The effect of wind on electricity CO_2 emissions: the case of Ireland

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1 Abstract

This paper identifies the impact of increasing wind generation on CO_2 emissions for the Irish Single Electricity Market (SEM) between 2008 and 2012. The SEM is a compulsory pool system, where plants bid their short-run marginal costs and are called to generate on the basis of their merit order, subject to reliability provisions.

With more wind generation, thermal plants are displaced and produce fewer CO_2 emissions. Less obviously, in order to maintain reliability of the system, a few thermal plants may be kept on at or close to their minimum stable capacity. When operating at low capacity thermal plants tend to be less efficient and therefore emit more CO_2 per MWh of electricity generated. This may not be fully captured by many studies that use deterministic unit commitment models, since they assume perfect foresight over the optimisation horizon and potentially underestimate the uncertainty faced by system operators when scheduling plants. The fact that thermal plants meet challenges with variable renewable resources is however well known (see Perez-Arriaga and Batlle, 2012 and Troy et al, 2010).

Our paper provides an econometric analysis of the effect of wind based on historical market outcomes.

We create a series of CO_2 emissions for the whole electricity system per hour by estimating emissions per plant per hour and aggregating across all plants. We use published heat rates, carbon content of fuels and electricity generation per plant to determine carbon dioxide emissions per plant in each period.

We then estimate the hourly model with the following autoregressive specification:

$$CO_t = \alpha + \beta L_t + \gamma W_t + \mu PC_{t-24} + \theta mar_t + \sum \kappa^s D_t^s + \epsilon_t \quad (1)$$

where $\epsilon_t = \rho\epsilon_{t-1}$

System CO_2 emissions in hour t depend on: the load L; wind generation W; the previous day's carbon dioxide permit prices PC, the generation margin mar; and finally a set of dummies D to account for days of the week and months.

Our results show that wind displaces 0.36 tonnes of CO_2 emissions per MWh of electricity on average. This is lower than the average emissions for the SEM, which vary between 0.47 and 0.53 tonnes of CO_2 per MWh generated in the same time period, but in line with emissions of an efficient CCGT.

References

Perez-Arriaga, I. and C. Batlle (2012) Impacts of intermittent renewables on electricity generation system operation, *Economics of Energy and Environmental Policy*, vol. 1 (2), 3-17

Troy, N., E. Denny and M. O'Malley (2010) Base-load cycling on a system with significant wind penetration, *IEEE Transactions on Power Systems*, vol. 25 (2), 1088-1097