Context:

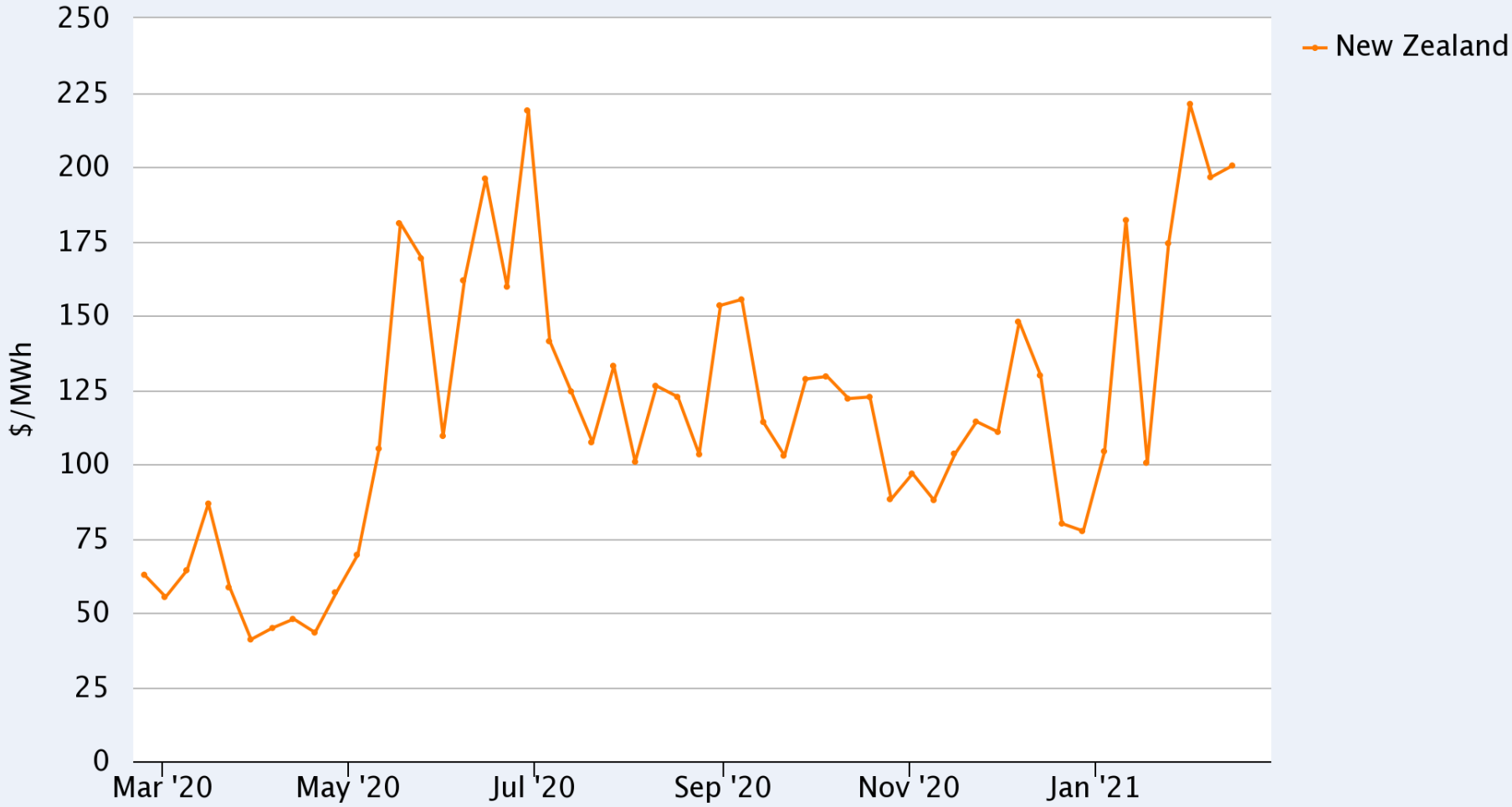
- This pack was developed by the Climate Change Commission for internal analysis purposes and has been released as part of the consultation process. It is suitable for technical industry experts.
- This slide deck presents a summary of results from electricity market modelling of scenarios. The results were obtained used Energy Link's E-Market and I-Gen models. The purpose of the modelling was to complement our main modelling tool ENZ.
- This was an insight gaining exercise. There are limitations to this modelling piece and inherit uncertainties. Care should be taken in interpretation of the modelled results, particularly regarding long to term prices.
- There are short term market dynamics which are not reflected in this modelling. For example, market prices are currently being impacted by low hydro storage and high gas prices (as of February 2021) – these dynamics are not reflected in these results.
- This modelling exercise was completed in November 2020. Since this time the electrification scenarios developed in ENZ and presented in the 2021 Draft Advice and Evidence Reports have been further refined. The scenarios shown in this document bound the final scenarios shown in the advice report, but they are not exactly equivalent.
- The wholesale pricing result for the ‘Central Pathway’ shown in the 2021 Draft Advice Report is the modelled Tailwinds scenario shown here. The electrification scenarios are very similar and this is a valid approximation considering model accuracy and uncertainty.
- All prices are in 2020 real NZDs.

