HOW LARGE SHOULD A PORTFOLIO OF WIND FARMS BE?

Richard Green, Imperial College Business School, +44 207 594 2611, r.green@imperial.ac.uk

Iain Staffell, Imperial College Business School, +44 207 594 2611, i.staffell@imperial.ac.uk

Overview

A portfolio of energy sources is likely to give better results, in terms of the trade-off between cost or profit and its variability, than relying on a single source (Awerbuch, 2000; Roques et al, 2006). Dispersing wind farms over a wide area can also reduce the impact of variations in wind speed and hence the intermittency of output (Sinden, 2007; Roques et al, 2010). Hour-to-hour variations in wind output are critical for system operation, but are unlikely to have a significant impact on profitability when measured over financially relevant timescales, such as a year. However, there can be significant year-to-year variations in wind conditions, which would have an impact on profitability, and these may differ between regions. There is also a systematic tendency for wind farms to receive prices below the time- or demand-weighted average electricity price, because the hours in which they generate are the hours in which their output depresses the price. In this context, a wind farm sited away from the bulk of a country's capacity, which therefore has different operational patterns, may receive a better average price. These are benefits from siting some stations away from the main area of wind generation, but they could be negated if this implies choosing a site with a lower average wind speed.

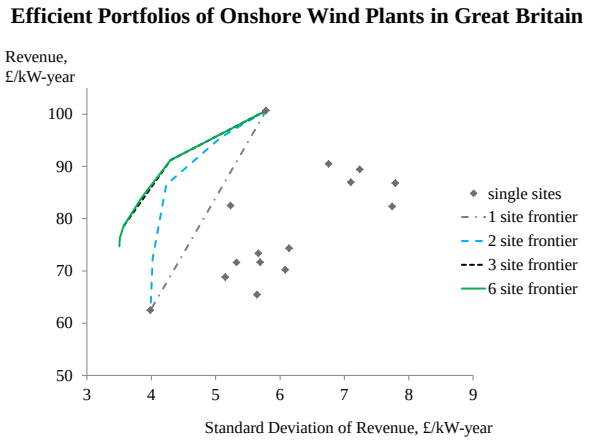
This paper constructs optimal portfolios of wind stations for Great Britain, calibrated to 2020, taking these effects into account.

Methods

We calculate annual figures for output and profits for 19 onshore and 11 offshore wind power stations, using 18 years of data. The procedure is based on Green and Vasilakos (2010), but using an updated data set. Wind speed data from the UK Met Office was converted into electricity output using commercial turbine power curves. Contemporaneous electricity demand data from National Grid was scaled to plausible 2020 levels. A supply function model of thermal generation was used to find equilibrium market prices for each hour. From these hourly prices and outputs, annual revenues for each station could be calculated. The mean and standard deviation of these annual figures was taken for each station. They were then combined in all possible portfolios so that portfolio mean revenues (per kW of capacity) and their standard deviation could be computed. The efficient frontiers were then derived, aiming for high revenues with a low standard deviation, depending upon the weighting placed on each.

Results

The simulated stations displayed a range of annual revenues and standard deviations, as expected. A portfolio of just three onshore stations allowed the owner to obtain a better combination of revenue and risk than owning a single plant; the additional benefits from larger portfolios were minimal. Many portfolios had a worse relationship between risk and revenue than a portfolio made up of a weighted average of the two best-performing (revenue maximising and risk-minimising) stations.



Conclusions

This research shows that there are portfolio benefits from owning more than one wind station, but that most of these can be gained from a relatively small portfolio. This implies that medium-size companies would not be at a disadvantage to the large incumbents, at least with respect to this aspect of their performance. The paper also shows that the variability in revenue coming from annual differences in wind patterns is relatively small – the coefficient of variation is less than 0.1. The strongest implication may be that developers should seek out the

sites with the best average wind conditions, even if they are all close together. Unfortunately, this may increase the hour-to-hour variability of wind output that the system operator has to cope with.

References

Awerbuch, S. (2000) "Getting It Right: The real cost impacts of a renewables portfolio standard" *Public Utilities Fortnightly* Feb 15: 44-52

Green, R.J. and N. Vasilakos (2010) "Market Behaviour with Large Amounts of Intermittent Generation" *Energy Policy*, vol. 38, no. 7, pp. 3211-3220

Roques, F.A., W. J. Nuttall, D.M. Newbery, R. de Neufville and S. Connors (2006) "Nuclear Power: a Hedge against Uncertain Gas and Carbon Prices?" *The Energy Journal* vol. 27 no. 4, pp 1-23

Roques, F., C. Hiroux, and M. Saguan (2010) "Optimal wind power deployment in Europe--A portfolio approach," Energy Policy, vol. 38, no. 7, pp. 3245-325

Sinden, G. (2007) "Characteristics of the UK wind resource: Long-term patterns and relationship to electricity demand", *Energy Policy*, vol. 35, no. 1, p.112-127