Long Term Forecasting of Wind Speed Using Historical Patterns

Centre for Renewable Energy Systems Technology

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Motivation & Objectives

- Problem definition
- Approach discussion
- Presentation of results from the data analysis
- Future plans
- Conclusions

Overview of Electricity Trading

Single Trade

- Trade Date
- Delivery Date
- Delivery Period
- Volume

Long-term forecasting contribution

- Indication of the remaining exposure over a particular period
- $\hat{I} = \hat{D} - (\hat{G} + FC)$

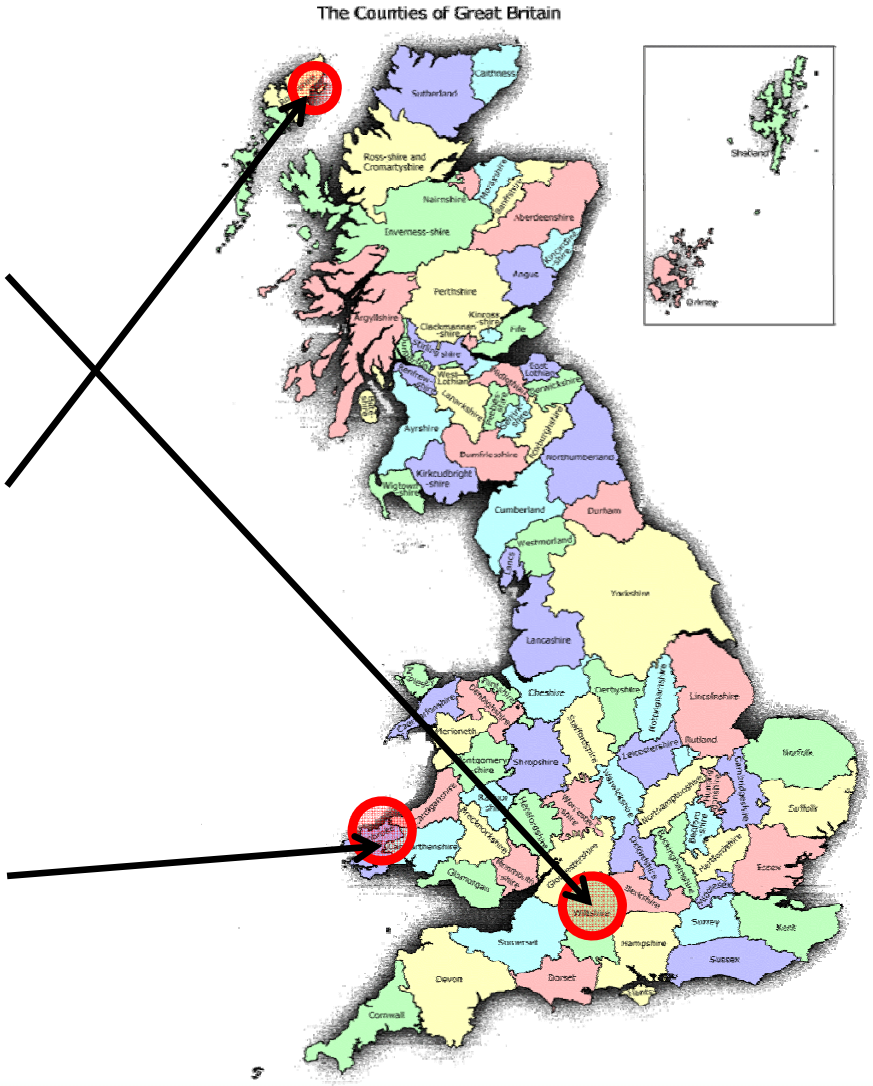
  $\hat{I}$ the forecasted Imbalance, $\hat{D}$ the forecasted Demand, $\hat{G}$ the forecasted Generation and FC the Firm's Forward Contracts
- Purchase of base load in advance

