PRICE DISCOVERY WITH 100% RENEWABLE ELECTRICITY SUPPLY – A MODELLING APPROACH

Prepared for Market Development Advisory Group

9 September 2021

What are we trying to find out?

1. How is spot price volatility likely to change in a transition to 100% renewable electricity?
   - Within day/week
   - Within year
   - Year to year

2. How sensitive is spot price volatility likely to be to changes in:
   - Generation costs
   - Demand growth
   - Consumer behaviour (EV charging, demand response)
   - Supplier behaviour (hydro storage use, battery use)
   - Supply/demand balance

This is a voyage of discovery - we expect volatility to increase but don't know how big the change will be.

How will we answer the question?

Physics + Economics = Possible price structures

- Focus on demand/supply balance in each hour
- Use 'residual demand' as measure of supply/demand balance (i.e. total demand – intermittent supply)
- Examine how shape of residual demand will change under 100% renewable electricity
- Account for flexibility limits – physical and informational

- Project future demand in 2035 and 2050 based on information about electrification, population growth etc
- Account for thermal retirements, existing and committed new generation and expected roof-top solar, distributed batteries, smart EV charging, and potential demand response.
- Iteratively add new generic supply of each type (wind and solar, grid batteries, green peakers, geothermal).
- Simulate the operation of the system over many weather (hydro, wind, solar etc) years to assess the levels of shortage and demand response, green peaker use and spill and the value of each type of new supply .
- Continue adding new supply until the expected market value of each type covers its fixed annualised investment and operating costs (i.e. simulate market – based investment).
- Undertake sensitivities to see effects if there is under/over investment

- Examine the nature and volatility of spot prices that emerge, within the day, over the year and from year to year as a function of inflow/wind/solar variation.
- Explore the sensitivity to:
  - balance of supply and demand
  - different water value contours
  - level of flexible supply (e.g. batteries, demand response etc).
- Explore trends in the GWAP/TWP ratios for each type of new supply as a function of the level of intermittent supply (2020, 2035 and 2050).
- Assess any issues that arise regarding the new investment signals, operational efficiency and security?

How is the system simulated?

Simulation approach

- The simulation is carried out week by week over 85 historical weather years. The lake levels at the end of each simulated year are used as the starting levels for the next simulated weather year.
- Within each simulated week the available supply resources (including demand response, batteries, green peakers, intermittent supply and offered hydro are dispatched to meet the hourly profile of demand in each island at minimum cost.
- Energy and capacity constraints and round-trip efficiencies are accounted for as well and inter-island transmission constraints and losses.

Hydro modelling

- Assume that hydro water values reflect the short run marginal cost of renewables when lakes are full and the risk of spill is high, and the cost of demand response when lakes are low, and the risk of shortage is high.
- It is noted that, in the absence of significant thermal plant, water values contours for intermediate lake levels are not well defined.
- It is proposed that these intermediate values are set around the level that reflects the cost of new renewable energy supply.
- The water values contours are profiled to ensure that dry years are covered.
- Undertake sensitivity to test different water value functions.

Intermittent supply and demand

- Include hourly wind and solar profiles based on historical data or synthetic profiles over the period 2000 to 2018.
- Include daily and weekly profiles based on history for underlying demand and for EV charging.

How will we report results?

Price duration curves

- Results will be reported as price duration curves (PDCs) on different time frames
- PDCs provide a ready means compare price structures over time and under different sensitivities

Chronological data

- Results will also be reported in chronological form
- Chronological data is particularly important to assess the effects of storage technologies
- Chronological data allows modeling of cycling of storage technologies and how it gets used and maxed out

