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Wind power in New Zealand

Renewable energy resource dynamics in a hydro-based power system

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Introduction

New Zealand supplies approximately 70% of its electricity demand with hydro power, with wind power covering roughly 5%. We study the spatial and temporal distribution of the wind and hydro resources, together with electricity demand and prices, with the objective to gain insights on the trade-offs of building wind power in different parts of the country.

It is particularly important to understand the impacts of a high penetration level of wind power on an electricity market that is already highly influenced by seasonal hydro power availability. Whether the seasonal patterns of wind, hydro and demand are correlated or not, and to what extent, gives relevant new information to energy systems planners as well as to investors.

This poster presents our research on correlation analysis between temporal and spatial energy resource availability (wind and hydro), and electricity prices.

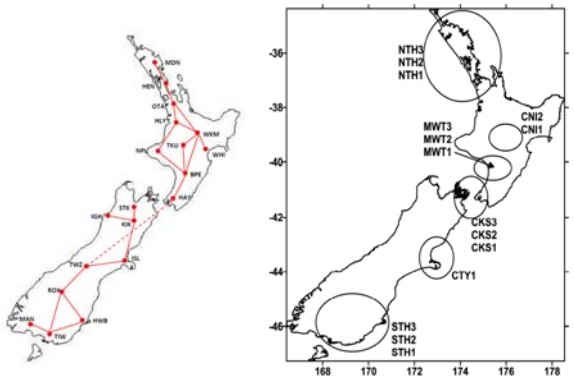

Figure 1: Schematic figure of the New Zealand power grid with main nodes (left) [1] and regions with current and potential future wind energy developments, representing the regions of wind speed data used in this study (right) [2].

Data

Wind speed data: a five-year data set of 15-min interval synthetic data constructed specifically for 15 current or potential wind power development sites (figure 1 – right) by the New Zealand Institute for Water and Atmospheric Research (NIWA) is used [2].

Electricity generation, demand and prices, and hydro storage levels: the Centralised Dataset (CDS), containing half-hourly data from several years published by the New Zealand Electricity Authority is used [3]. This data has been aggregated to 18 nodes across the country (figure 1 – left).

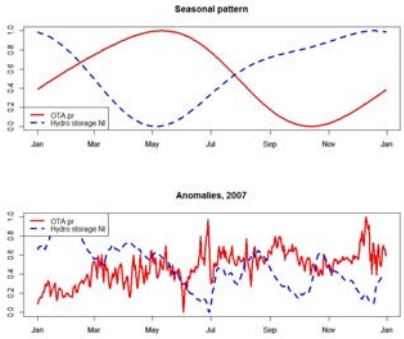

Figure 2: Seasonal fourier fit (above) and anomalies in 2007 (below) of **electricity prices at OTA node** and the **hydro storage level of the North Island**.

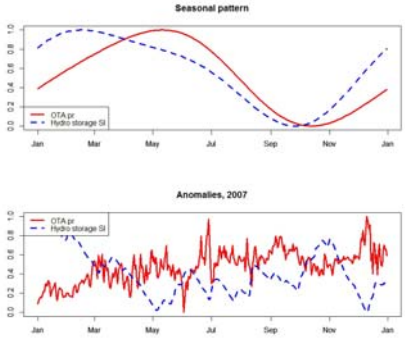

Figure 3: Seasonal fourier fit (above) and anomalies in 2007 (below) of **electricity prices at OTA node** and the **hydro storage level of the South Island**.

Methodology

Phase 1: Moving average approach
A moving average approximation was used to study correlation between variables at different temporal scales ranging from hourly to seasonal (3 months).

Phase 2: Fourier fit approach
The significance of the seasonal component in correlation results was further studied by separating the annual seasonal pattern and the deviations from that pattern; the anomalies. This was done by fitting a second order Fourier function to the time-series data to estimate the seasonal pattern. Correlation was studied between both the seasonal patterns and the anomalies.

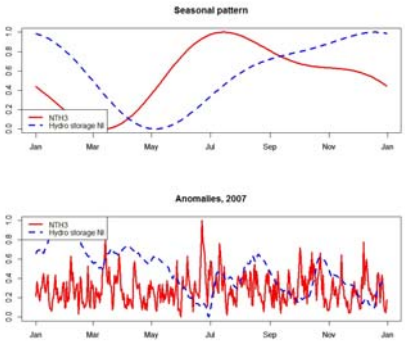

Figure 4: Seasonal fourier fit (above) and anomalies in 2007 (below) of **wind speed measurements at NTH3** and the **hydro storage level of the North Island**.

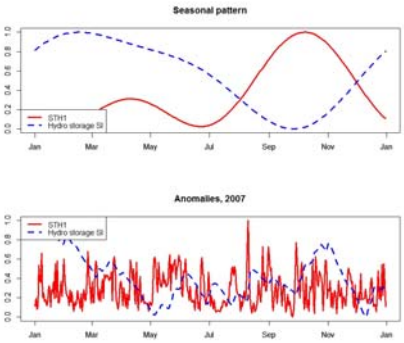

Figure 5: Seasonal fourier fit (above) and anomalies in 2007 (below) of **wind speed measurements at STH1** and the **hydro storage level of the South Island**.

Results

Figures 2-5 show example cases from the Fourier fitting, giving both the seasonal curves and the anomalies of two variables.

Results indicate clear seasonal patterns for the renewable energy resources as well as price and demand. However, the correlation study shows that it may be the anomalies, i.e. the deviation from the expected seasonal value, that have a more significant correlation with electricity prices than the seasonal pattern itself.

Discussion & future research

From the electricity system planners perspective it is important to understand both the seasonal and stochastic behaviour of the relevant renewable energy resources, as well as its impact on electricity prices. Investors, on the other hand, may find this information relevant in order to maximise their profits, when deciding on a suitable location for wind power development.

The research is continued with detailed analysis or the results for all nodes and wind sites, studying the case of dry years in particular, and including correlation with demand patterns.

References

[1] D. Young, S. Poletti, O. Browne, *Can Agent-Based Models Forecast Spot Prices in Electricity Markets? Evidence from the New Zealand Electricity Market*, 2013.
[2] NIWA www.niwa.co.nz/environmental-information/research-projects/synthetic-wind-data
[3] CDS – Electricity Authority www.ea.govt.nz/industry/monitoring/cds/

Acknowledgements

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