# Balancing the energy trilemma

## - Modelling the NZ electricity system out to 2050

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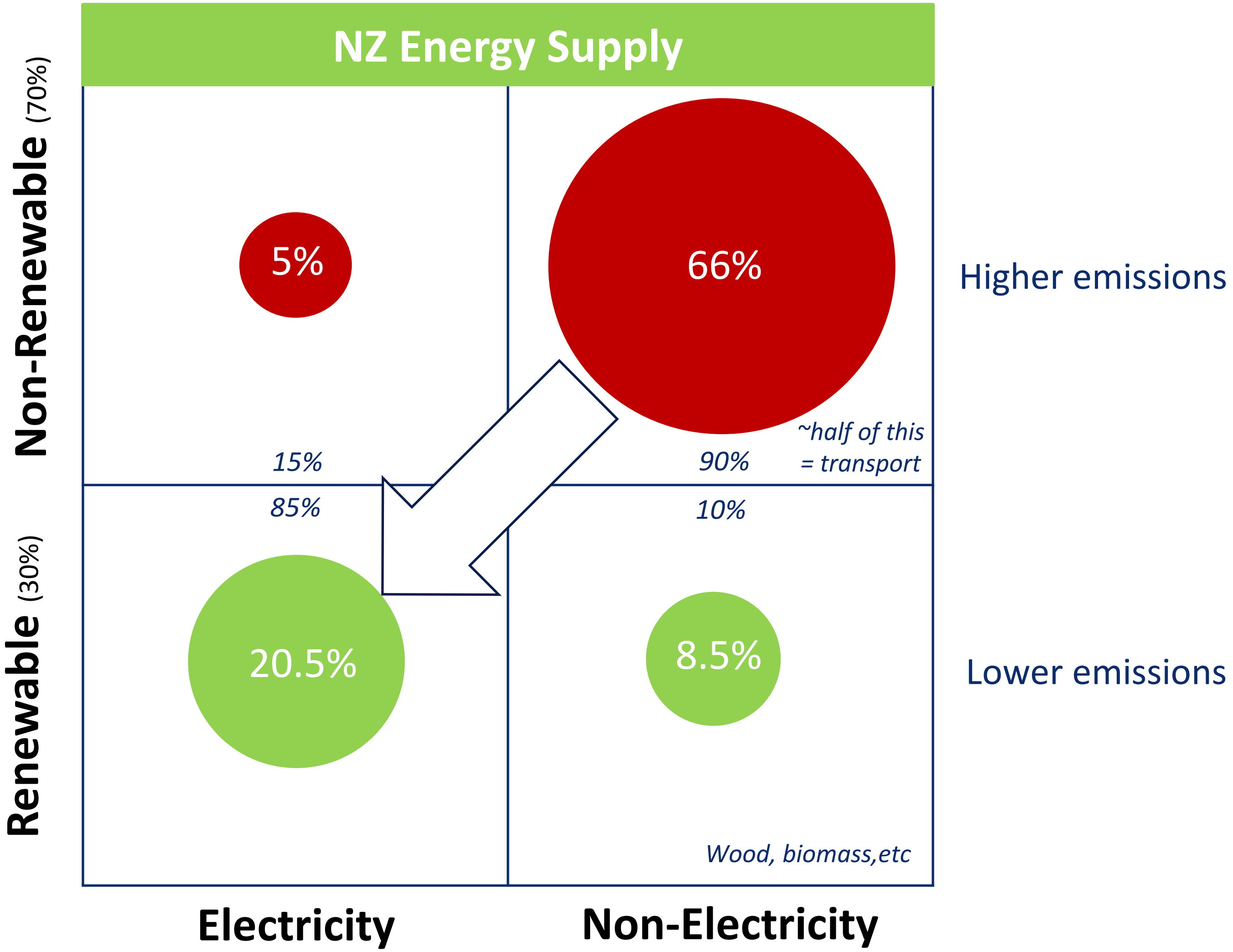
Security of supply

The energy trilemma

Emissions

Cost

# Decarbonising the NZ energy system



# Overview

- Model
- Two scenarios

Model inputs:

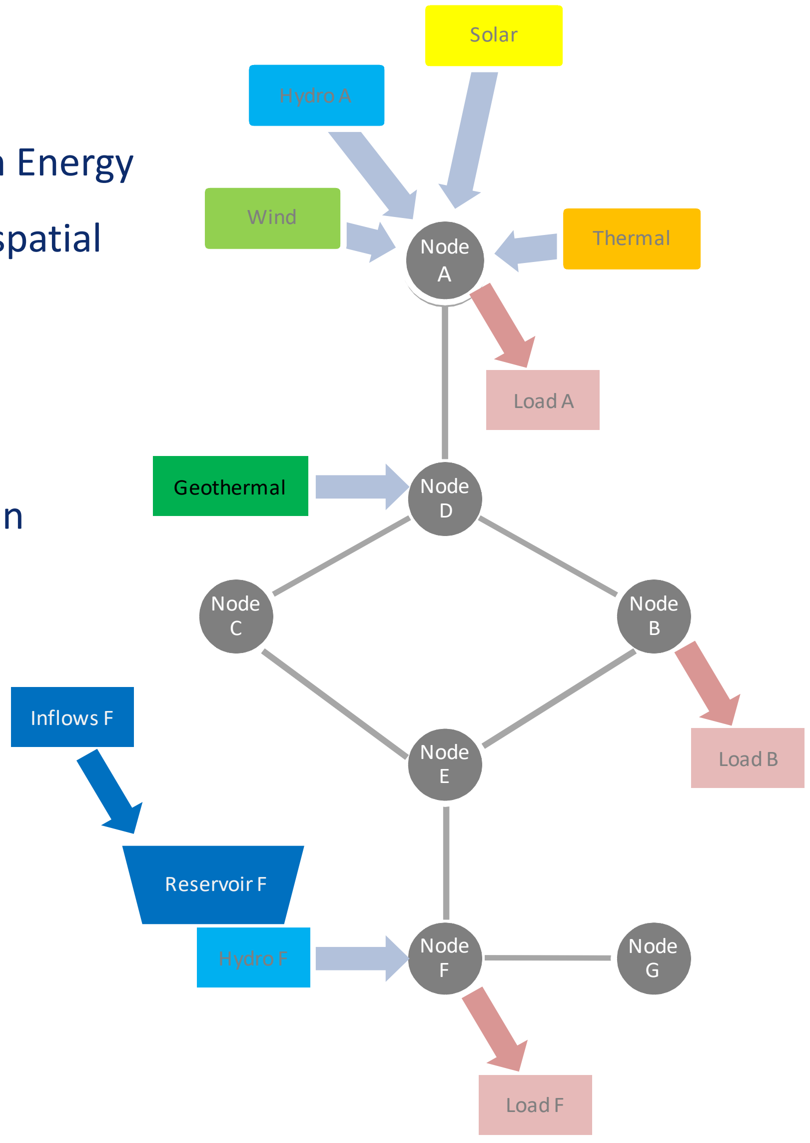
- electricity demand
- wind and water
- technology cost declines

