LARGE-SCALE SOLAR DEPLOYMENT IN THE NEW ZEALAND HYDRO BASED ELECTRICITY MARKET.

Stephen Poletti, University of Auckland, +6499237664, s.poletti@auckland.ac.nz
Mina Gholami, University of Auckland, +6499237664, m.bahramigholami@auckland.ac.nz

Overview

The policy goal adopted by many countries to limit temperature increases often includes a commitment to increase the supply of renewable electricity generation. In this paper, we discuss the potential contribution that solar PV could make to New Zealand's electricity mix, to help achieve the government's target to increase the amount of renewable generation from 75% to 90% by 2025. Building a low carbon electricity system is challenging, as renewable electricity supply is often volatile. A promising strategy is to diversify the types of renewable generation so that net demand is less intermittent. (Pritchard, Zakeri and Philpott, 2010; and Hirth, 2013).

In the context of solar, there are concerns that large solar penetration leads to the risk of over generation (when demand is low and it is sunny). Furthermore, after sunset other generators have to ramp up very quickly to serve the evening peak in demand (the so-called duck chart (California ISO, 2013)). In spite of these concerns, solar capacity has continued to increase worldwide owing to government subsidies as well as economies of scale and technology improvements.

As solar PV costs come down there has been a dramatic increase in capacity in New Zealand- albeit from a low base. Between 2014 and 2017, installed capacity increased 10 times to 50MW. Further cost decreases expected over the next decade are likely to increase the uptake of solar PV. Miller et al. (2016) estimate that eventually installed solar capacity in New Zealand could be as high as 5.5GW. To put this in context the current peak demand in New Zealand is about 6.5GW.

A potential obstacle to increasing the amount of renewable generation for the New Zealand market is the reduction in hydro generation (which produces 57% of total generation), and the need to increase other generation during dry years. During dry years, there are low inflows in the period leading up to winter, when the need for generation is highest. From winter onwards, much of the precipitation falls as snow inflows are small until the snow melts in spring. During dry years generation is reduced during the months leading up to winter to conserve hydro generation potential, which leads to water having a scarcity value and higher electricity prices. One of the aims of our investigation is to see how increased solar will affect the market during dry years, and to what extent are they complimentary sources of renewable energy. We are interested in seeing how solar interacts with demand which will help understand the long-run market impact of large amounts of solar PV.

Methods

We used data on potential solar generation, hydro inflows, and demand to examine the likely impact solar could have on the New Zealand electricity system. We found a negative *seasonal* correlation between monthly solar PV and demand - which for New Zealand peaks in winter. There is a positive correlation between *hourly* PV output and demand for the lowest 80% of demand periods, however thereafter solar availability decreases sharply. This is because demand peaks in winter with the highest demand periods in the evening after the sun has gone down. We also find a negative correlation between accumulated inflows into the hydro dams and accumulated solar generation during the crucial months leading up to winter, which could have a positive market impact. To analyse the affect that large amounts of solar would have on the market we used a Generation Expansion Model to find the long-run generation mix for different amounts of solar penetration (for further details see Browne, Poletti and Young, 2015). We then used a market solver to find prices over the course of a year for different "meteorological years". The market solver found the competitive market solution assuming generation bidding in at cost with one exception, which was hydro where the marginal cost of generation includes the scarcity value of water. The program kept track of inflows and generation outflows and updated the hydro lake storage levels each simulated day. We then compared simulations for a "dry" year and a "wet" year to see whether in the long-run equilibrium solar PV had a negative or a positive impact on the market.

Results

Large-scale deployment of solar saw an increase in system costs with the long-run equilibrium price increasing by an average 27% over both of the years we ran simulations for. In this scenario, solar generation was 19% of the total electricity generated. However, the increase in renewables was much more modest, only 4% as solar displaced other forms of renewable electricity generation. The medium solar scenario, with half the amount of installed solar of the large-scale deployment scenario showed almost the same increase in overall renewable generation of 4% but with much lower price increases of 8%.

Conclusions

The simulations found that the strong negative seasonal correlation between solar generation and demand sees long run system costs increase as the amount of solar increases and displaces other types of generation. The lack of solar generation during the evening peak in winter saw extremely high prices during this time with overall volatility increasing significantly as solar penetration increased. Even though solar generation is higher in dry years, this is not enough extra generation to offset the lower hydro availability. The negative impact on the market is stronger for dry years and for large-scale deployment of solar PV.

Furthermore, the large increase in renewable solar PV generation does not have a commensurate impact on the overall amount of renewable generation as the energy is sometimes delivered when it is not needed which results in renewable generation being spilled.

There is not a strong case for policies such as feed-in tariffs to promote large-scale deployment of solar PV in New Zealand. It is likely that other forms of renewable energy such as wind would be more cost effective. Modest amounts of solar penetration see the share of renewables increase by the same as the large-scale deployment with a much smaller increase in prices. Thus, there could be a case for encouraging a modest amount of solar PV as part of the renewable mix. We also argue that there is a case for policies to increase the number of customers on real-time price contracts to encourage demand shifting to periods where solar is more available.

References

Browne, O., Poletti, S., & Young, D. (2015). How does market power affect the impact of large scale wind investment in'energy only'wholesale electricity markets? Energy Policy, 87(C), 17-27.

California ISO. (2013). “The duck curve”. Retrieved from https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

Hirth, L. (2013). “The market value of variable renewables: The effect of solar wind power variability on their relative price”. Energy Economics, 38, 218-236.

Miller, A., S. McNab, S. Lemon, and A.Wood, (2016). “The Economics and Potential Uptake of PV Solar Power by Region and PV System Cost”. http://www.epecentre.ac.nz/research/eea%20conference%20papers%202016/Sharee%20McNab_The%20Uptake%20Potential%20of%20PV%20Based%20on%20Economics.pdf.

Pritchard, G., G. Zakeri, and A. Philpott, A. (2010). “A single-settlement, energy-only electric power market for unpredictable and intermittent participants”. Operations research, 58(4-part-2), 1210-1219.