Data Collection

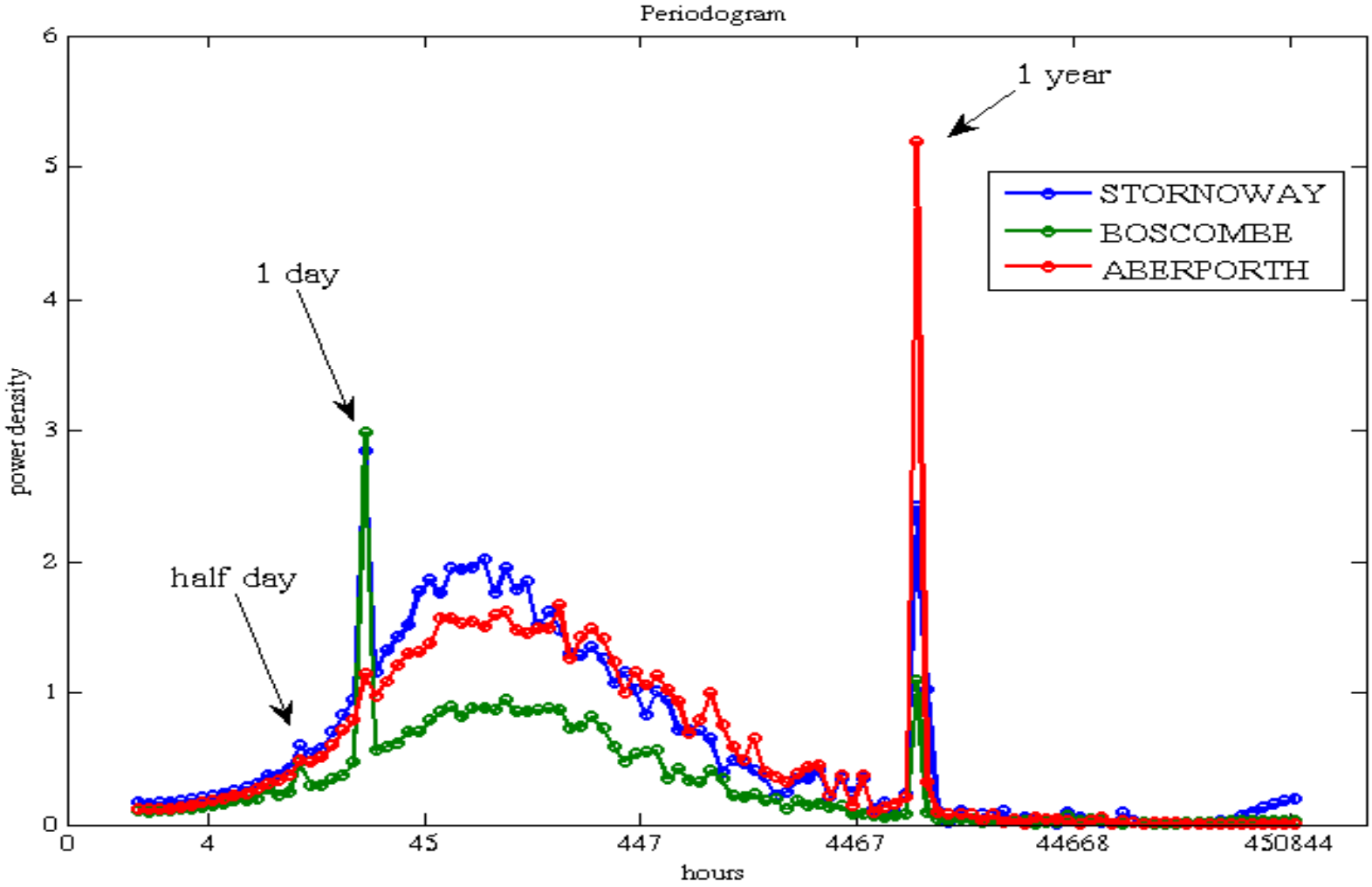
- **M**et Office **I**ntegrated **D**ata **A**rchive **S**ystem (MIDAS)
  - Time length goes back to late ’40s
  - 50044 different stations across the UK (climate, synoptic, etc.)
  - UK daily mean wind data (speed, direction & max gust speed)
  - UK daily temperature data
  - UK hourly & daily weather observation data
- Station Selection
  - Refinement & search for lack of consistency
  - Reveal of any pattern within the time series

Sites Used in the Study

Country	Records	Location
England	*395552*	*Birmingham Airport*
England	***448363***	***Boscombe down - Wiltshire***
England	*463312*	*Manchester Airport*
Scotland	*448363*	*Lerwick - Shetland*
Scotland	***448684***	***Stornoway Airport***
Scotland	*373003*	*Edinburgh Airport*
Scotland	*342267*	*West Freugh – Wigtownshire*
Scotland	*450277*	*Argyll & Bute*
Wales	*451319*	*Gwynedd – Isle of Anglessey*
Wales	***450844***	***Aberporth - Dyfed***
N. Ireland	*521888*	*Belfast Int. Airport*