Model outputs

- generation plant changes
- price
- % renewable
- electricity emissions

# Tools - LPCon NZ power system model

- Two-phase simulation and optimisation model of the NZ power system, owned by Meridian Energy
- Uses a linear programming construct to match demand and supply on a fine temporal and spatial scale, to produce an efficient least cost energy system.
- Spatial resolution nodal (285 nodes) / regional (22 regions) / island (2).
- 30 year lead time.
- Weekly granularity, but 15 block load duration curve representation of within week variation (day/night/peak/off peak).
- 86 years of hydrological data and wind for every hydro catchment or area.
- Includes representation of:
  - **Prices**, cost to generate, **offers** into the electricity market.
  - **Generation capacity**: hydro, wind, coal, gas, geothermal, solar, both current & projected.
  - Hydro **storage**, inflows (past and future), hydrological constraints, cascading releases, minimum flows, consent conditions, spill.
  - Electricity **demand** projections
  - **Transmission** network, line flows, line losses and constraints.
  - Dynamic system risk and fast and slow **reserves**.
  - Planned and forced **outages** for all plant and transmission lines.
  - **Demand response**



# Two scenarios: Evolution and Revolution

## Evolution: Adaptive BAU scenario

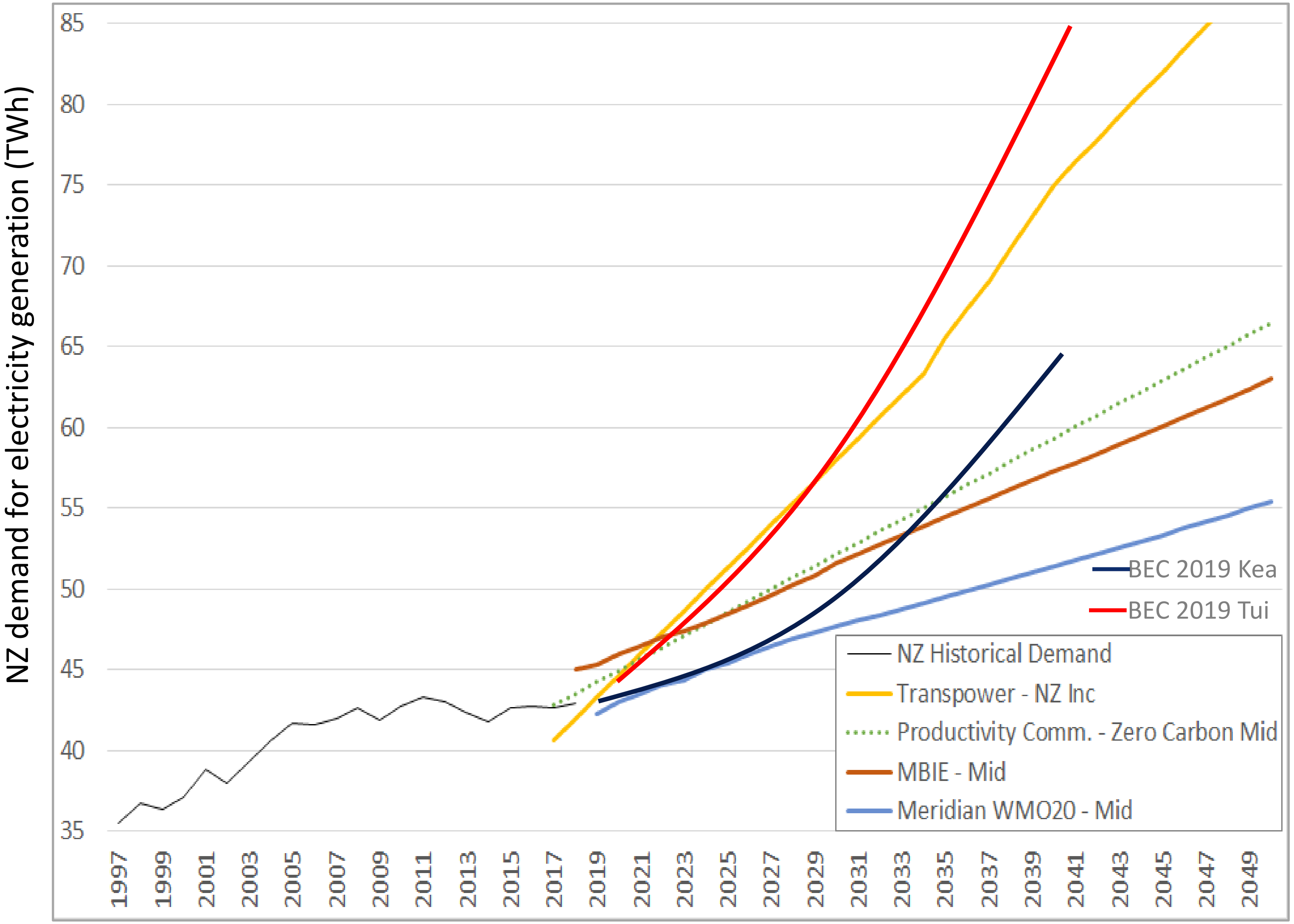
- Modest decarbonisation / emissions reduction.
- Some gas peaking plant remains
- Renewable share ⇨ 95+%
- Carbon price ⇨ \$50/t $CO_2$e

