MARKET POWER AND SYSTEM COST: THE LONG RUN IMPACT OF LARGE AMOUNTS OF WIND ELECTRICITY GENERATION?

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Overview

The rise of intermittent generation such as wind and solar in electricity networks has raised concerns about the reliability of supply in, and the design of, electricity markets. Two facts which are well understood in the literature are: Firstly, increasing the penetration of intermittent generation requires an increase in peaking generation to ensure security of supply during periods where the intermittent resource is unavailable; Secondly, increasing penetration of intermittent generation leads to greater price and dispatch volatility. But it remains an open question as to how these two factors interact with market power in different electricity markets.

There has been much discussion recently around the question of whether increased intermittent generation may mean that electricity markets – particularly Energy Only markets-need redesigning. For example (Hall, 2014) writes that "….. capacity remuneration mechanisms [are] 'unavoidable' in countries with large shares of renewables with zero marginal costs, such as Germany, said Paul Giesbertz, head of infrastructure and market policies at Statkraft Markets, the German-based arm of Norwegian utility Statkraft." The reason advanced is that although Energy Only markets could recover investment costs "with regular high prices in some hours, but it was unrealistic to think the public would accept a 'structural appearance of scarcity' [Giesbertz] said" The German government has just released a green paper (Federal Ministry for Economic Affairs and Energy, 2014) which discusses different possible market design changes to allow the market to work efficiently even with large amounts of intermittent renewable generation. One of the options considered is a capacity market.

The Energy Only market can work in theory with significant amounts of renewables – if the price spikes are tolerated as discussed above. Much of the time the price will be set by the renewables and the price will be close to zero. However there will be times when the prices spikes on the spot market when there is little generation from renewables and the demand supply imbalance is tight. The number of periods where this occurs will need to increase with large amounts of intermittent generation so that plants can cover costs. In a setting with market power tight demand/supply conditions are precisely those periods where firms can exercise market power –which means there will be more opportunity for firms to exercise market power as the penetration of renewables increases. Which in turn may well exacerbate the price spikes and undermine public support for the market. Counteracting this is the fact that there will be an increasing number of periods where the price is zero. The overall impact on average prices is not clear.

In this paper we examine the interaction between capacity investment, wind penetration and market power by first using a least-cost generation expansion model to simulate capacity investment with increasing amounts of wind generation, then using a computer agent-based model to predict electricity prices in the presence of market power. We find the degree to which firms are able to exercise market power depends critically on the ratio of capacity to peak demand. For our preferred long run generation scenario we show market power increases as wind penetration increases and prices overall increase. The market power in turn leads to inefficient dispatch which is exacerbated with large amounts of wind generation.

Methods

To model electricity prices realistically we use a computer agent based model developed by Young et. al. (2014) which uses a modified Roth and Erev algorithm and applies it to a 19-node simplification of the New Zealand electricity market. The computer agents have a portfolio of generator assets and bid into the market. Profits are computed, using a simplified dispatch model of the New Zealand market, which are fed into the learning algorithm. New bids are constructed and the process is repeated until prices converge. The NZ Electricity Authoritie's Generation Expansion Model (EA, 2010) is used to generate a number of different scenarios for 2025 with varying amounts of intermittent wind generation. The demand projections from the Statement of Opportunity (EA, 2010) are used as well as expected line upgrades. Simulated wind data was obtained from National Institute of Water and Atmosphere.. Different amounts of installed wind capacity scenarios are constructed with the constraint being that the competitive prices are constant. The long run generation expansion model is used to determine the capacity mix for each wind penetration scenario. Then strategic behaviour is modelled to simulate wholesale prices for the generated capacity mixes with different amounts of wind using the agent based model.

Results

The New Zealand electricity market is a unique market for testing the merit order effect as large amounts of generation is likely to be required to bid into the spot market at zero price, much of which is intermittent. Unlike many countries wind is not subsidised. Furthermore the electricity network is stand-alone with no interconnection to other electricity grids. The results here suggest that the existing grid with planned line upgrades to 2025 is viable for our central scenario of 20% wind penetration. As expected price volatility increases with market power and with higher wind penetration. Our results support Twomey and Neuhoff's (2010) theoretical result that with market power thermal plants are able to exercise market power more than the intermittent wind generators. With large amounts of wind prices are much more volatile with extra wind pushing down returns on existing wind farms (the merit order effect) As the amount of wind penetration increases it skews the price duration curve with large amounts of zero price hours combined with more higher price events.

We find the degree to which peakers are able to exercise market power depends critically on the ratio of capacity to peak demand. When capacity is low relative to peak demand we find that peakers can persistently exercise market power when there is little wind leading to implausibly large market prices and rents to generators. When capacity is low relative to peak demand peak generators are unable to exercise market power and generate any return on their capacity costs. We also find the surprising result that market power rents increase as wind penetration increases despite an increase in the number of periods when prices are zero. However we also find that that the exercise of market power leads to a loss of efficiency by distorting dispatch from its marginal cost optimal which is least cost. The loss of efficiency is significant and increases as wind penetration increases. This also leads to increased greenhouse gas emissions compared to competitive dispatch. We show that even with large amounts of installed wind all plants including peak plants cover their fixed costs however this is due to the large amounts of market power firms are able to exercise. We also show that if the market is competitive peak plants can cover their fixed costs.

Conclusions

The objective of this paper was to investigate the impact of increasing intermittent generation on firms ability to exercise market power. It was seen that there are two effects which counteract each other. The first is the merit order effect – an increasing fraction of the generation mix bids into the market at zero. When the wind is blowing this pushes down prices. However when the wind isn't blowing then firms are able to exercise market power.
Despite high wind penetration driving prices to zero much of the time, tighter capacity margins allow firms more scope to charge higher markups when the wind *doesn't* blow. The resulting higher prices gives thermal reserve capacity units the opportunity to generate revenue both more frequently (due to higher capacity factors) and at a higher price than they otherwise would achieve, providing the incentives to build such units.

We saw average prices and market power *increase* as wind penetration increased.Furthermore the returns to peakers *increase* as installed wind capacity increased which seems somewhat counterintuitive. This is encouraging since more peakers are needed to sustain the market as the intermittent renewable generation increases. Energy Only Markets can be sustained with large amounts of intermittent wind but only by firms being able to exercise considerable market power.

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