based capacity mechanisms where the volume is set by attainment of a system adequacy criteria, such as a given system reserve margin or loss-of-load probability. The mechanisms analyzed include targeted and market based mechanisms that are centralized or decentralized.

Results

Scarcity Pricing Insufficient to Meet Reliability Targets: If the reliability target is a fixed 15% reserve margin, then energy-only markets provide insufficient incentive for the development of new natural gas generation to meet reliability targets, in part because scarcity-based prices are neither high enough nor frequent enough to incent construction. At a minimum, if a system reliability corresponding to a 15% reserve margin is desired, either targeted capacity payments to new natural gas generators or payments to all capacity are necessary to cover the missing money not provided in the energy market. This could also be interpreted as suggesting that 15% reserve margins are not justified economically by the value they provide to consumers, but this assumes that costs of outages to consumers are efficiently translated into price signals in the market, which is not the case in today's distribution markets.

Solar Needs Subsidies: In general, under our assumptions, solar development without subsidies is not optimal with either high or low natural gas prices. Some high solar insolation sites in locations with high natural gas prices and lack of lower cost baseload coal and nuclear facilities might be approaching prices that will include solar in optimal portfolios without subsidies, but these locations are not common. The high solar penetration occurring in some markets is due to explicit subsidies, or implicit subsidies in the form of net metering against high (non-marginal cost based) retail rates that are much greater than marginal generation costs. It should be noted that the analysis of this report was initially conducted using EIA generation cost assumptions from 2014. However, analyses based on the 2015 EIA values turn out to be more favorable for solar technologies, as costs have fallen. Additional new information on all assumptions should be periodically reviewed.

Wind Development Depends on Fuel Prices: Optimal wind development increases as natural gas prices increase. The low gas prices currently in the U.S. do not support the level of optimal wind development that is mandated by various state RPS requirements therefore some form of additional support is necessary. With high gas prices, wind producers are still profitable receiving energy-only payments for what they produce even though it is sometimes necessary to curtail wind without payment when wind production exceeds load. Optimal wind development increases as low cost baseload facilities decrease. As aging generation infrastructure is retired, additional wind resources will be profitable.

Wind May Receive Economic Rents: If siting or other restrictions limit wind development to below the amount needed to minimize system costs, economic rents may be earned in energy-only markets. This occurs even if price caps or missing scarcity pricing mechanisms suppress energy prices. Mixes that are farther from the optimum yield greater rents for wind. Additionally, an economically optimal system may incentivize additional high capacity factor wind development as technology costs fall or efficiency improves, while at the same time pre-existing lower capacity factor wind farms may no longer cover initial investment costs due to overall lower energy market payments created by the additional wind.

On the other hand, if gas prices are low, then augmenting the energy market by adding a market-based capacity payment to renewables for the amount contributed at system peak still does not provide enough economic incentive for investment to achieve the most ambitious state Renewable Portfolio Standards in the U.S. (e.g., California's 33%). Renewable generation that is required to meet portfolio standards when natural gas prices are low, in general, needs to receive additional forms of payment (tax credits, renewable energy credit revenues) to support the social policy.

Baseload Capacity Lacks Incentives for Modernization when Gas Prices are Low and Renewable Investment is Higher than the Least Cost Level: Existing baseload assets that are already significantly depreciated and that have low fuel costs, such as coal and nuclear, earn rents in an energy-only market with no renewables, especially when gas prices are high. But the rents shrink as the amount of renewable generation increases and substitute fossil fuel prices decrease, thus providing less incentive for modernization. As policy-driven subsidies cause renewable penetration to increase beyond the cost minimizing level, capacity payments may be necessary to provide efficient incentives for baseload upgrades.

Conclusions

The transition of electric industry to cleaner generation resources and competitive markets has presented new challenges for stimulating generation investment. New natural gas investment is not fully covered in the simple energy-only markets simulated with a fixed reserve margin. Due to the sensitivity of optimal capacity mechanisms to fuel prices, renewable requirements and existing capacity composition, there may not be a single best mechanism to stimulate optimal investment in new generation sources, especially those that are cleaner and more costly. A mechanism should be chosen that efficiently supports long-term energy delivery goals and maintains system adequacy.