## Revolution: Low carbon scenario

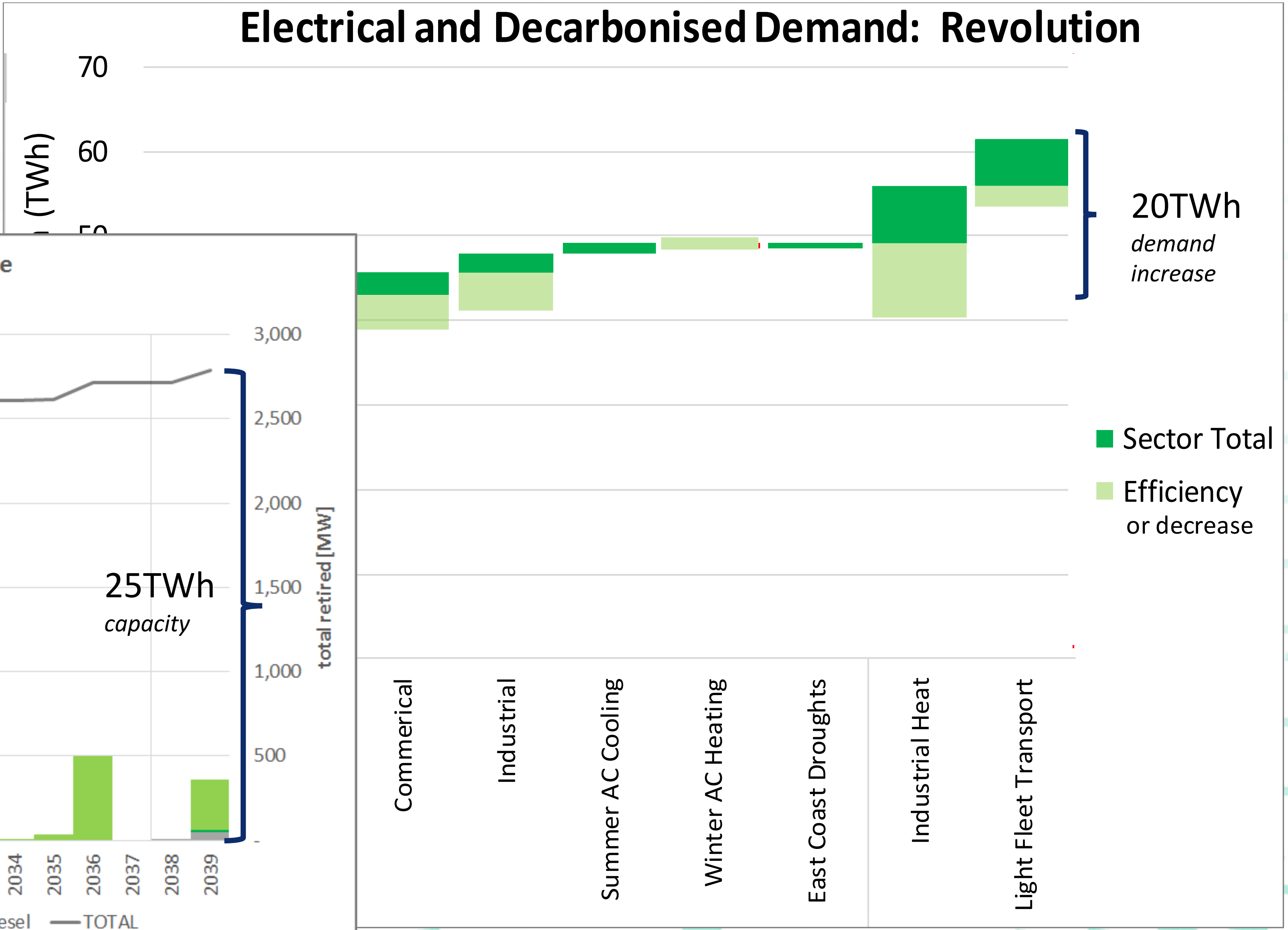
- Strong decarbonisation / emissions reduction.
- No thermal plant remains
- Renewable share ⇨ 100%
- Carbon price ⇨ \$100/t $CO_2$e

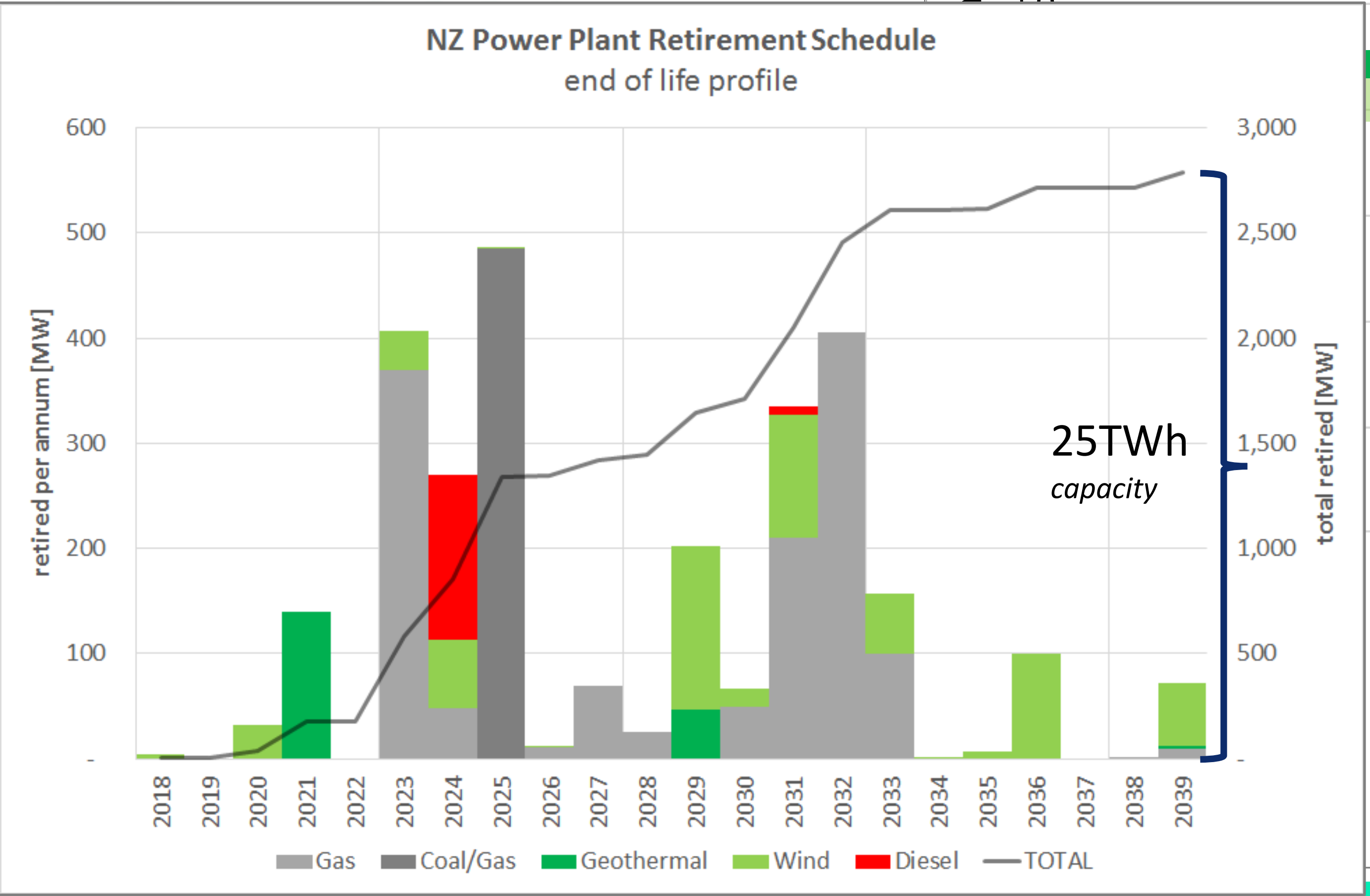
# Demand projections

- Consensus that demand will rise.
- Baseline demand:
  - ➢ increases in population
  - ➢ increases in GDP
  - ➢ offset by efficiency gains.
- PLUS "climate change impacts":
  - ➢ Electrification of transport & industrial heat processes.
  - ➢ Increased air conditioning load
  - ➢ Decreased heating load
  - ➢ Increased irrigation load East Coast
- Large uncertainties.

