Meeting Date: 26 October 2022

WIND GENERATION FORECASTING AND MONITORING

SECURITY AND RELIABILITY COUNCIL

This paper introduces a presentation from the Authority's monitoring team on wind monitoring. Adequate monitoring is increasingly important to security and reliability due to the sector's significant investment in wind generation and its intermittency and unpredictability.

Note: This paper has been prepared for the purpose of the Security and Reliability Council (SRC). Content should not be interpreted as representing the views or policy of the Electricity Authority.

Wind forecasting and monitoring

1.1.1 The secretariat, on the SRC's behalf, has accepted an invitation from the Authority's monitoring team of a presentation on current wind generation scenarios and forecasting work.

1.1.2 New Zealand has significant capacity for generating electricity from wind. The country's unique shape and location translates to a near continuous westerly flow, as the 'roaring forties' cross the Pacific Ocean without other landmasses nearby to disrupt their flow.

1.1.3 When combined with topographical features such as Cook Strait, and the Manawatu Gorge, these features create significant potential generation opportunities for wind to provide renewable generation to support our hydro-dominant power system.

1.1.4 In power system terms this abundance means wind in the New Zealand context has a high "capacity factor". Capacity factor is the ratio of actual electrical energy output over a given period of time to the theoretical maximum electrical energy output over that period.

1.1.5 However, capacity factor is only part of the equation. While New Zealand's average capacity factor is high, there are periods of high pressure where the wind may drop, sometimes for long periods. This can have an increasing impact on the stability of the system, as the amount of wind generation increases in the generation mix. The New Zealand Wind Energy Association predicts that wind could reach 20 percent of New Zealand's annual generation by 2035.

1.1.6 The presentation (**Appendix A**) provides information about the basis for the research and the methods used to obtain the data, including seasonal and locational variations and initial conclusions from work to date.

1.1.7 The analysis will support an Authority-initiated review of current intermittent generation offer provisions, with consultation proposed for later this financial year. The analysis will also serve to gauge the precision of deriving wind generation information based on wind and weather data we currently have available.

1.1.8 Representatives from the Authority will attend and present and be available for questions.

Questions for the SRC to consider

The SRC is asked to consider the following general questions.

Q1.	**What feedback does the SRC have for the monitoring team that could usefully be included in future work in this area?**
Q2.	**What comment does the SRC have about the project's methodology and findings to date?**
Q3.	**What further information, if any, does the SRC wish to have provided to it by the Authority via the secretariat?**
Q4.	**What advice, if any, does the SRC wish to provide to the Authority?**

Appendix A: Wind presentation from the Electricity Authority's monitoring team

Wind Power

Firm Generation & Forecast

26 October 2022

Firm Generation

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Research Question & Goals

How much firm generation can wind energy provide to New Zealand?

Goals:

- Model the wind behaviour at the turbine hub height
- Model the performance of wind turbines across the country
- Find the minimum expected performance of the set of modelled turbines at any given hour

Methods

Wind Speed Data

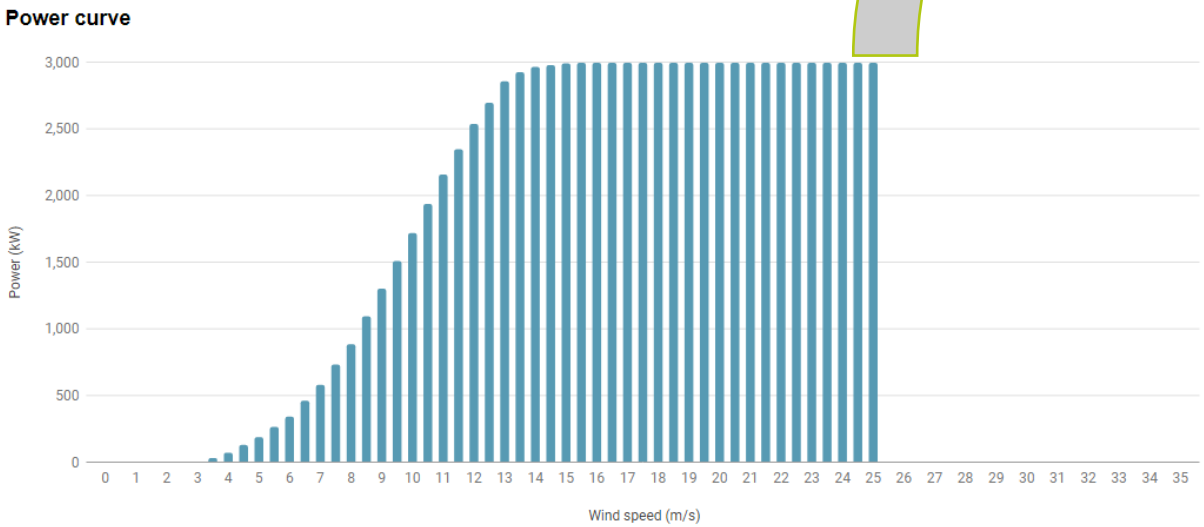
- 7 years of data: 2015-2021 – recorded hourly
- Data from 89 weather stations
- Variations in air density and pressure included in the modelling
- Wind speed data adjusted to match the turbine hub height

