Quantifying the impact of wind power generation in day-ahead market: The case of Denmark

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Overview

The share of wind power in electricity generation has been significantly growing in many countries. The European Union's 2020 climate and energy package particularly specifies that one of the three objectives is to raise the share of EU energy consumption produced from renewable resources to 20% by 2020. Promoting wind power in generation technology mix plays an important role in reducing greenhouse gas emission in order to meet EU's energy target. Among European countries, early deregulation and investments have contributed today's considerable share of wind power in Denmark. Plus, Nordic market has been a liberalized system with relatively long history. These attribute Denmark as an ideal case to study the impact of wind generation on wholesale market.

On the one hand, wind electricity generation's nearly zero marginal cost of production is foreseed to draw spot prices downward to competitive level. Therefore generators' market power is mitigated. On the other hand, the intermittency and uncontrollability of wind power may increase price volatilities in spot market, thus influence investors' investment decisions and create speculation opportunities. Using hourly data between 2008-2012, the present paper is to investigate the impacts of intermittent wind power generation on day-ahead wholesale prices and volatilities by applying a GARCH (generalized autoregressive conditional heteroskedastic) model, at both aggregated level and disaggregated level in Denmark. We further analyze the impacts on markups of conventional and wind power generators in order to quantify the impact on firms' market power.

Methods

The data of hourly electricity spot prices are retrieved from Nordpool. Hourly data on wind generation, generation from altenative technologies, electricity consumption, total capacity and daily cross-border exchanges in Eastern and Western Danish zones are obtained from the website of the Danish TSO. Data on weather conditions are collected from the website weatheronline.

First proposed by Bollerslev et al. (1988), multivariate GARCH (MGARCH) models have been applied increasingly in finance and energy literature for price predictions. However very few papers have apply GARCH model to quantify the effect of wind power on spot prices. We combine GARCH with a vector autoregressive (VAR) model for the mean equation in order to put our analyses in a richer dynamic framework. The model is specified with controls for capacity, electricity demand, electricity import or export, and weather conditions in autoregressive terms.

We further test the robustness of the model by running separate regressions for Western and Eastern trading zones as well as by using weekly and monthly variances instead of daily variances.

Results

As preliminary results, all coefficients are highly significant and variance parameters are positive, satisfying the model's restriction. The empirical results show that the intermittent wind power generation reduces electricity prices in spot market and it increases the short-term price volatilities. However wind power generation reduces volatilities when we refer to a larger time horizon, namely weekly or monthly range. The calculated markups for both conventional and renewable generators are lower with intermittent wind power generation.

Conclusions

We study the impact of intermittent wind power generation on electricity prices and volitilities in the day-ahead spot market in Denmark. We conclude that wind power generation could mitigate market power in concentrated electricity wholesale market but meanwhile it gives rise to speculations since it increases price volatilities in the short run. However the long-run price volatilities decrease with wind power generation. We conclude that policy implication of the study is to strengthen investment supports to renewable technologies and the Danish experience can be borrowed by other countries.

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