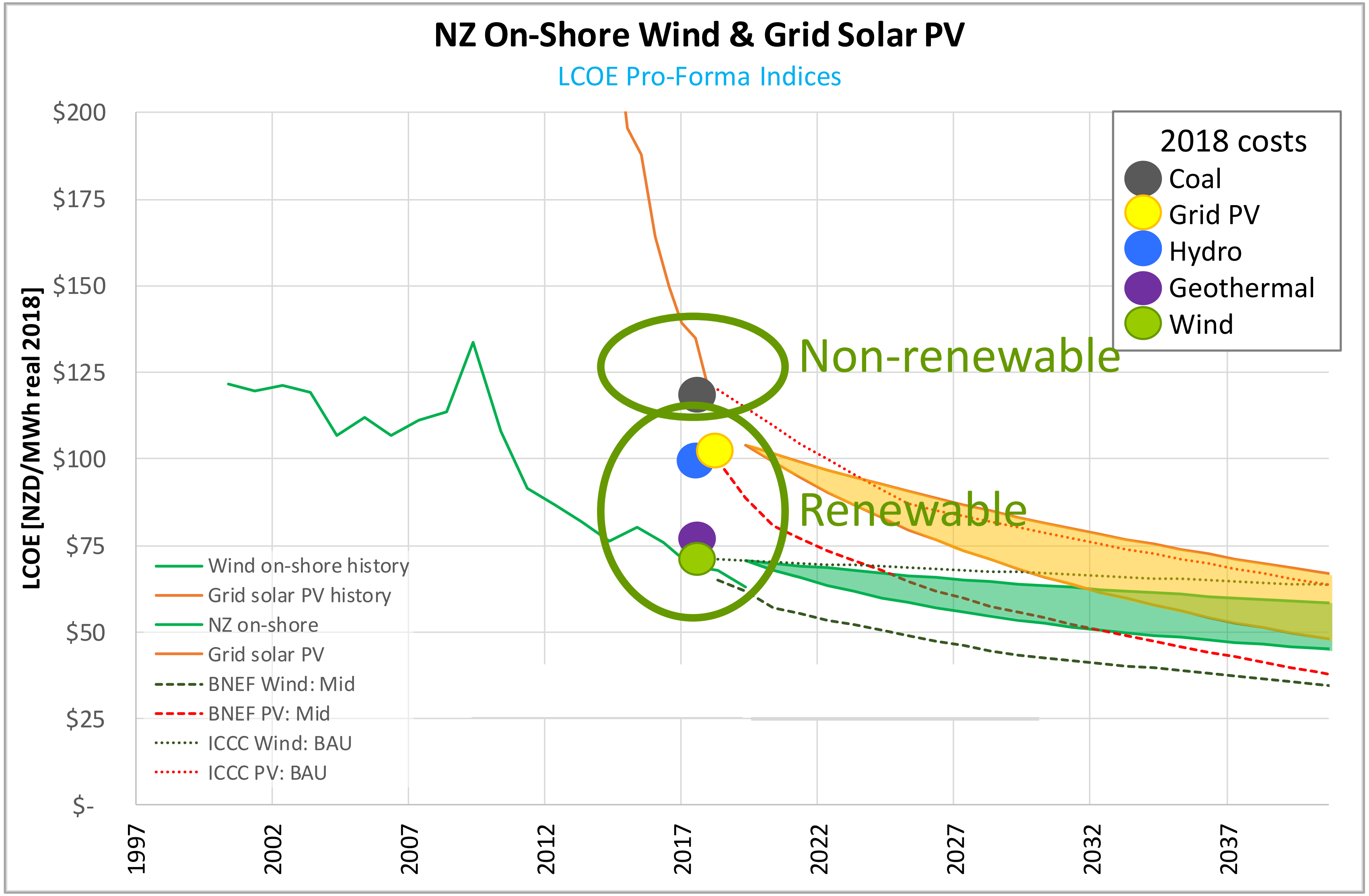


# Demand side changes: the need for additional generation

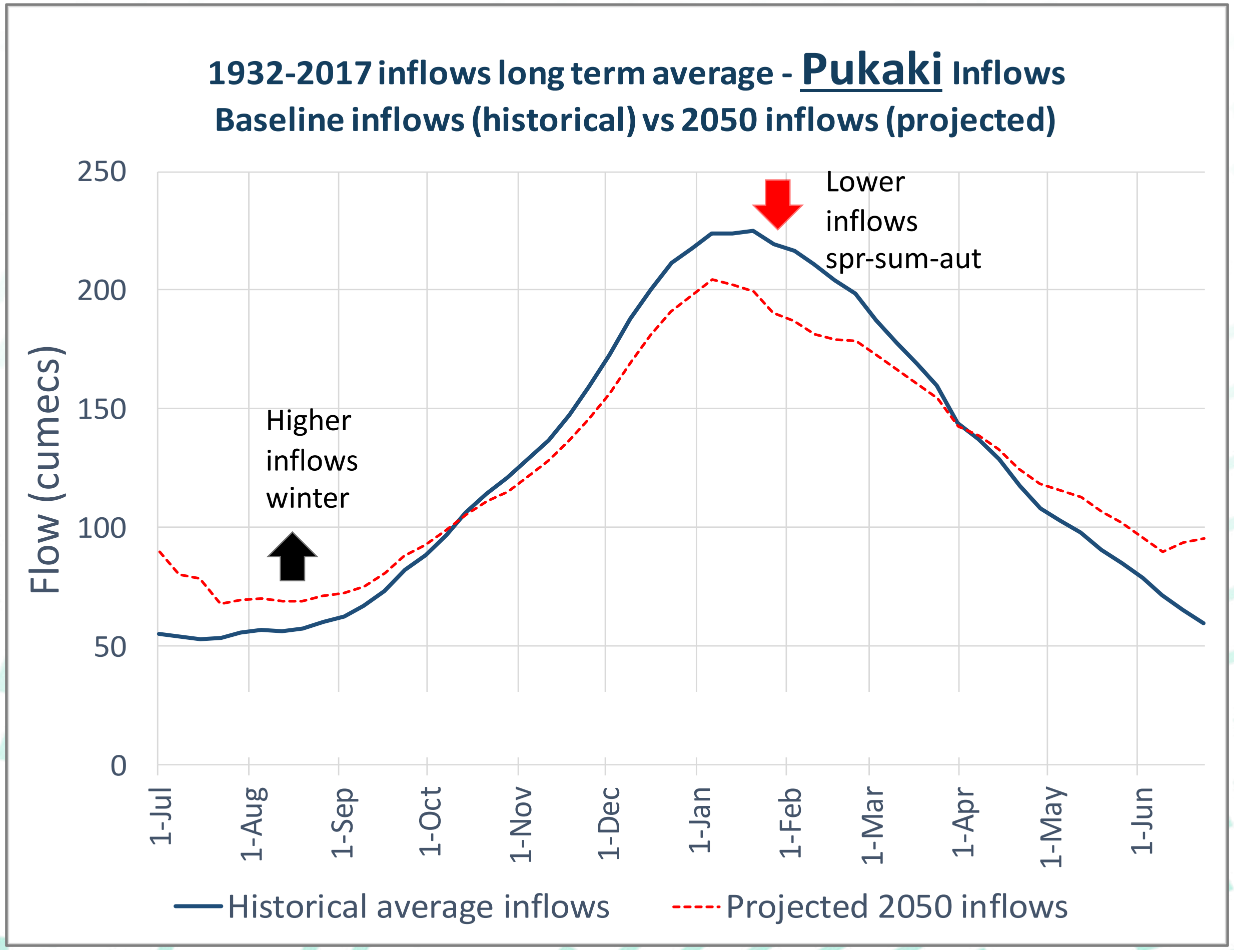


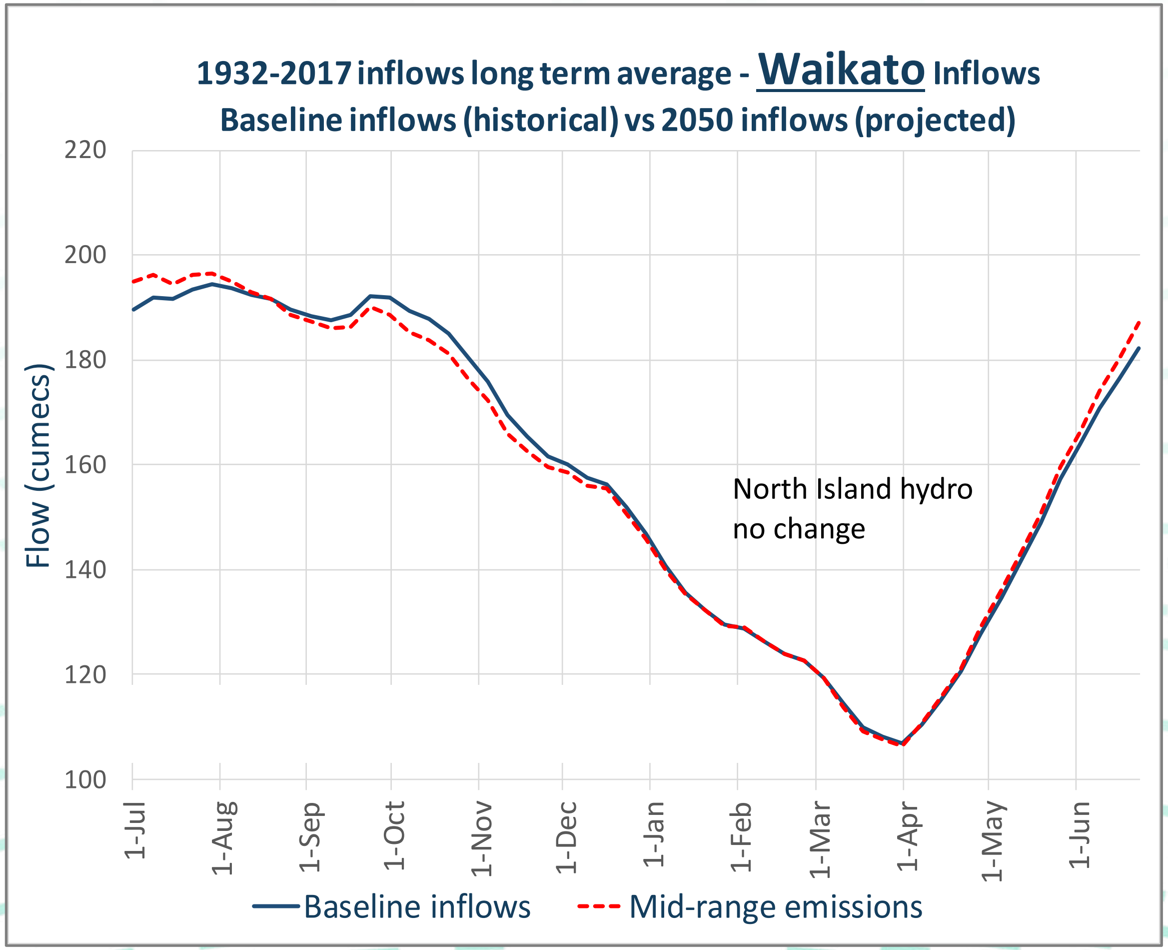