$$v_{90} = v_0[m/s]\frac{ln(h_2[m]/z_0[m])}{ln(h_1[m]/z_0[m])}$$

Wind Power Modelling

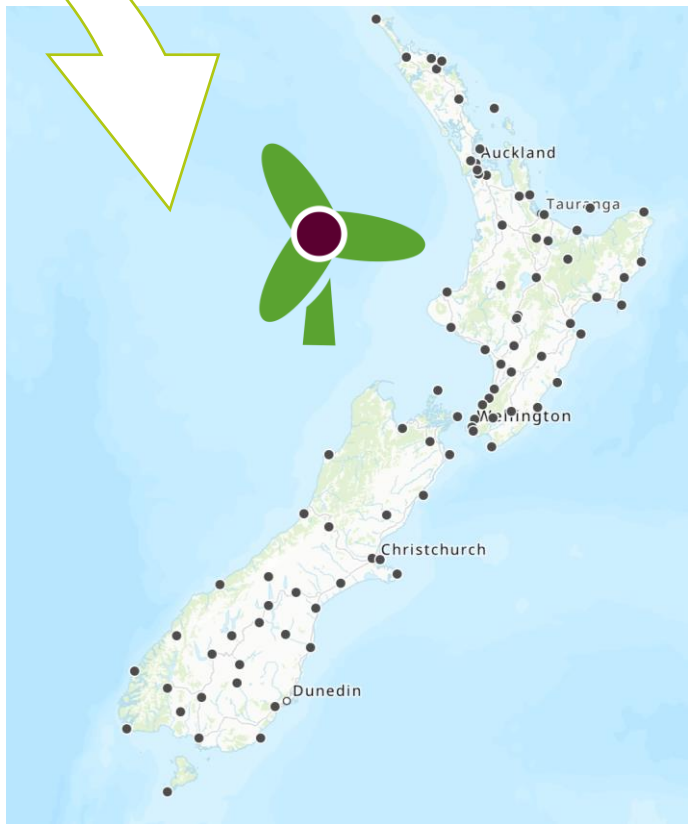
- 89 locations = 89 modelled wind turbines (Vestas V112/3000)
- Power modelled using the turbine power curve

In Short



Vestas V112 Power Curve

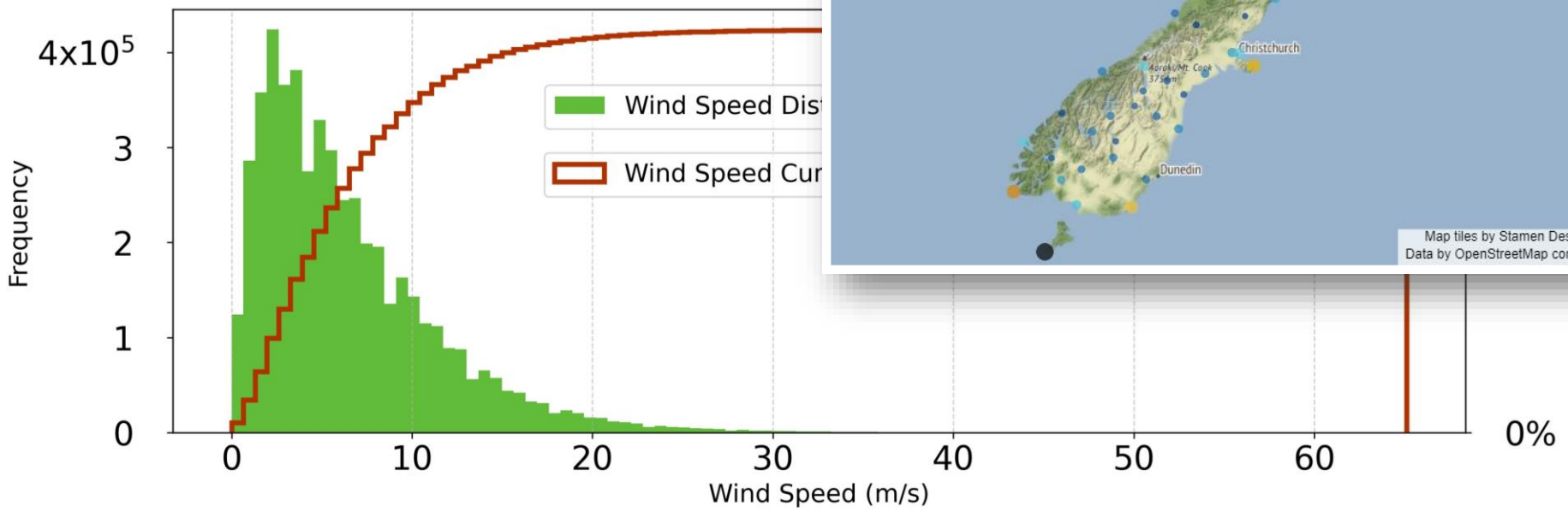
Source: [The Wind Power Wind Energy Market Intelligence]