Electricity market modelling of CCC electrification scenarios

Feb 2021 Presentation

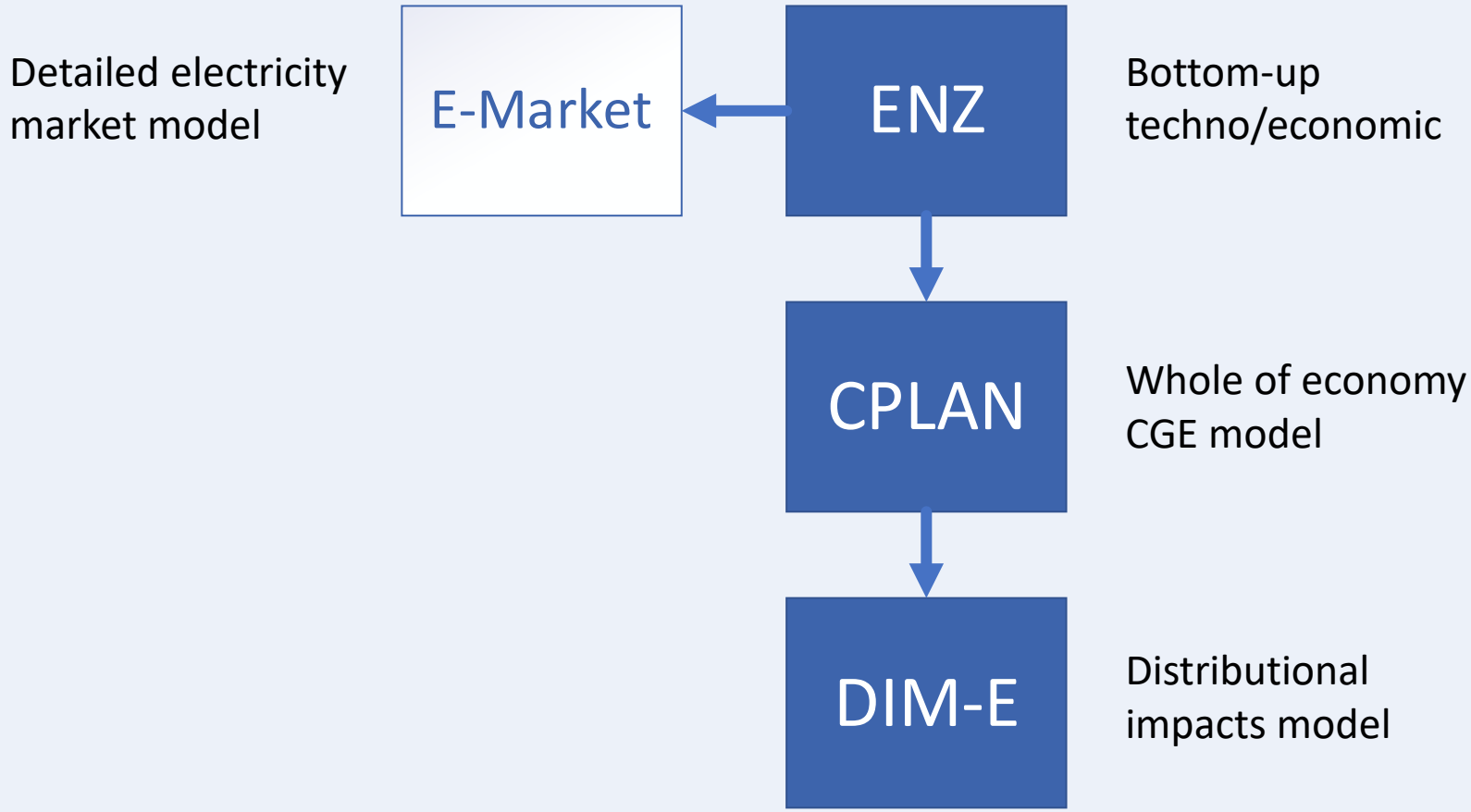
He Pou a Rangi
Climate Change Commission