# Supply side changes: cost of new builds



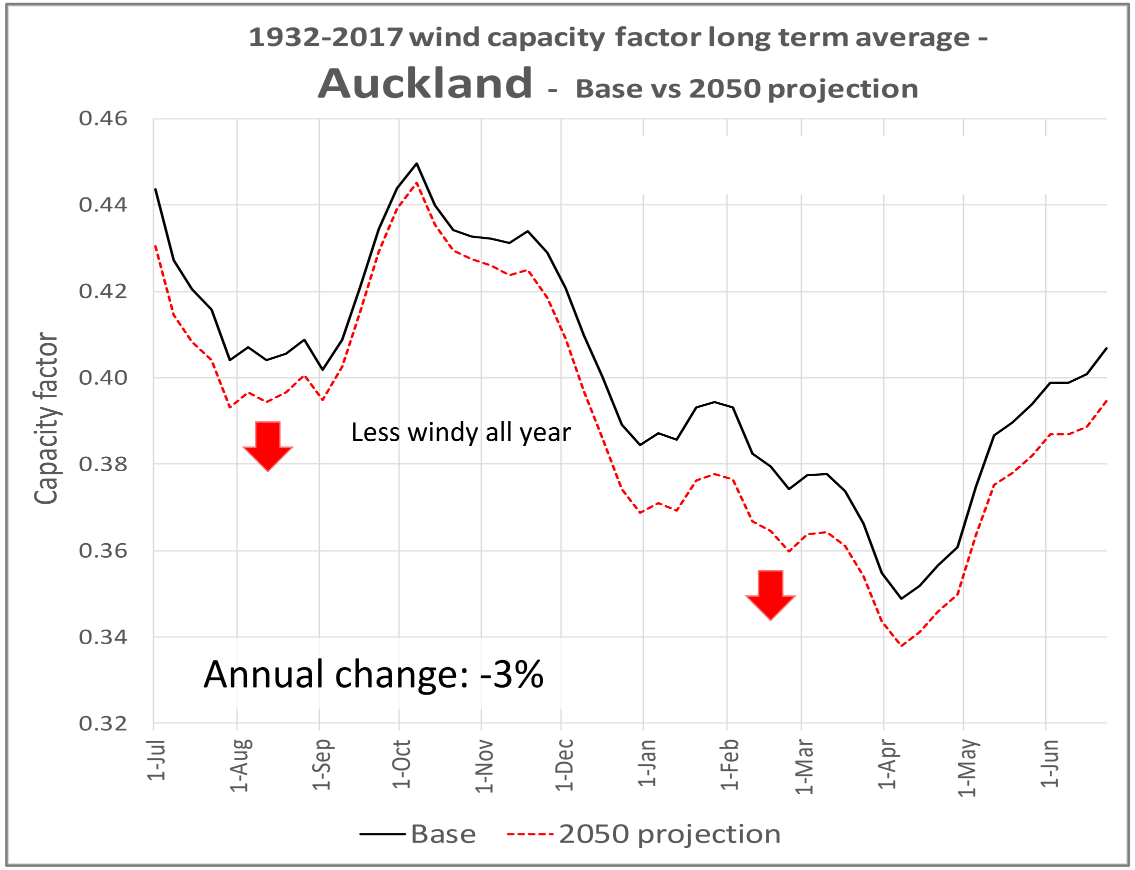
# Supply side changes: modelled changes to inflows by 2050