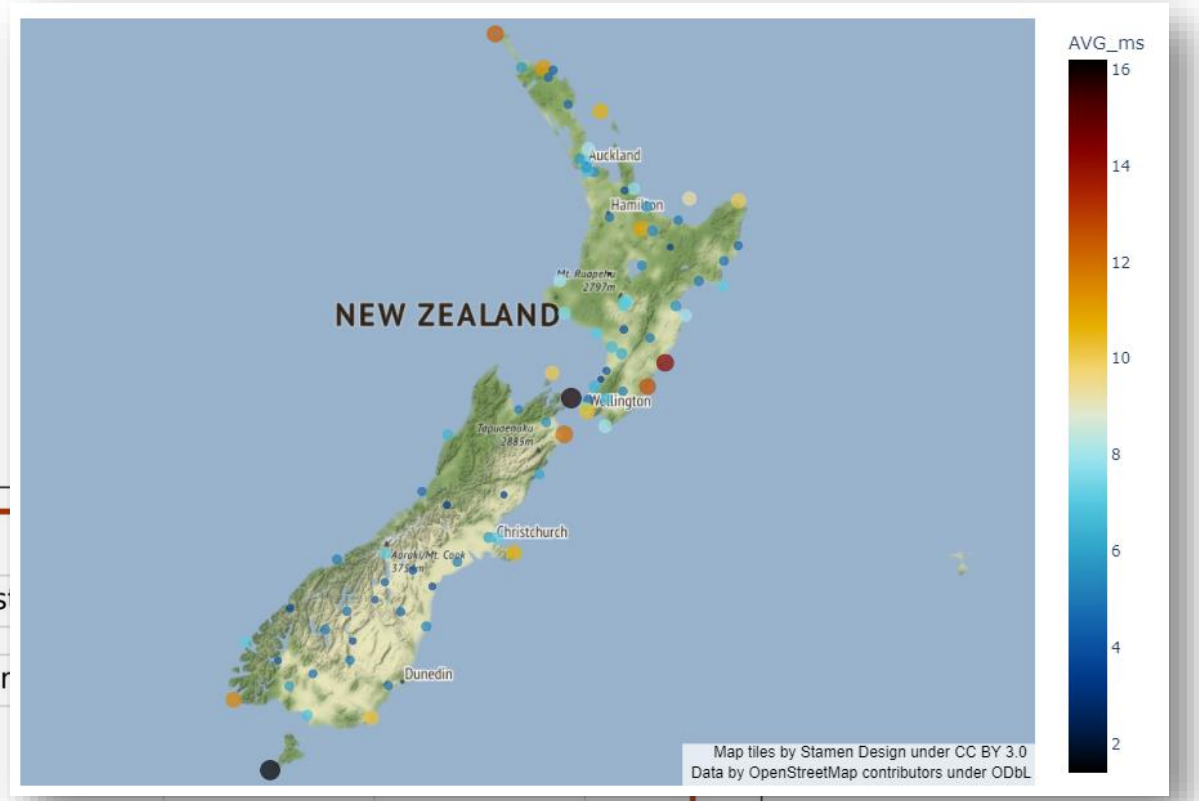


Wind Speed at a Glance

- Results represent the whole country
- Considerable variation between locations

89 stations
2015-2021





