MSc Business Analytics Dissertation

Power Curve Modelling for Wind Farm Performance Management

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Introduction

- Wind turbine power curves show the relationship between wind speed and turbine power output
- Power curves are critical for wind farm performance management.
- There is an opportunity to use turbine operational data, in addition to wind speed, to model turbine power curve behaviour.

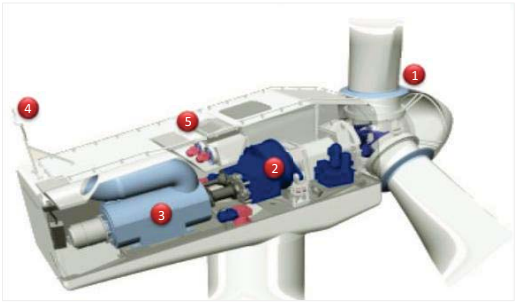

Fig. 1 Wind Turbine Operational Data

- >2 years of 10 minute operational data from a wind farm with 21 turbines. Measurements from turbine components:
  1. Rotor
  2. Gearbox
  3. Generator
  4. Environmental measurements
  5. Nacelle (turbine housing) measurements

Methodology

- Exploratory analysis on all turbines in 2012 showed that the actual power curves deviated from the reference power curves provided by the manufacturer.
- 9 representative turbines selected for detailed modelling.

Modelling Detail:

Approaches to modelling the power curves using operational data:

1. Multiple Linear Regression
2. Generalised Linear Modelling (GLM)
3. Multiple Linear Regression with Kalman Filtering
4. Simple linear model (observed power vs. reference power curve)
5. Simple rolling bias correction.

- Models assessed using Root Mean Squared Error and other metrics.

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(P_e(i) - P_a(i))^2}$$

Results

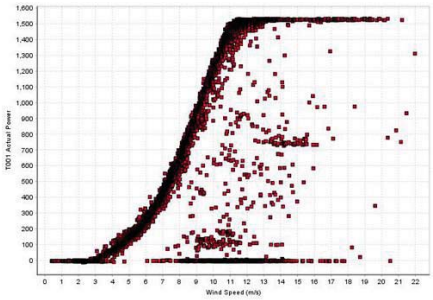

Fig. 2 Actual power curve with wide dispersion

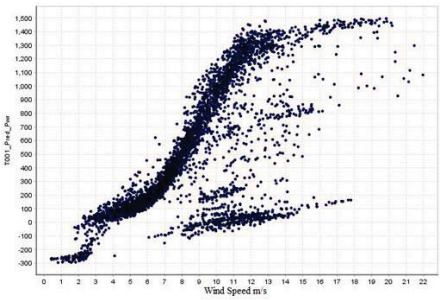

Fig. 3 Regression predicted power cure with wide dispersion

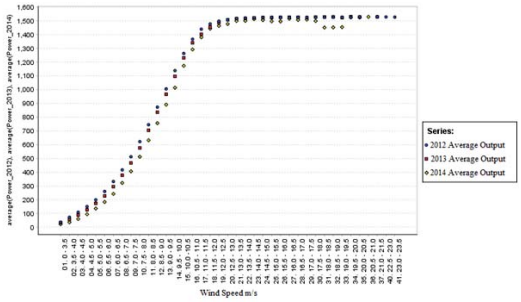

Fig. 4 Observed changes in power curve over time

- Multiple Linear Regression and GLM perform well – particularly with power curves of wide dispersion
- Kalman filters work well for some turbines but not for others
- Simple Linear Model and simple rolling bias correction do not perform significantly better than reference power curve.
- Operational model predicts many of the data points outside the reference curve.
- Testing of model highlighted changes in the observed power curves in the wind farm over a two year period.

Conclusions

- Linear regression using both environmental and operational data resulted in a lower RMSE than the reference curve in the test period.
- The model performed well when tested on power curves with wide dispersion but less well when tested on monthly power curves with less wide dispersion.
- As this work was completed on one wind farm, further research could investigate operational data models on other wind farms with other turbine types and exploring other modelling techniques.
- Potential business applications for the model include power curve monitoring (to identify potential changes in power curve over time) and turbine fault identification.

Acknowledgement

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