Predicting power output for off-shore wind farms: can a simple machine learning algorithm out-perform numerical weather prediction over short time horizons?

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Scientific background

The power output from wind farms is inherently random since the input energy source, the wind, is itself a highly fluctuating quantity. This poses a challenge to both energy suppliers and generators in the assessing the correct price to attach to future energy contracts coming from wind sources in the energy markets. In the UK, electricity is traded on a wholesale market, with generators and suppliers entering into contracts with each other for every half hour of every day; sometimes years in advance. For each half hour - known as a settlement period - they can continue to trade up to 1 hour beforehand. Numerical weather prediction (NWP) codes play an essential role in predicting the availability of wind power. NWP provides predictive skill for time horizons of hours out to several days. It has been suggested that in the future, the UK might move to a 5 minute ('real time') electricity market model. Over such short times, it may be that 'nowcasting' (ie looking at the current state of the weather at a location of interest) may provide better predictive power than computationally expensive NWP codes. The goal of this project is to assess whether simple machine learning algorithms driven by real-time data from a UK off-shore wind farm can out-perform the predictions made by an NWP code tasked with making the same predictions.

Research challenge

You will be provided with a timeseries of the 10 minute averaged wind speed and power output from a UK off-shore wind farm along with outputs of several NWP codes with varying time horizons. See Figs. 1 and 2. The relationship between the fluctuations of the wind speed and fluctuations of the power is itself an interesting question.

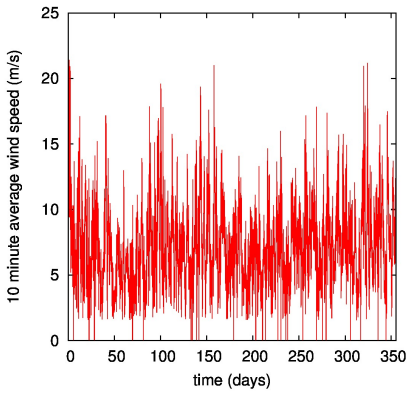

Figure 1: Time series of the 10 minute averaged wind speed from a UK offshore wind farm.

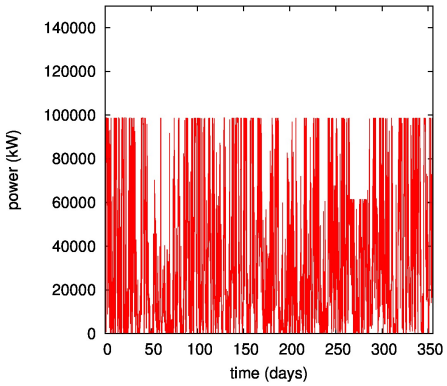

Figure 2: Time series of the 10 minute averaged power from a UK offshore wind farm.

The idea of the project is to use the wind speed data as input to train some simple and inexpensive machine learning algorithms (for example low order ARIMA models or neural networks) which try to predict the wind speed and/or the output power out to some time horizon in the future. The predictive skill score of these algorithms will be calculated for different time horizons and compared with the corresponding skill scores for NWP.

An interesting complementary avenue of exploration for a more theoretically minded student would be to characterise the extreme value statistics of fluctuations in the wind speed and output power since it is large fluctuations which are of particular interest to generators and suppliers due to their disruptive effects.

Pre-requisites

You should be interested in data analysis since this is a heavily data-driven project. You should also be reasonably proficient at coding

Additional considerations

This project is being offered as a MathSys or Erasmus Mundus M1 MSc project. It is currently not clear that there will be a follow-on PhD project available.