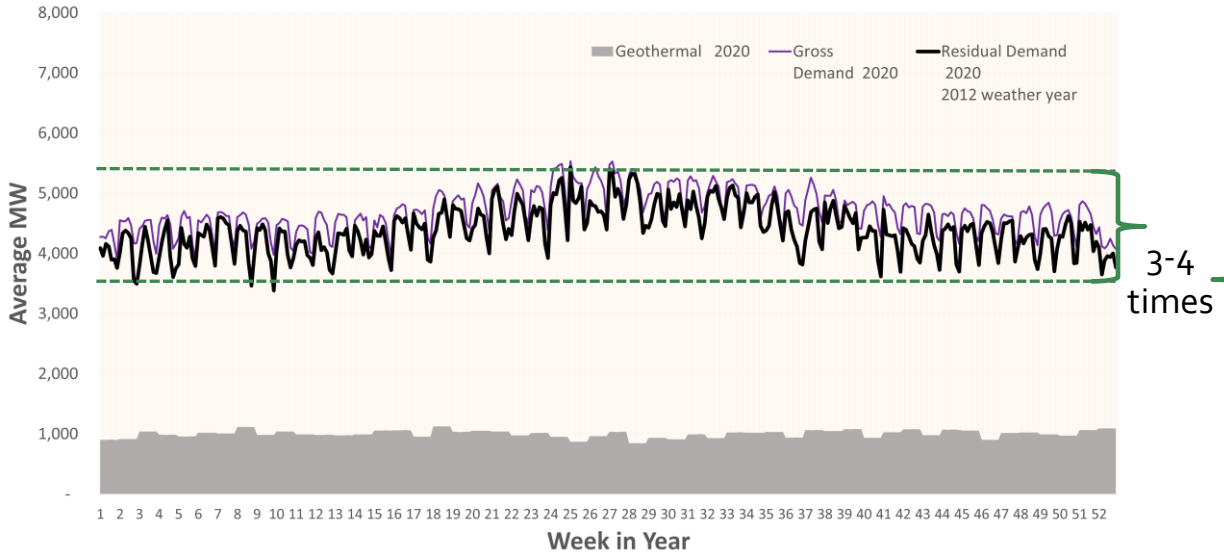
Comparisons

- Comparisons will be provided to show how modelled future price structures compare to NZ historical data and some overseas jurisdictions
- This comparative information helps to understand how different the future may be – and how tolerable or unmanageable the volatility will become

Appendix

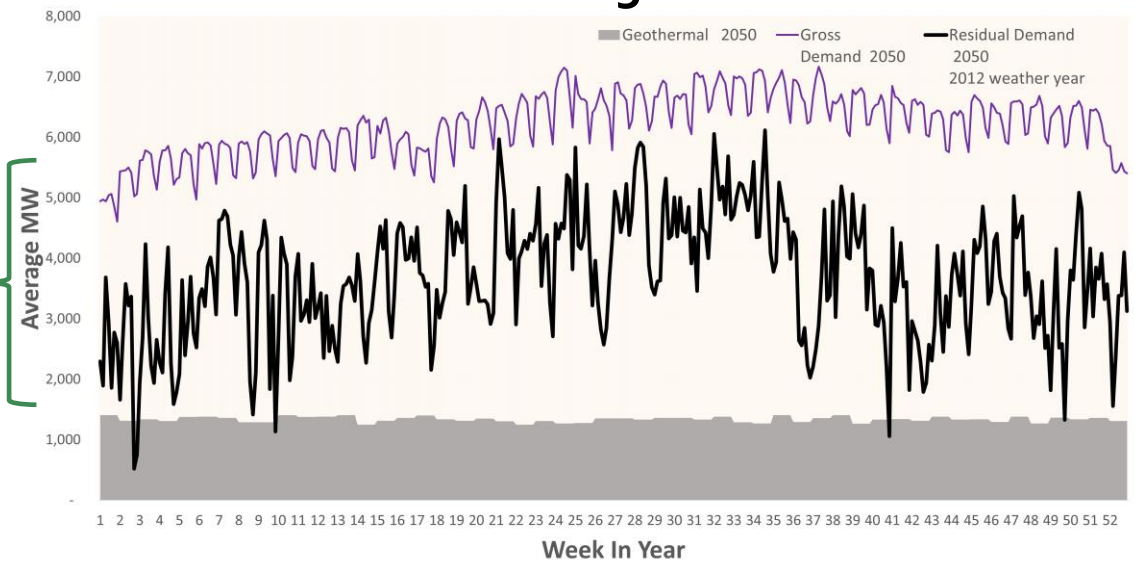
We face substantial increases in short run variability:

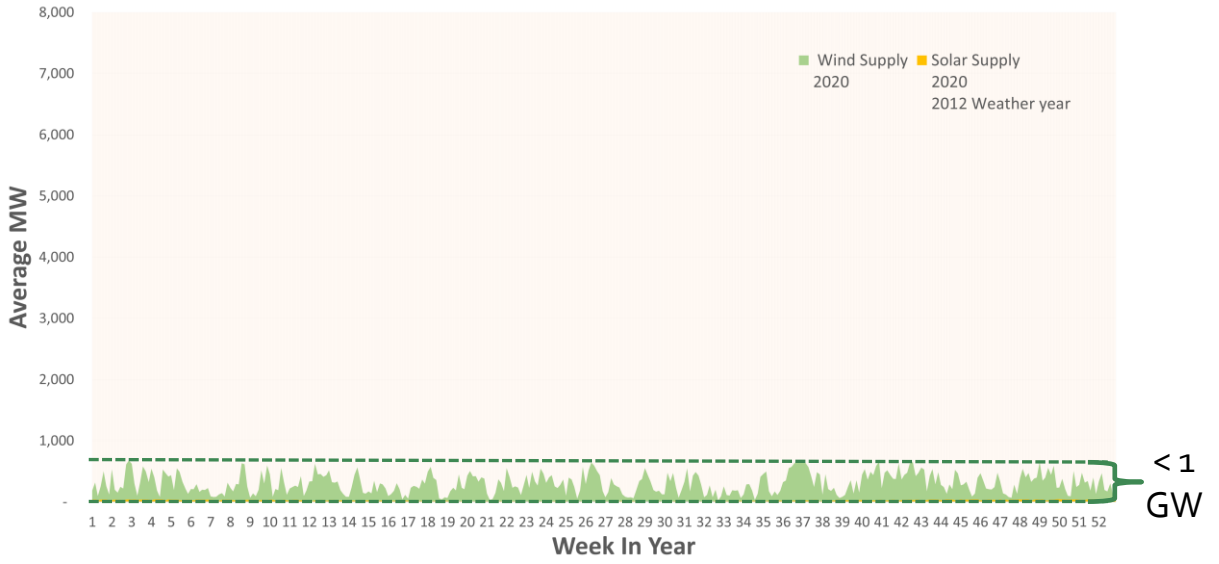
2020



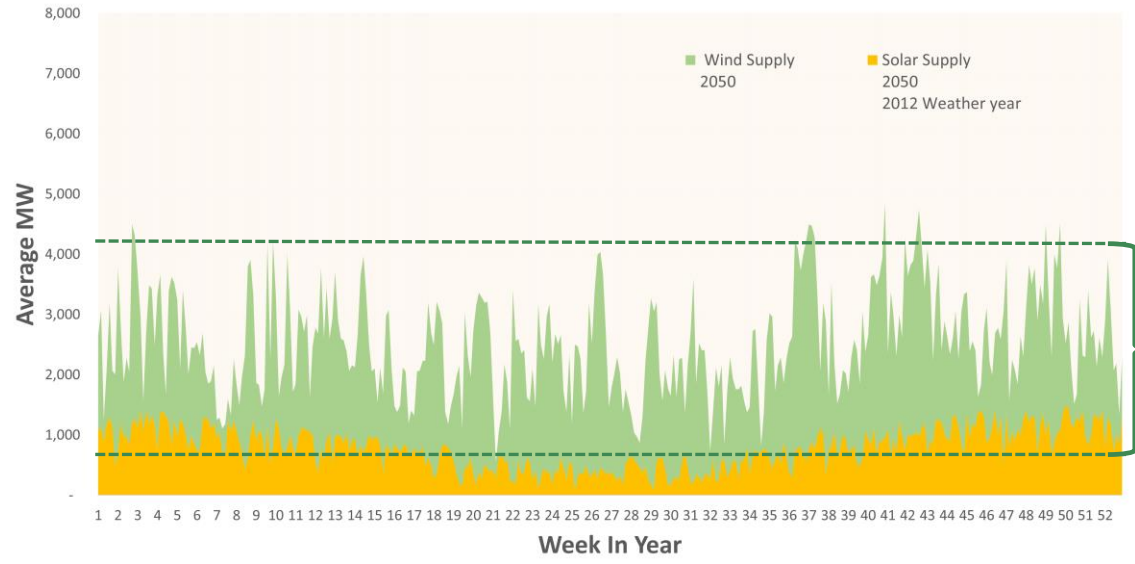
3-4 times