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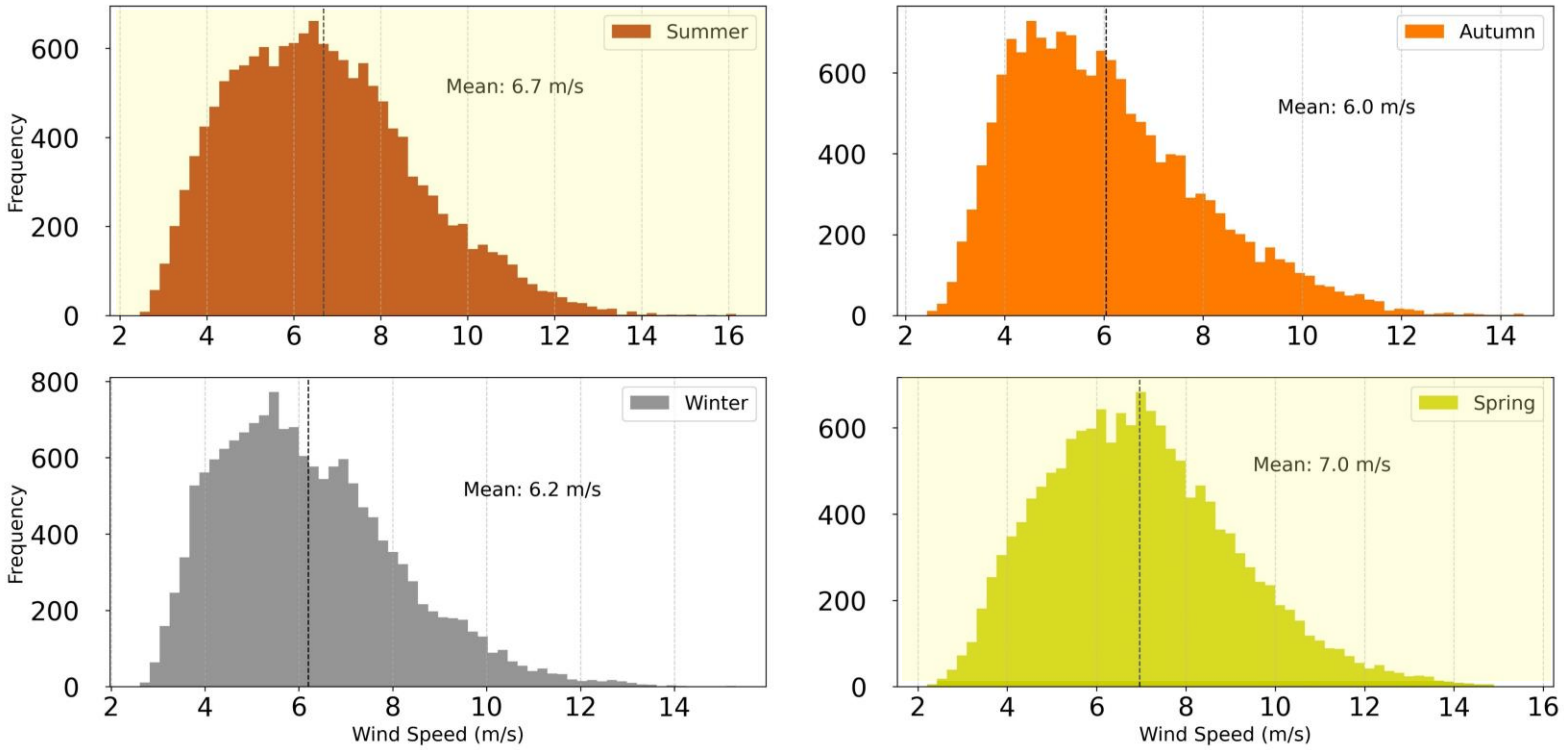
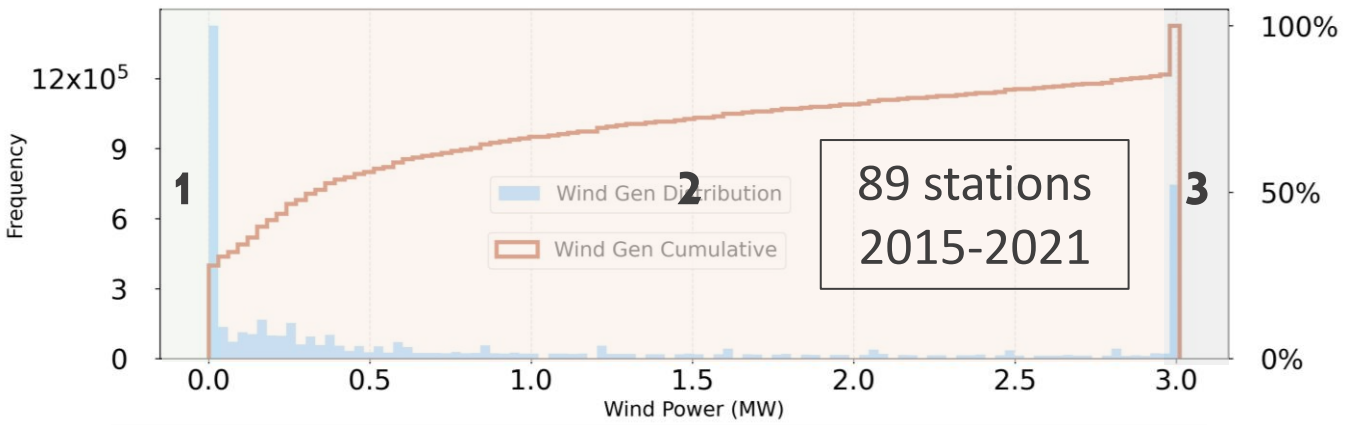
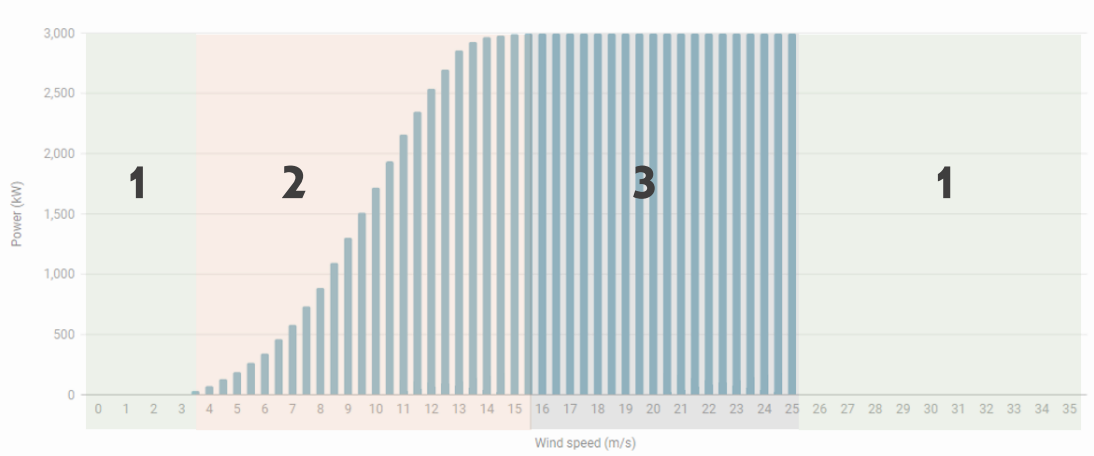
Wind Speed Distribution Flows with Seasons