Current market conditions



emi.ea.govt.nz/r/kwlnv

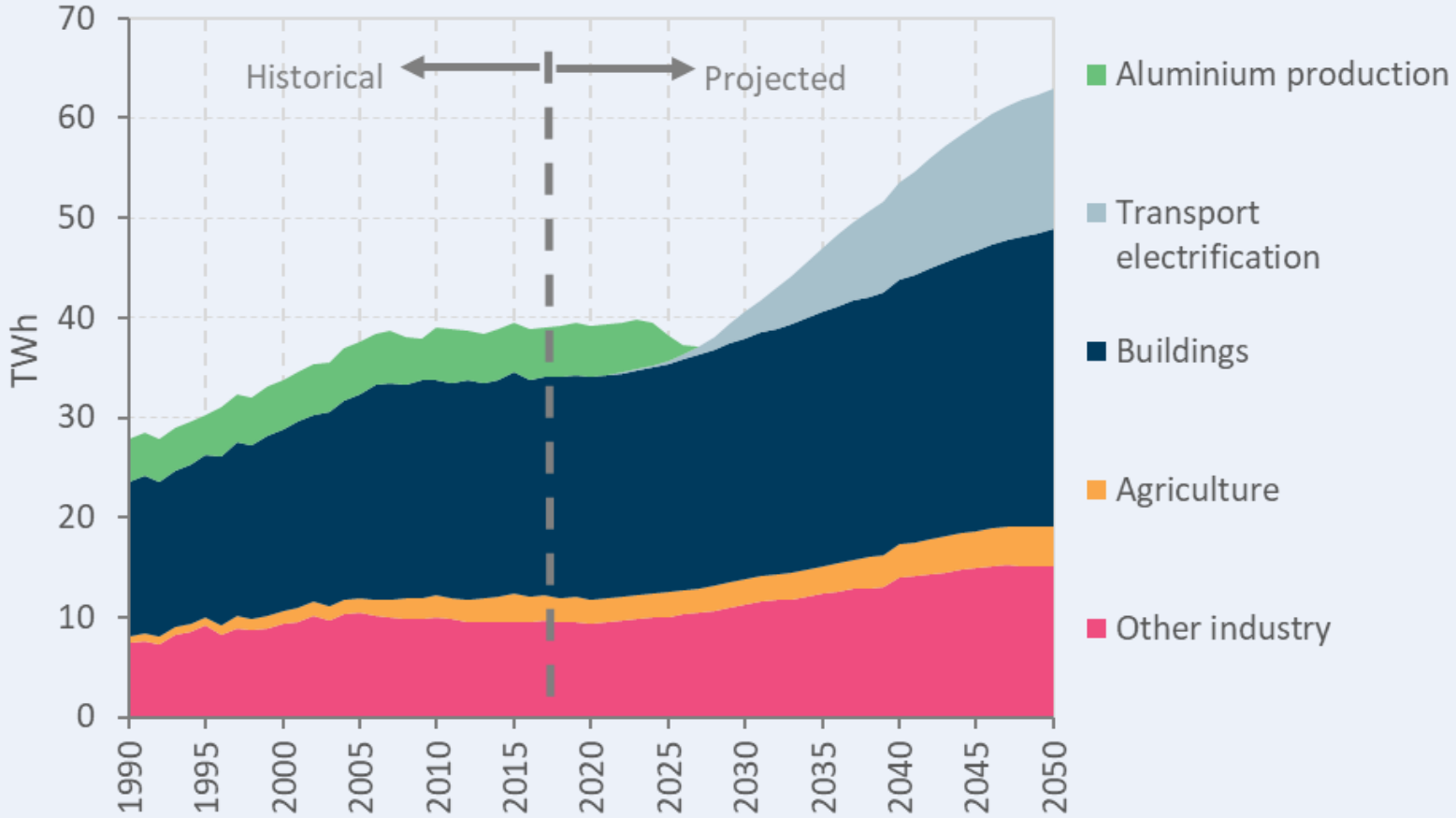
Our modelling system



Context and purpose

- Complement the basic electricity system of ENZ with Energy Link's more detailed market model.
- Include a detailed list of future generation projects.
- With dynamic demand modelling.
- Test electricity system with simulated hydro flows, wind and solar patterns.
- Validate ENZ market price and thermal operation.
- Gain insight into impact of Tiwai closure and Lake Onslow pumped storage scheme.