2050





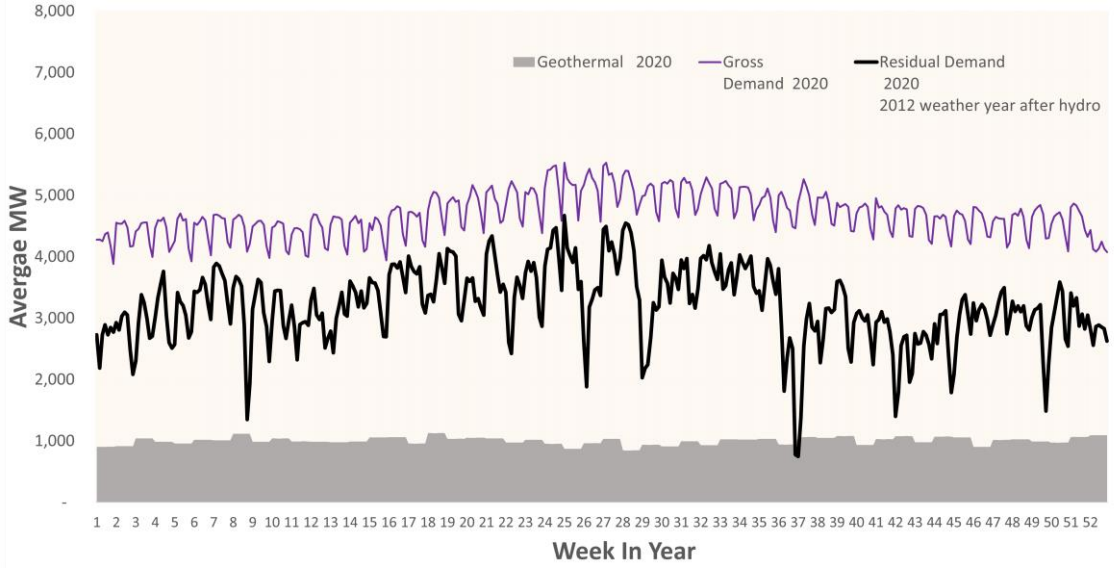
< 1 GW



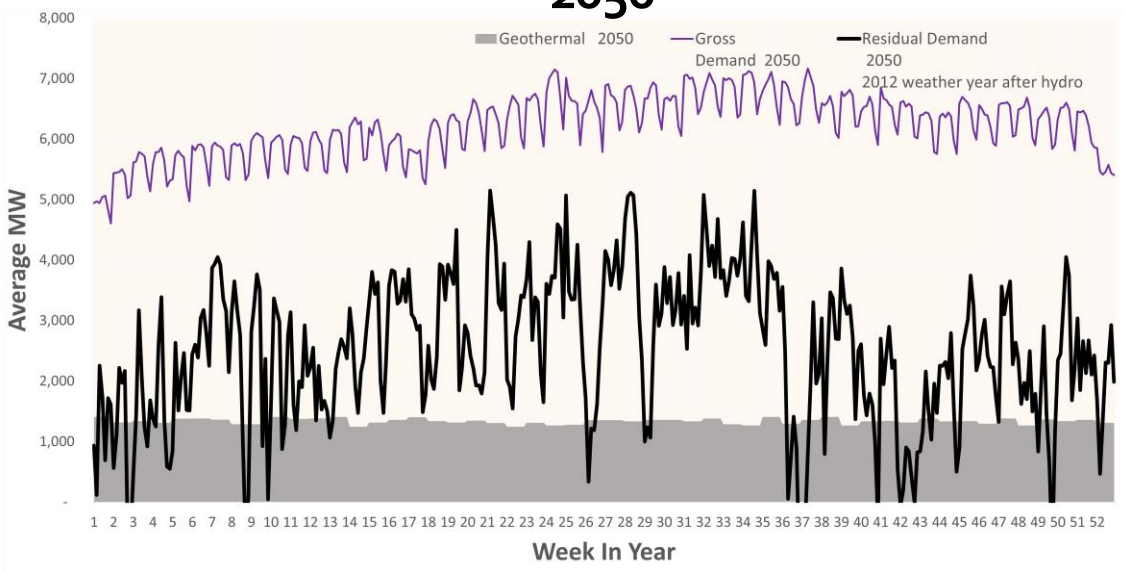