- Higher wind speeds during Spring and Summer months
- Winter and Autumn: lower wind speed values



Modelled Wind Energy Generation – Whole Country





Year	Annual Wind Gen (MWh)	Average Capacity Factor
2015	684,875.47	32.79%
2016	666,306.95	32.22%
2017	646,799.21	30.86%
2018	686,132.01	30.64%
2019	756,901.87	33.00%
2020	720,140.19	31.85%
2021	681,311.35	30.64%

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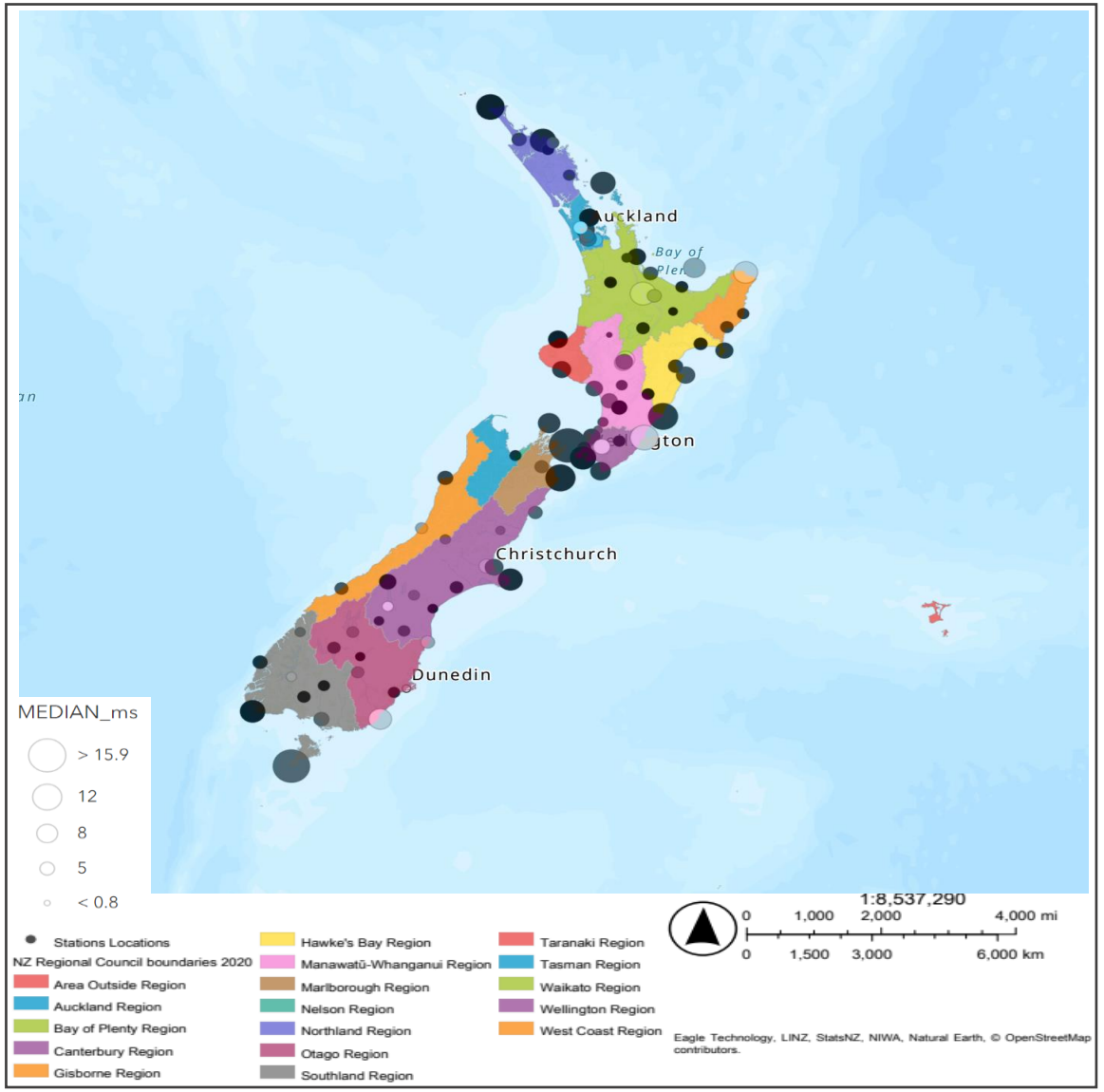
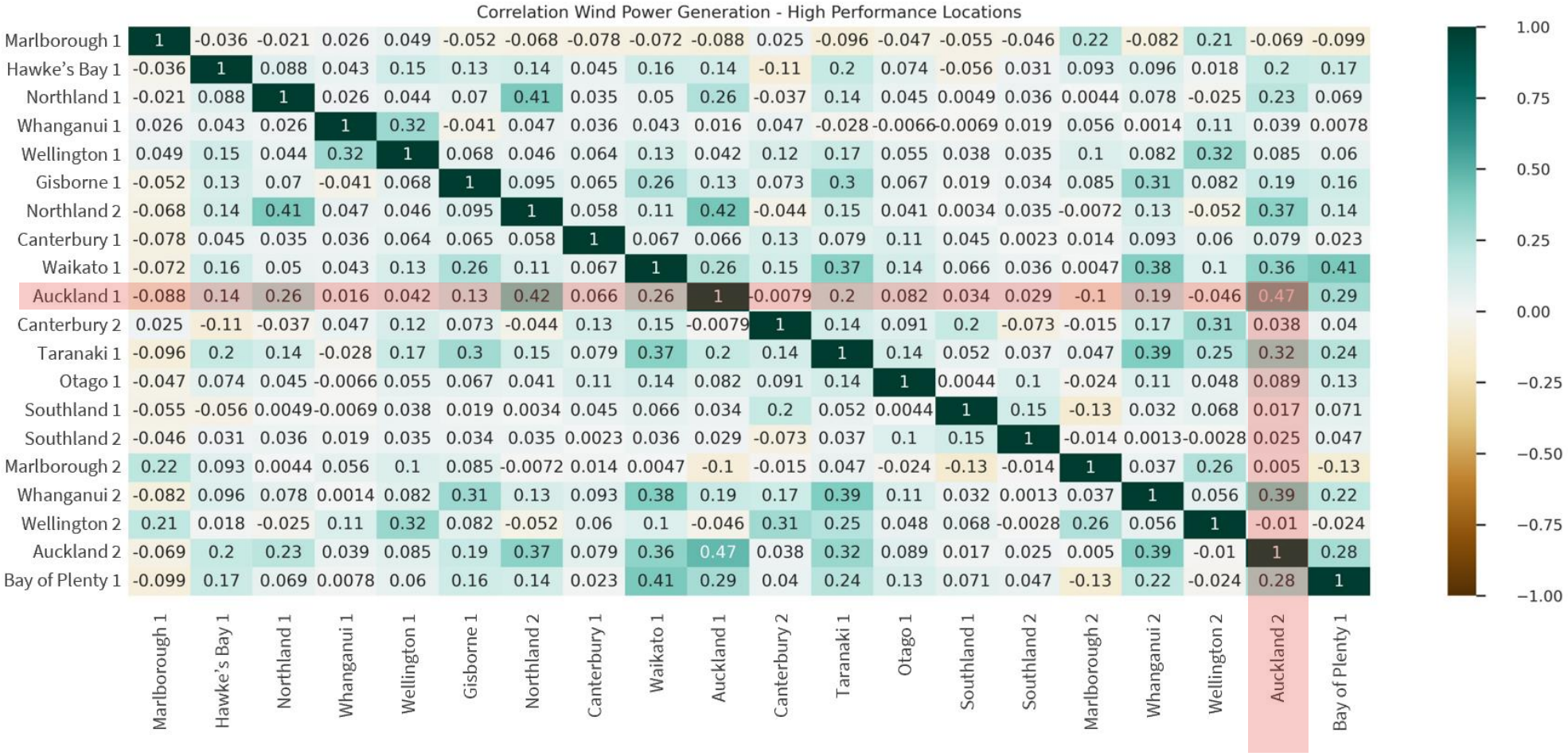
Divide and Conquer

- The data set is large – hard to visualize the results
- The solution: divide the country according to its regional councils
  - 17 regions
  - Most regions have more than 3 locations (weather stations)

