Renewable Generation and Capacity Markets

By Peter H. Griffes*

Introduction and Summary

Capacity markets have become an important feature of a restructured electricity industry. They are needed to provide sufficient cost recovery where with energy market prices are restricted from providing sufficiently high signals to induce new generation. Over the last decade, there has also been a significant upswing in the renewable generation designed to replace greenhouse gas producing sources of energy. The introduction of intermittent renewable generation into bid-based restructured markets, especially as these resources achieve higher penetrations, can have a profound impact on the energy revenues to conventional generation, and consequently increase the necessity of capacity payments. As intermittent renewable generation penetration increases in restructured markets, there needs to be a greater reliance on capacity market compensation to ensure viability of conventional generation, needed to maintain reliability.

Capacity Markets are a Fixture of Restructured Electricity Markets

Capacity markets have become a necessary feature of restructured markets[1]. Capacity payments compensate generators for being available to participate in the energy markets. Such capacity markets can take many forms including bilateral contracting with load serving entities as well as centralized auctions operated by system operators who clear the market, invoice load serving entities, and send payments to generators.

Capacity markets are needed to provide revenue sufficiency and assure reliability where sole reliance on energy market revenues may not cover the long-term cost of generation (or short term cost for existing units to stay afloat). Energy prices in such markets are generally set by the bids of marginal generator taking into account transmission availability. However, energy revenues based on competitive prices are often not compensatory to cover longer-term cost of building and operating a new plant. For example, in the California market in 2013, the Department of Market Monitoring estimated that energy market revenues for a new combined cycle plant would be $296.39/kW-yr. in comparison to the $256.78/kW-yr. in operating costs and $175.80/kW-yr. in annualized fixed costs.[2] The remainder of the costs would have to be covered by capacity market revenues.

Consequently, restructured markets have taken on resource adequacy requirements as a means to ensuring there is sufficient capacity to meet the anticipated needs of the system. Capacity markets are a necessary part of a restructured electric industry to produce sufficient revenues to generators.

Renewable Resources have Developed Significantly in Recent Years.

Over the last decade, concerns with climate change have pushed public policy to adopt a greater reliance on renewable resources. There is a wide range of different renewable generation, including hydro, geothermal, wind, biomass, and solar. Some renewable fuel sources are more easily storable than others. For instance, depending on the topology and availability, hydro power can be stored in reservoirs and released at times of greatest value. Biomass fuel is also readily storable, and geothermal is likely only to be tapped at locations where it is readily available. If fuel is able to be stored, then curtailing these resources when not needed, or detrimental to reliability, and then allowing their energy to be produced at other time times may not impact the economics of their operations. Other sources of renewable power are not as easily stored, and if they are compensated based on production, then they would need to generate when fuel is available to allow them to cover the plants development and operation costs. Wind and solar are such sources of renewable energy. If curtailment is not allowed and storage is not an economic option, then intermittent integration into the electrical grid may require more controllable resources to address the intermittence. Further, renewable resources have a different cost structure than conventional generation. Running costs for renewables can be quite low since payments for fuel are not necessary because power is produced through natural means: falling water, blowing wind or shining sun.

Renewable Participation in Bid-based Energy Markets

In restructured electricity markets, the presence of a significant number of renewable generators can have a profound impact on the market. There are three areas where renewables will impact capacity markets: displacement, increase costs and reduction in prices.

First, in bid-based energy market where the dispatch is based on generators' bids, renewable resources can affect which resources are dispatched in the market. In comparison to conventional fossil-fired generation, renewables are likely to have a lower running cost. Consequently, renewable generators can often bid much lower than conventional generation. This will lead to renewable generation being dispatched ahead of conventional plants. Thus, renewable generation

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displaces conventional generation in bid-based markets. This displacement lowers the capacity factor of conventional generators and reduces the time conventional generators are selling in the market. This reduced output reduces energy revenues to conventional generators.

Second, more intermittent renewables require greater flexibility on the part of all generation on the system. More variable output produced by renewable resources requires conventional generation to operate with greater variability to accommodate the increased variation. Significant demands for flexible output, including more starts/stops per day as well as cycling more often from minimum to maximum output, will likely increase the wear and tear on conventional generators and lead to higher operations and maintenance (O&M) costs and the need to schedule more frequent maintenance outages. Increased O&M costs and less availability due to more frequent maintenance will also have a financial impact on the conventional generators, likely cutting into the profitability of the generator. Consequently, conventional generation will be operating less often as well as having to operate in a manner that increases operating costs. These factors work to reduce the net energy revenue earned by conventional generators.

Third, there is an additional impact of renewable generation on energy prices. In bid-based markets, prices are set by the running costs of the marginal plants. Because renewable generators can have low running costs, prices can be quite low in markets where a renewable generator is marginal. Also, social policies to promote renewable generation often provide non-market incentives that influence market outcomes. For example, a production tax credit can produce positive net revenues to a generator even with negative market revenues. Consequently, renewable generators can be willing to pay other market participants to produce, resulting in negative prices for the entire electricity market.

As renewable generation penetration increases, the likelihood that such generation will be on the margin is greater, placing downward pressure on energy market prices. However, conventional generators will still be needed to provide flexibility to address renewable variability. This conventional generation may be subjected to very low energy prices. Therefore, ancillary services should be designed to provide needed flexibility at compensatory rates to conventional generators providing the service. If such ancillary services have not been implemented, there can be a significant impact on conventional generation revenue.

Consequently, the impacts of renewable generation in restructured, bid-based markets place a much greater need for a capacity market. Conventional generators are needed to balance renewable intermittence, but will face lower output, higher O&M costs and lower energy prices. These factors place a premium on enhanced ancillary services products to provide flexibility and greater reliance on capacity market revenues.

Implications for Capacity Markets

From the discussion above, there are empirical implications for capacity markets and reliance of capacity payments with respect to renewable generation as a proportion of a supply portfolio. While these implications are not tested here, general conclusions can be drawn as renewable generation penetration increases.

First, markets with a larger portion of renewable sources as intermittent will have greater need for capacity payments to conventional generation providing flexibility. Thus, markets with more intermittent wind and solar capacity will likely need greater capacity payments than markets with geothermal and controllable hydro resources.

Further, over time, there will be a greater need for the adoption and potentially refinement of capacity market payment streams for conventional generation providing flexibility as the penetration of intermittent renewable resources in a market increases. Thus, some of the moves to enhance existing capacity market structures can be seen in part as a response to increased intermittent renewables. For example, California's move to implement flexible resources requirements in its capacity market structure helps address issues arising from the adoption of an aggressive renewable portfolio standard.

Summary and Conclusion

Development of renewable resources can have a profound impact on revenues for conventional generators, and change the balance of energy and capacity market revenues. There are three causes for this impact on conventional generators. First, intermittent renewable resources reduce conventional generator revenue from quantity of electricity expected to be sold. Second, intermittent renewable resources reduce conventional generator revenue from selling at lower prices or scheduling energy directly into markets regardless of marginal cost. Third, increased flexibility requirements increase costs for conventional generators from more variable operations. These all work to reduce the energy revenues to conventional generators. Consequently, restructured markets with a greater proportion of intermittent renewable generation should have higher capacity payments than those with non-intermittent renewable generation.

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