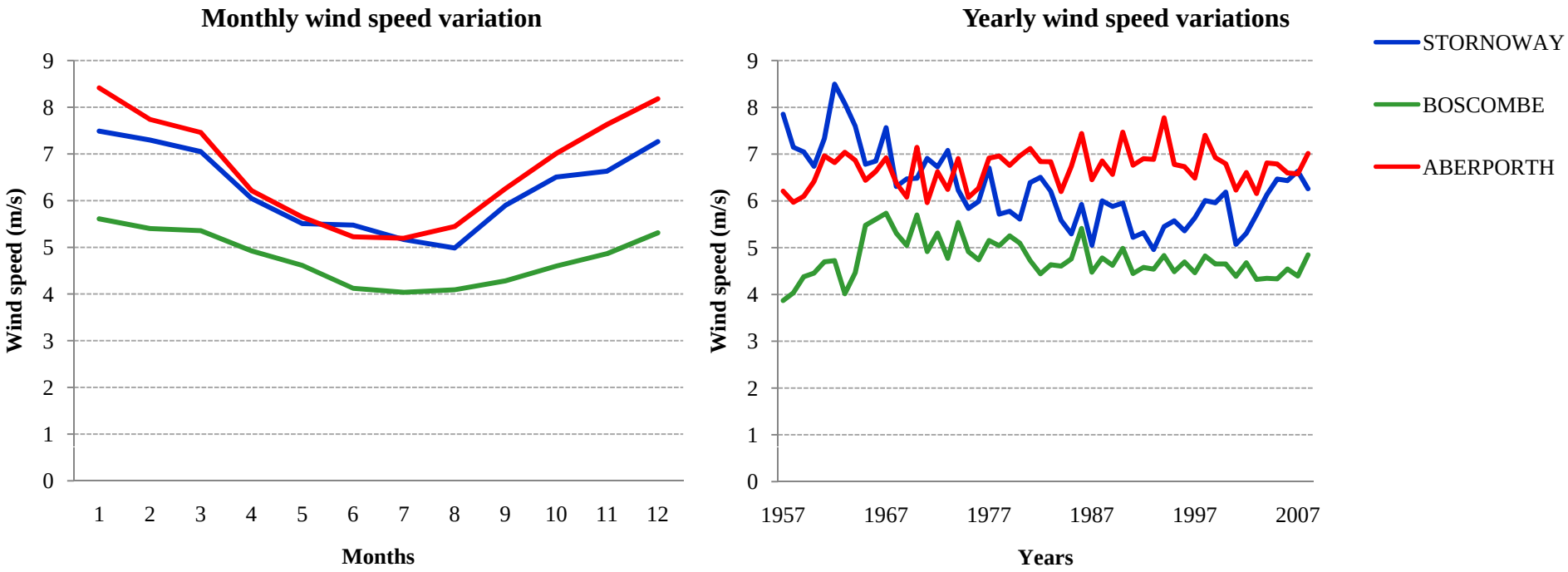


Power Density



Data Analysis

Profile of Wind Speed by Station



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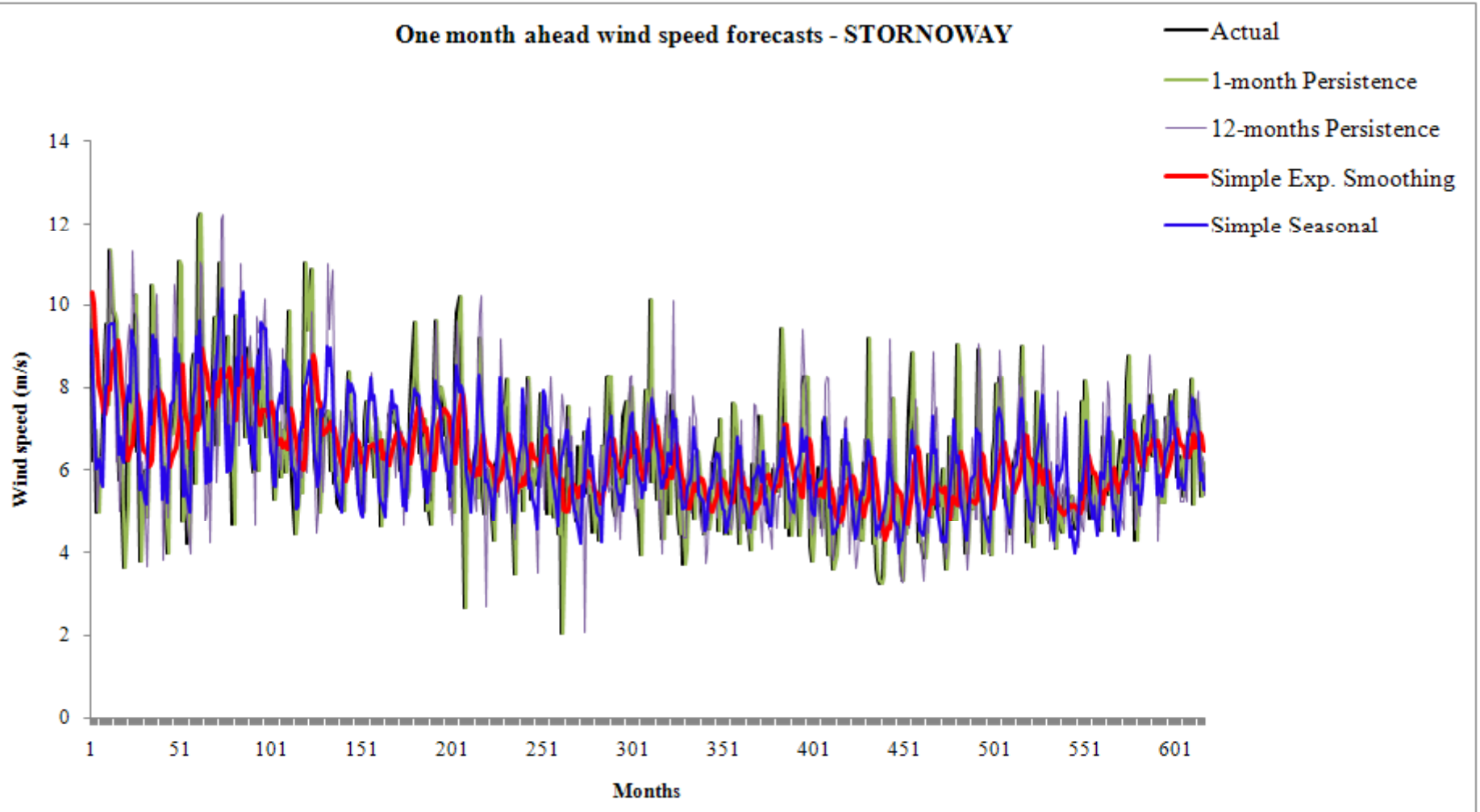
One Month Ahead Wind Speed Forecasting



Forecasting Error

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{e_t}{Y_t}\times 100\right| = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{Y_t - \hat{Y}_t}{Y_t}\times 100\right|$$

Station	**1- month Persistence**	**12 - months Persistence**	**Simple Exp. Smoothing**	**Simple Seasonal**
	$\hat{Y}_t = Y_{t-1}$	$\hat{Y}_t = Y_{t-(t+p)}$ where p = 12	ARIMA (0,1,1)	ARIMA$(0,1,(1,s,s+1))(0,1,0)$ wheres the currentseasonalpoint
Stornoway Airport	*18.1 %*	*17.9 %*	*21.3 %*	*14.9 %*
Boscombe down - Wiltshire	*16.8 %*	*16.5 %*	*18.7 %*	*15.3 %*
Aberporth - Dyfed	*19.4 %*	*17.6 %*	*24 %*	*14.1 %*

Conclusions

- Time series analysis showed
  - Existence of seasonal pattern
  - Seasonal models outperform over simple ones
- Academic & Industrial Strands
  - Optimizing purchase of base load
  - Optimizing Power Systems scheduling
  - Long-term wind speed forecasts as an add-on module in the short-term models

Future Work

- Investigation of existence of any correlation between different atmospheric variables with respect to wind speed seasonal variations
- Evaluating existing forecasting techniques on MIDAS database
- Analogue forecasting
- Using real-life data from one of the UK's energy suppliers for validating the long-term wind speed forecasting
- Propose optimum model

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Thank you for your attention!