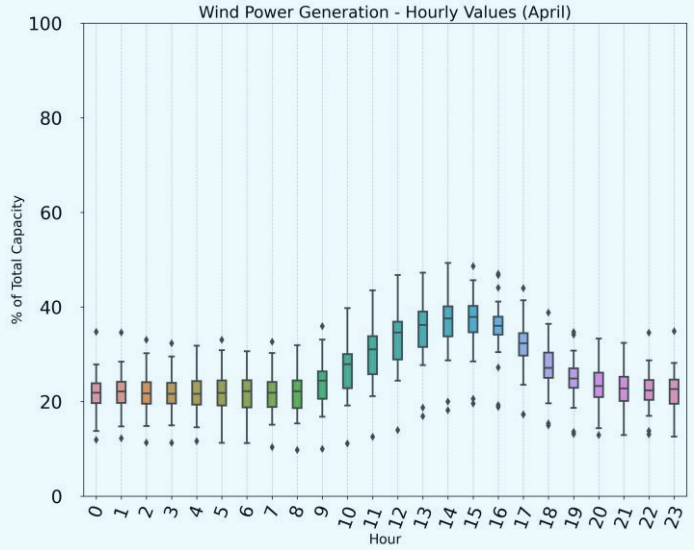


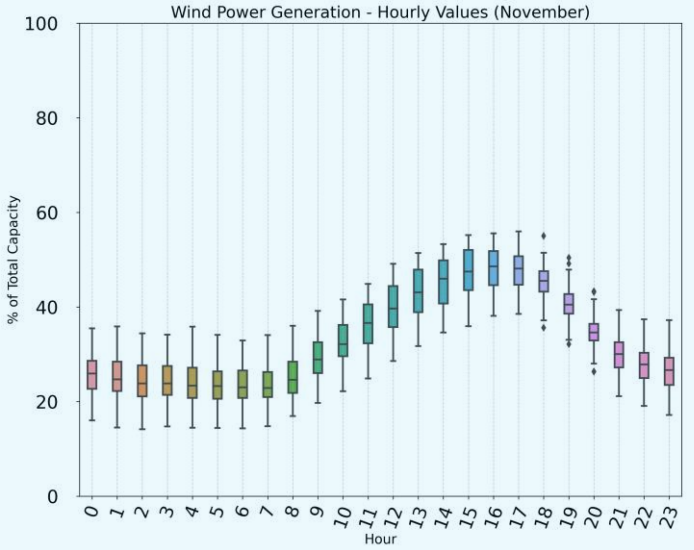
Intra and Inter-Region Behaviour



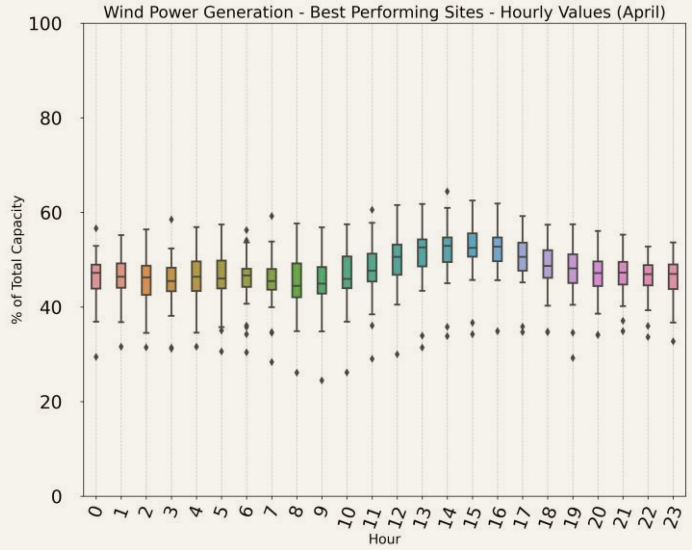
A Look at Hourly Values

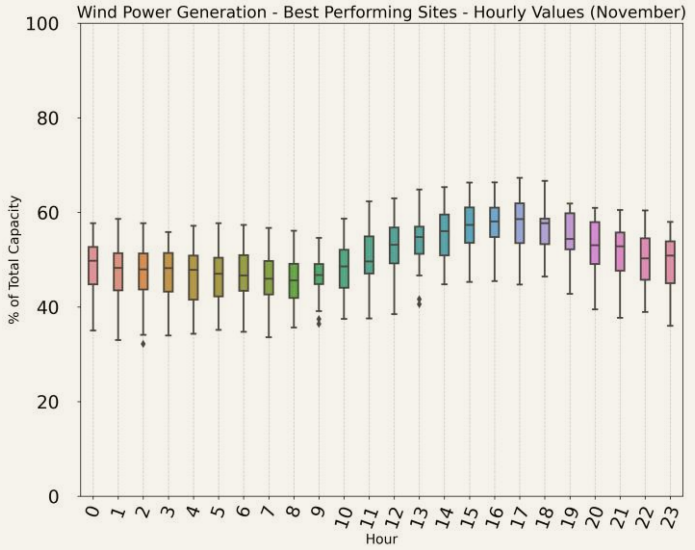
Entire Set





High Performance





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Comparative Performance

Whole Country		
Year	Annual Wind Gen (MWh)	Average Capacity Factor
2015	684,875.47	32.79%
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2020	720,140.19	31.85%
2021	681,311.35	30.64%

High-Performance Sites		
Year	% Gen Relative to Original Set	Average Capacity Factor
2015	37.2	57.93
2016	35.2	56.47
2017	37.3	55.56
2018	40.1	56.40
2019	39.6	58.06
2020	38.4	57.04
2021	36.3	55.99