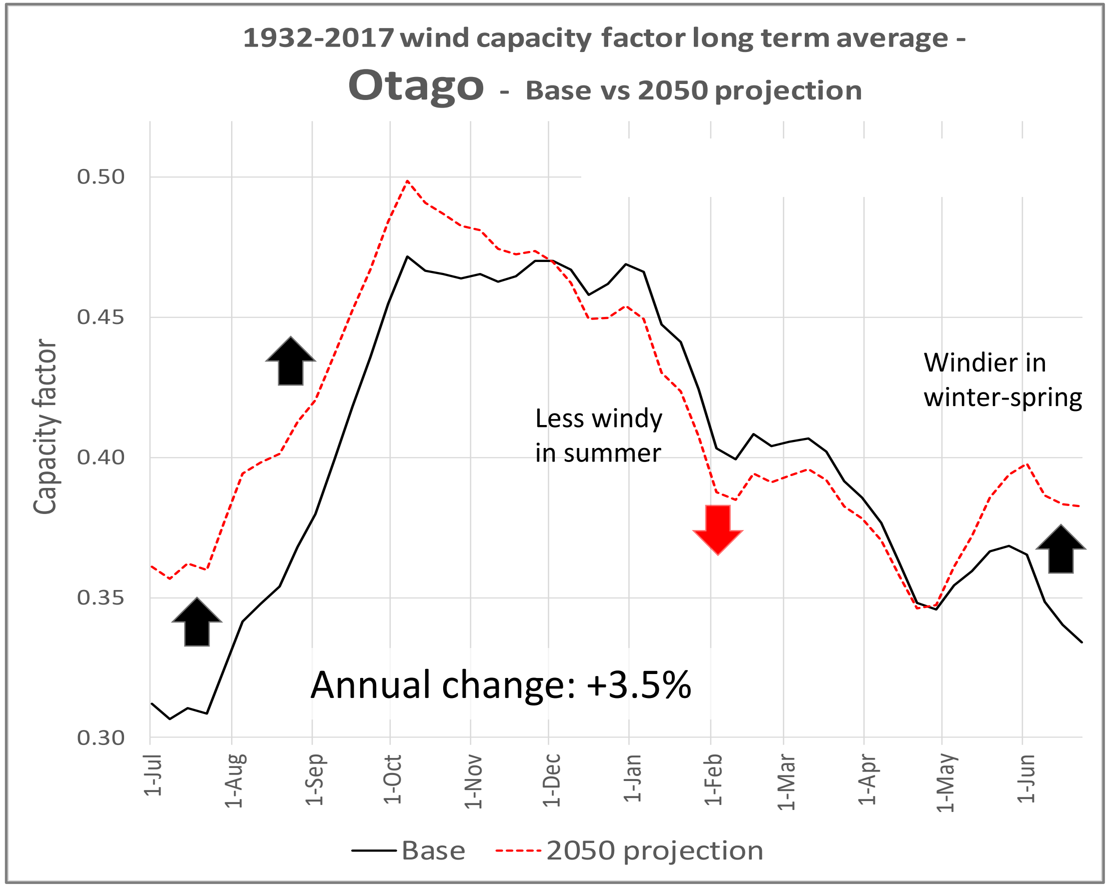


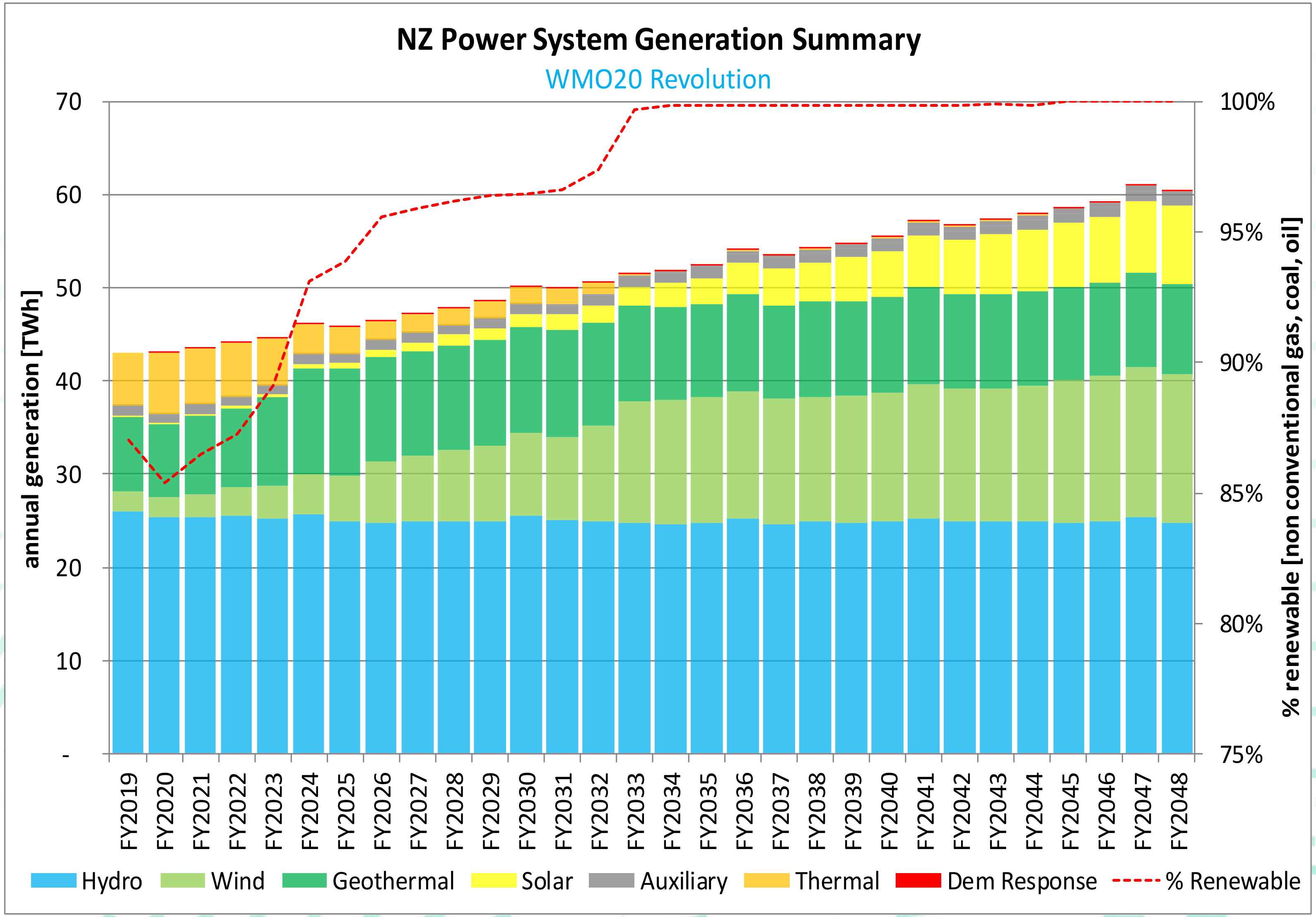

Meridian.

