Technology Strategy Board
Driving Innovation

Knowledge Transfer Network
Industrial Mathematics

# Where the wind blows

**ANTI-CORRELATION OF WIND FLEET OUTPUT FOR TRANSMISSION PLANNING**
**National Grid / UCL**

## The need

In the next decade, the UK will come to depend more and more on wind power to generate electricity. This represents a step change in the way the power system is run, particularly because of the random and unpredictable nature of the supply of electricity from wind energy. This project focussed on the impacts of the change for the UK power transmission network.

In order to make decisions about future investment in transmission assets, National Grid needs to understand the likely variations in wind speed in the UK, both as a function of time (time of year and time of day) and as a function of geographic zone.

## The outcomes

The aim of the project was to identify the distribution of contribution of wind power to the flow of electricity from one part of Great Britain to the remainder of Great Britain, i.e. across a transmission boundary, for example from Scotland to England. The 90% or the 95% point of this distribution determines the quantity of transmission boundary capability, that National Grid must build, to comply with the security requirements of its Transmission Licence.

To produce an output which was of use to decision makers at National Grid, numerous individual characteristics of historical wind data were studied. This led to several qualitative and some quantitative features of wind patterns of particular importance to transmission.

The second part of the project involved devising a methodology which could model wind generation and which would be robust to changes in the location of connected wind farms. This in turn will become an input to the models that are used routinely in estimating transmission requirements, which were previously designed for a generation system in which wind energy played only a negligible part.

*"The project has applied some respectable statistics to the correlations of wind farm outputs, on top of the amateur methods previously attempted. We now better understand the anti-correlation of wind farms outputs."*

**Paul Plumptre**
**National Grid**

# Technical summary

Several strategies were used to try to model the power output of wind farms, in concert with attempts to understand and to describe the dataset in a way that would illuminate its essential structure.

The difficulties were mainly in finding a straightforward way to represent the dependencies between wind speeds in different areas of the UK. One strategy, that of conditional distributions, proved reliable but its complexity became overwhelming for more than a few zones. Other usual statistical methods, such as linear regression, were hampered by the nature of the data; distributions of wind power outputs are bimodal and therefore far from Normal.

Finally a multivariate Weibull model was developed to represent outputs across geographic zones. In mathematical terms this used a 'Weibull copula', analogous to the well known 'Normal copula'. In practical terms, this approach was intuitively appealing because it mapped power outputs onto a distribution known to approximate accurately the variations in average wind speed. Thus although the Weibull distributions in the model may not have corresponded directly to actual measured wind speed, they were sufficiently close for their correlations to behave in a regular way.

Modelling of wind outputs then took place firstly for a subset of the geographic zones in the original data as a trial set, secondly for the complete set of 27 zones across the UK, and thirdly for a modified set of 14 zones which were chosen to reflect projected wind farm installations as well as areas of particular importance for the transmission network.


*"This was an exciting opportunity to make the connections between probability theory and the practice of statistics in business decision-making."*

**Jack Grahl**
**University College London**

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EPSRC
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# Project Details

**Partners**
National Grid plc
UCL

**Project investment**
£9,000

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