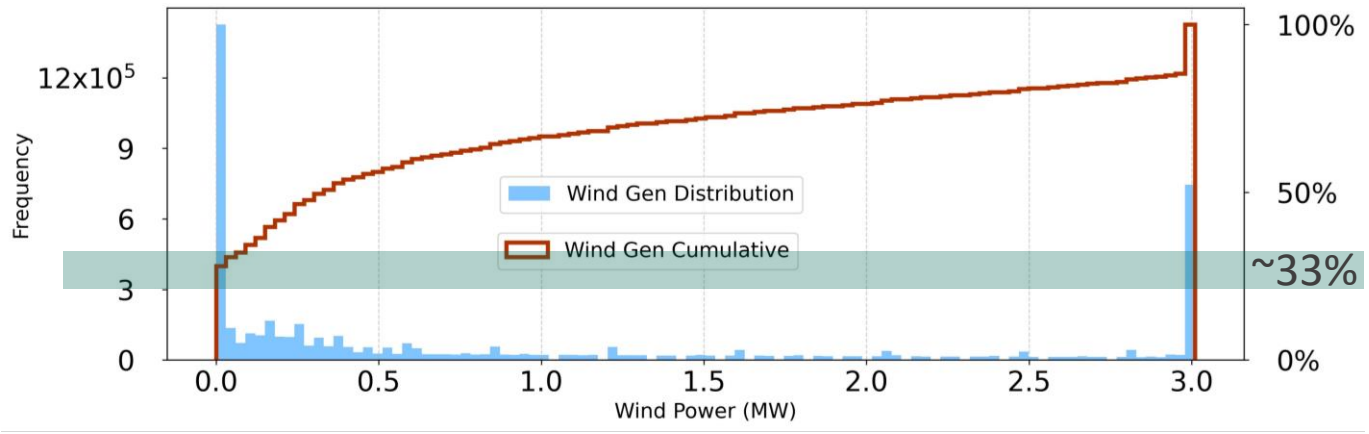
Conclusions

1. Wind power distribution: generation was at or below 0.1 MW for more than 33% of the time *(Whole Country)*

2. Hourly averages show large fluctuations in wind energy generation *(daytime higher than night-time)*

3. Focusing on high-performance sites decrease variability in generation and increase capacity factors

4. Correlation is lower when considering only the high-performance sites



Wind Forecast

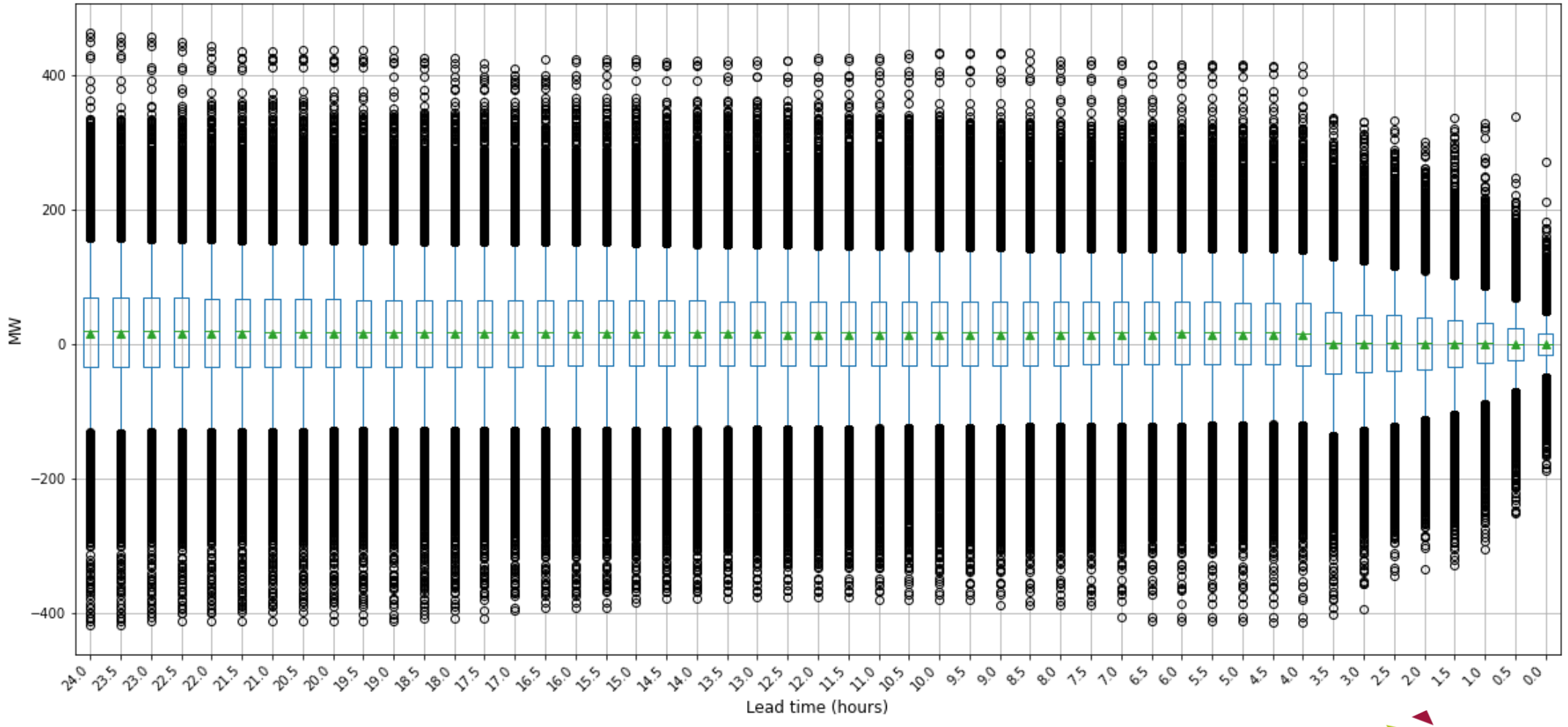
Motivation

- Inaccurate wind generation forecasts were a factor in the 9 August 2021 grid emergency
- Slow-start thermals must make a commitment decision 6 to 12 hours ahead of real-time
- Inaccurate forecasts increase risk for slow-start thermals and system as a whole
- We wanted to statistically assess the accuracy of wind generation forecasts

Method

- We investigated the accuracy leading up to real-time over a 12-month period
- Compared cleared wind generation between forecast schedules and final pricing schedules
- Forecast schedules generally clear at the “forecast of generation potential”
- Final pricing schedules generally clear at the metered quantity

Total forecast error over April 2021 to March 2022



Code requirements for intermittent generators

- Must submit a revised forecast of generation potential at least once per half-hour during the last two hours before the start of the trading period
- Must be based on a resource persistence model, unless otherwise agreed with the Authority
- Assumes the variable resource conditions when the forecast is made will persist throughout the trading period to which the forecast relates
- It appears most wind generators do use a resource persistence model in the last few hours