# Supply side changes: modelled changes to wind farm capacity factor



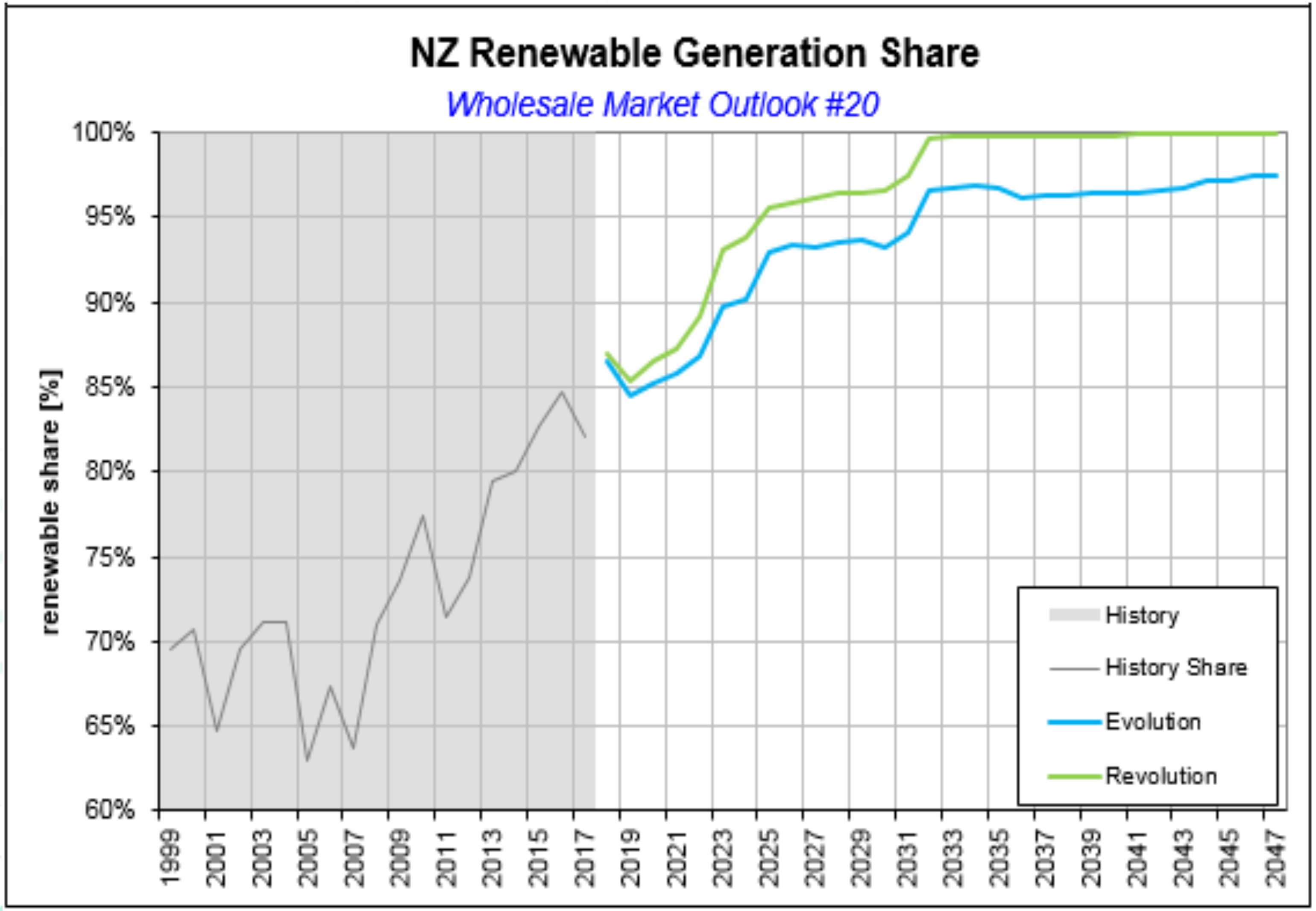



# Generation Summary

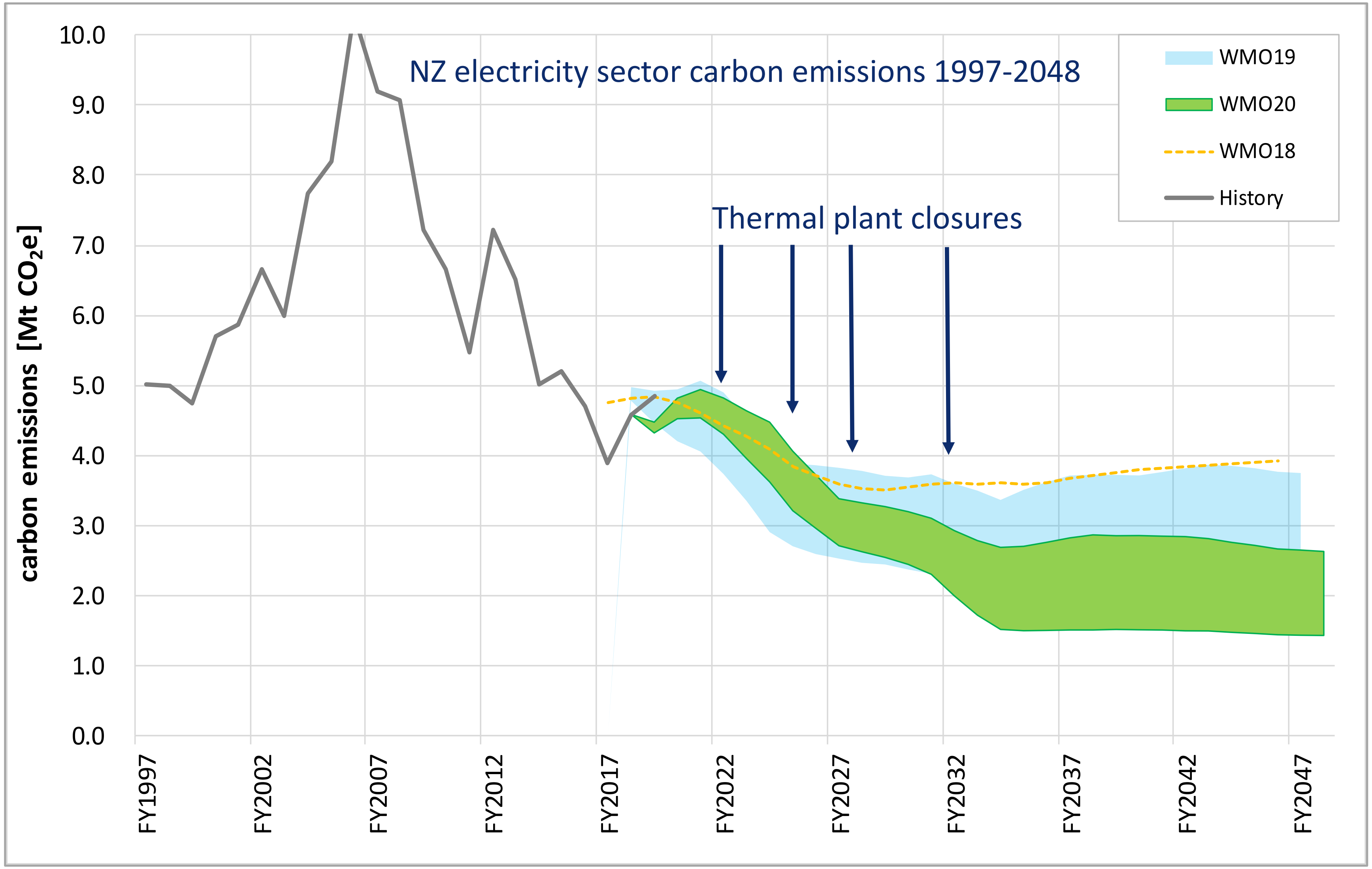


# Percent renewable electricity

- 100% renewable possible IF:
  - existing power system flexibility is fully utilised (hydro, geothermal)
  - new and flexible technologies emerge, eg. dispatchable demand, batteries

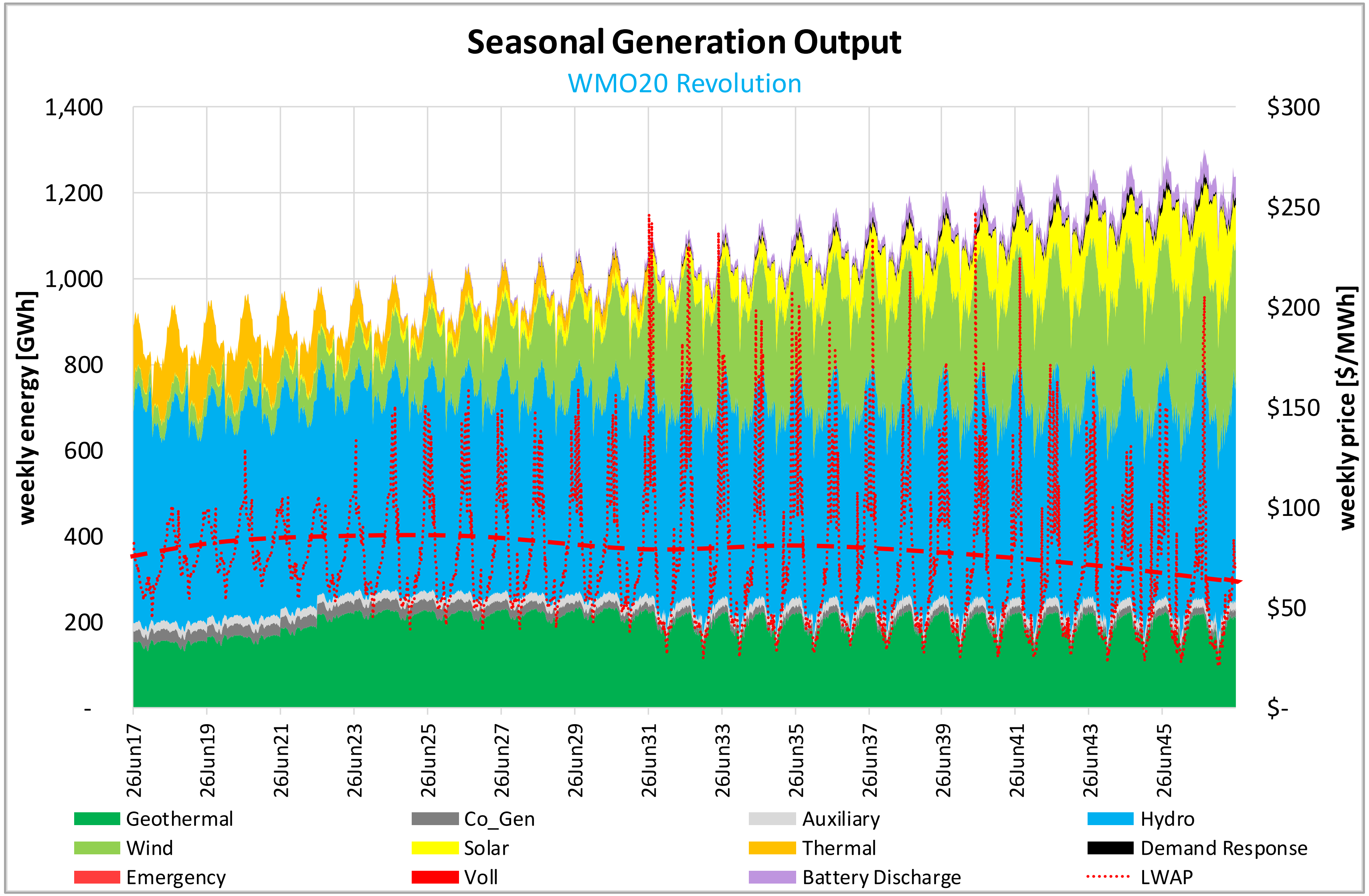


# Supply side changes: carbon emissions from electricity generation



# Price

- On average, prices projected to be same or lower.
- BUT much more volatile than in the past, due to increasing proportion of intermittent renewables in the system.
- Demand response, hydro flexibility, and batteries will become increasingly important to manage this volatility.



# Summary

Our modelling indicates that:

- The electricity system will continue to decarbonise itself as this is the most efficient outcome.
- The electricity system will also enable the decarbonisation of a significant portion of transport and industry.
- Significant new generation build planning and investment is needed, with reasonable lead times.
- Increasing intermittency will require firming from:
  - Some gas peaking plant over the medium term.
  - Retention of hydro capability and flexibility, particularly hydro storage (as the “battery bank”).
  - Demand side participation and batteries (incl. V2G) essential.
- BUT! We believe the energy trilemma CAN be kept in balance.