The Spatial Analysis of Wind Generation on Nodal Prices: Evidence from New Zealand

Le Wen, Energy Centre, University of Auckland, Phone +64 9 923 7594, E-mail: l.wen@auckland.ac.nz
Basil Sharp, Energy Centre, University of Auckland, Phone +64 9 923 5366, E-mail: b.sharp@auckland.ac.nz

Overview

The expansion of wind generation in New Zealand potentially provides an important contribution to achieving the goal of having 90% of electricity generated from renewable resources by 2025. Due to the limited expansion of hydro capacity expected in the future, as much as 20% may need to be generated by wind if this target is to be achieved. Understanding the behaviour of nodal prices is crucially important for valuation and risk management of real assets and financial claims. The non-storability of electricity, the characteristics of demand and supply and the structure of the market and the market power of the generators all contribute to the observed high volatility of electricity prices (Escribano et al., 2011).

Electricity generation in New Zealand is hydro-dominated, with around 60% of electricity generated by hydro. New Zealand lacks significant capacity for water storage to provide reliable hydro generation. The total capacity of hydro lakes in New Zealand is about 3.6 TWh which can only meet about 5 weeks of winter demand (van Campen et al., 2011). This makes the New Zealand electricity system vulnerable to dry periods. South Island controlled storage represents about 85% of New Zealand's controlled storage capacity. The electricity surplus of one island is transferred to the other island by a high-voltage direct current (HVDC) link. During dry periods, HVDC provides the South Island consumers with access to the North Island's thermal generation capacity. During wet periods, the HVDC transfers surplus South Island hydroelectric power northwards to the North Island.

To the best of our knowledge, none of studies have examined the relationship among wind generation, price and price variance in the New Zealand electricity market. In addition, there are not any studies which have applied spatial models into nodal prices studies. Inspired by the first law of geography: "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970), we use a spatial model to examine the effects of wind power on nodal prices. We hypothesize that the nodal price is influenced not only by factors at the grid injection point but also factors at the neighboring nodes. Following the method used by Woo et al. (2011) who studied the four ERCOT Zonal market-price, we also estimate the effect of a 10% increase in wind generation installed capacity on price and price variance. The findings are expected to provide important evidence for requiring security of supply management which stabilizes the balance between wind capacity and conventional capacity, the balance between electricity supply and demand.

The paper is structured as follows. Section 2 describes the NZEM background, data and the statistical evidence. Sections 3 and 4 describe the methodology and the empirical results. Section 5 concludes this paper.

Methods

Spatial Models.

Results

- The evidence indicates that, after controlling for unobserved heterogeneity, negative spatial spillovers for wind power.Using a spatial Durbin (SDM) model we estimate direct effects of a marginal increase of 100 MW in wind generation at node i is associated with a reduction in the price at node i of $4.9 per MWh during the winter months and $20 per MWh during the summer months. The indirect effects of a 100 MW increase in wind generation at a neighbouring is associated with a price drop of $27.3 in summer and $95.7 per MWh in winter. The point estimates of the total effect of a 100 MWh increase in wind generation on nodal prices are a reduction of $86.4/Mwh in spring, $116/MWh in summer, $106.9/MWh in autumn, and $32.2/MWh in winter, and these effects are statistically significant.
- The price effects of a 10% increase in the installed wind generation capacity vary among seasons. It ranges from 2.25% in winter to 11.44% in spring. The larger extent of price reduction is along with the larger variance changes except in spring. In spring, the electricity was imported from the South Island to the North Island via HVDC link. The amount of electricity mostly generated by hydro in the South

Island balanced the shortage of electricity in the North Island. In this situation, the price variation from wind would be reduced by hydro generation.

Conclusions

With an average load factor of around 45% it is highly likely that wind generation will expand in the near future, particularly if demand grows. Adding more intermittent wind generation into the electricity system will create challenges for the system operator and market participants. On the one hand, electricity generated by wind is independent and non-adjustable with respect to electricity demand. Our results show that high levels of variable renewable electricity production can been balanced by adjusting the output from hydro and thermal power plants. Unlike Norway, for example, New Zealand cannot achieve balance by adjusting imports/exports. The entry of load balancing investments into the market will depend on the cost of alternative technologies relative to existing sources of supply. Price volatility in the wind-hydro system and in the wind-thermal-hydro system is of interest. The economic limit of wind penetration is clearly a topic for future research.

References

Escribano, A., Ignacio Peña, J., & Villaplana, P. (2011): "Modelling Electricity Prices: International Evidence," Oxford Bulletin of Economics and Statistics, 73(5), 622-650.

Tobler, W. (1970): "A computer movie simulating urban growth in the Detroit region," Economic Geography, 46: 234–40.

van Campen, B., Poletti, S., Young, D.,& Zakeri,G. (2011): "A Guide to the New Zealand Electricity Market," University of Auckland Energy Centre.

Woo, C. K., Horowitz, I., Moore, J., & Pacheco, A. (2011): "The impact of wind generation on the electricity spot-market price level and variance: The Texas experience," Energy Policy, 39(7), 3939-3944.