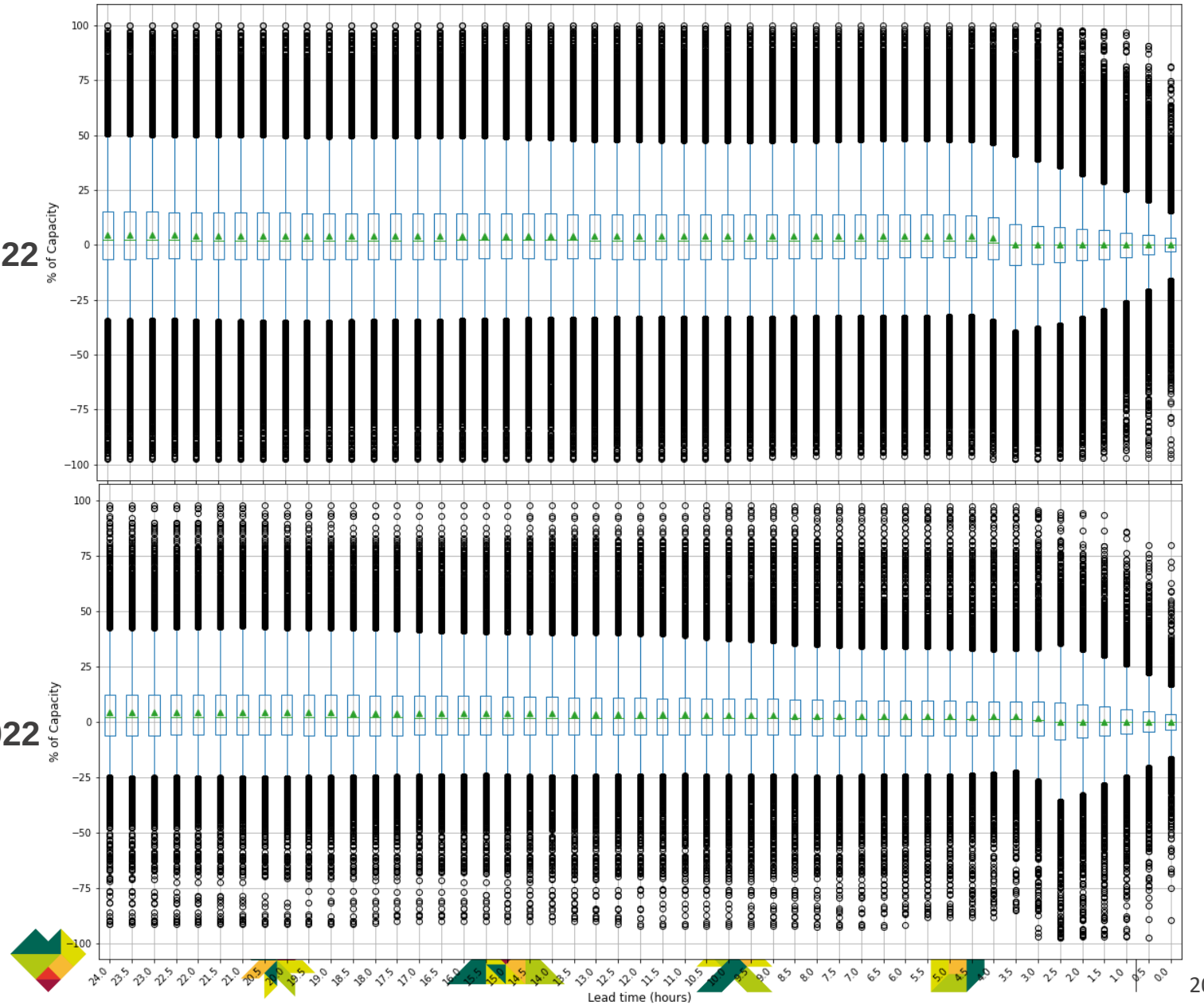
Proprietary forecasting software

- We understand Genesis started using proprietary wind generation forecasting software at Waipipi windfarm on 8 June 2022
- (Waipipi is operated by Genesis under a PPA with Mercury)
- Mercury also uses the same forecasting software at their Turitea windfarm
- Show better accuracy than some other windfarms
- Still appear to revert to resource persistence model in the last few hours
- System Operator also trialled the software – more accurate than resource persistence

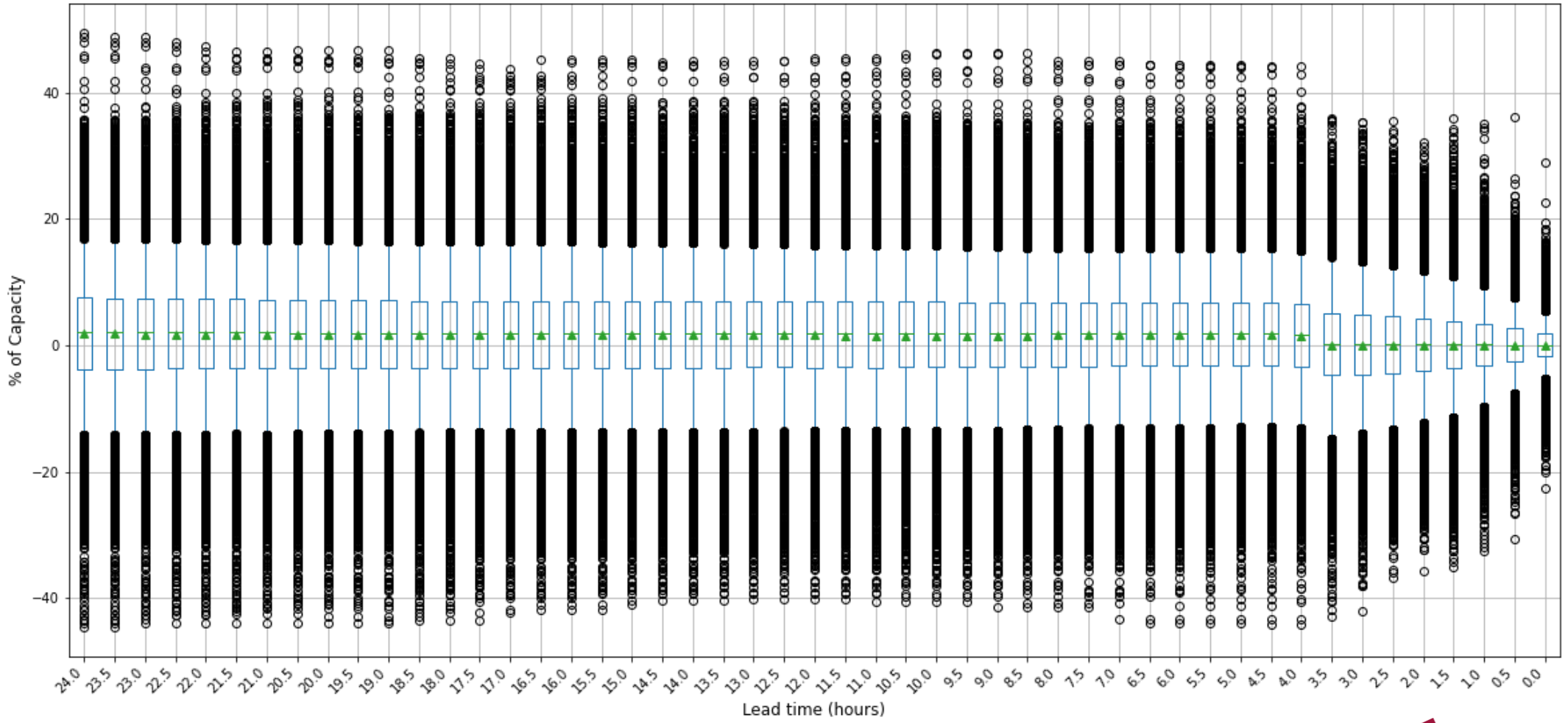
Waipipi forecast error

Old forecast
April 2021 to Mar 2022

New forecast
9 June to 11 Sept 2022



Total forecast percent error over April 2021 to March 2022



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Next steps

- The Authority has initiated a project to review the current intermittent generation offer provisions, which this analysis will support
- Consultation is planned for the second half of the 2022/23 financial year
- There is scope for “raising the bar” (more accurate forecasting software is available)