3·5 GW

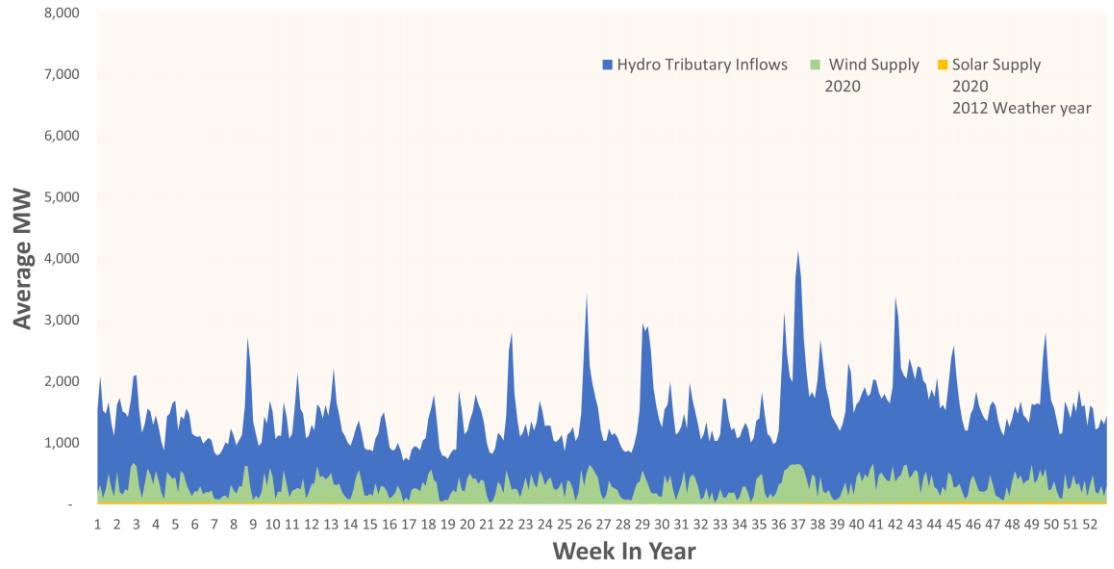
But we are used to dealing with weather variability:

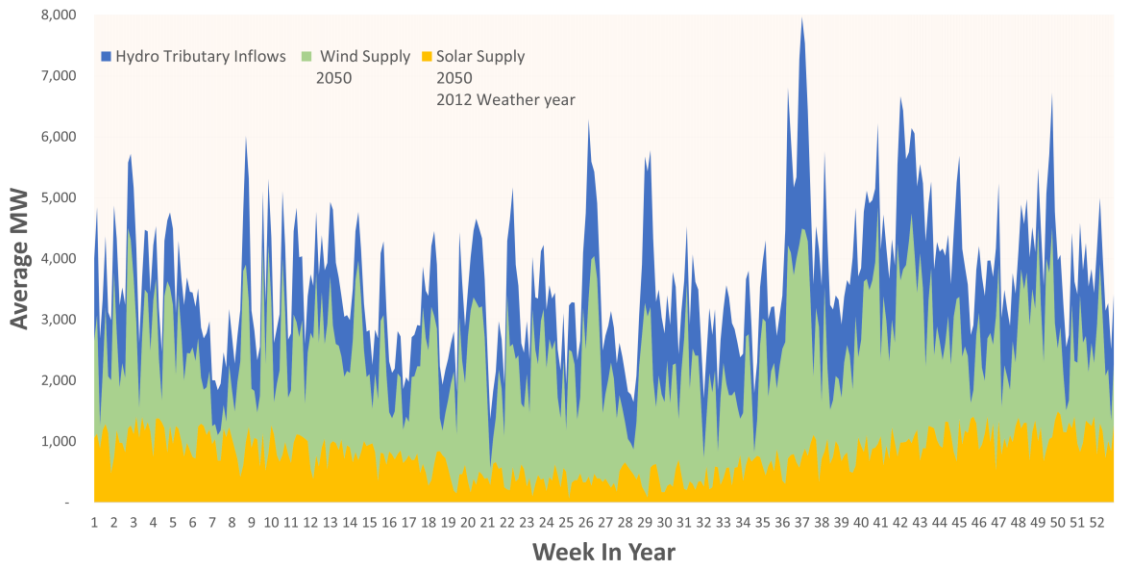
2020



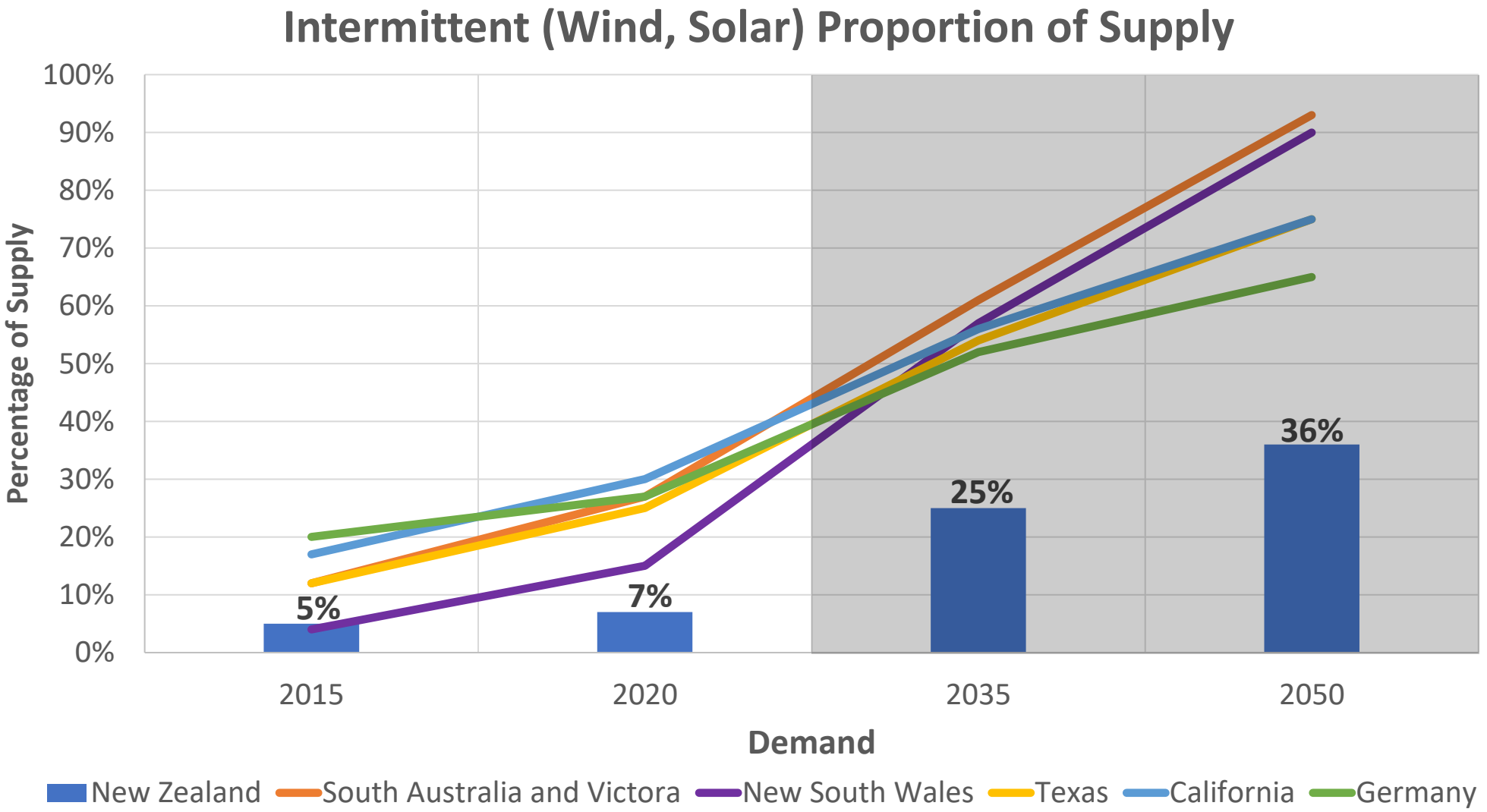
2050







How NZ intermittent renewables compares to other markets



Highlighted region values are indicative projections

About Concept

For more than 20 years, we have been providing expert advice on policy, regulation, strategy and economics. We are energy sector specialists with growing expertise in carbon, telecommunications and water.

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