Demand growth



Generation stack

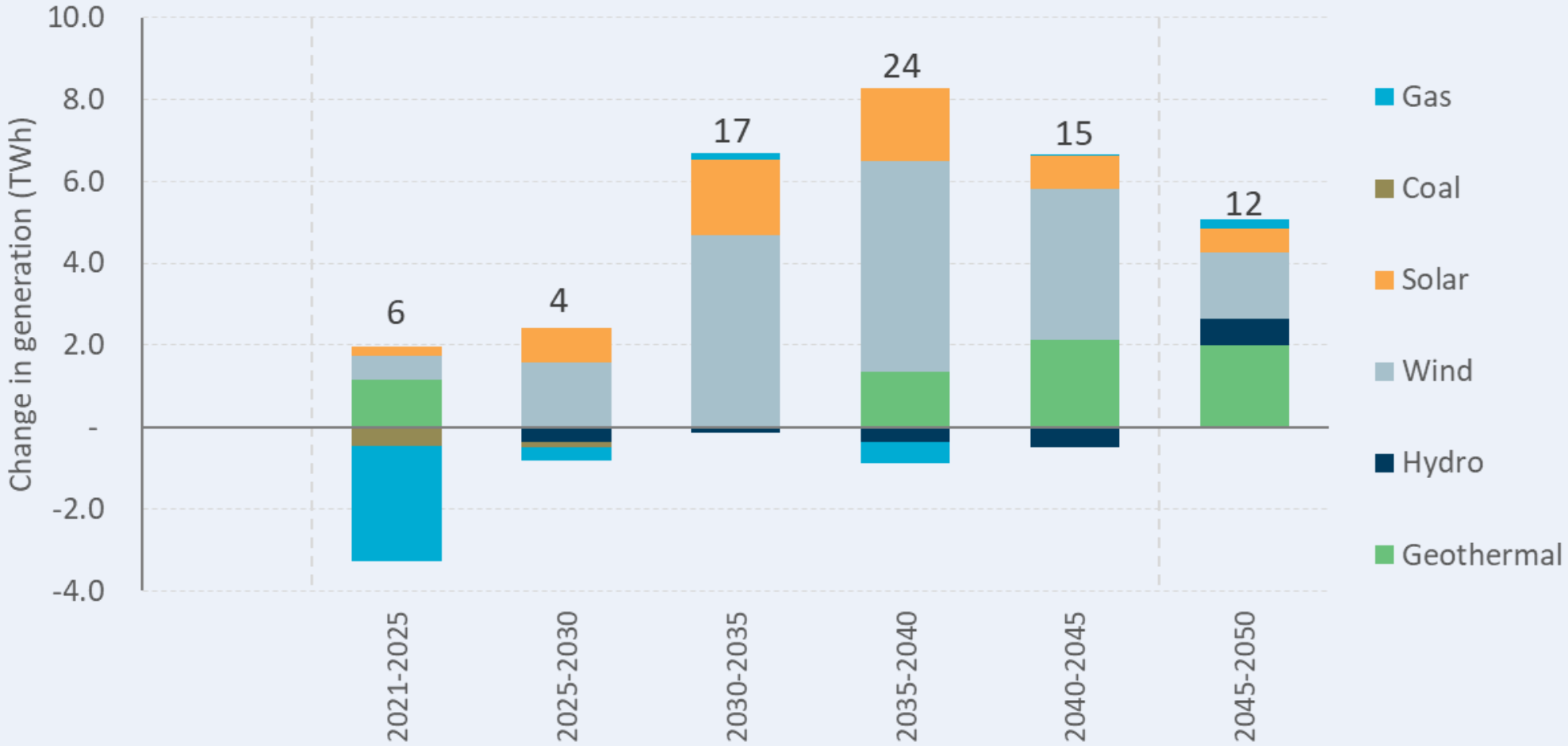
	Wind	Solar	Geothermal	Hydro	Peaker
Number of projects	47	11	15	12	6
Potential Total Installed capacity (GW)	5.60	1.73	1.11	0.65	0.86
Total generation (GWh)	19,640	3,330	9,060	3,380	750
Min 2020 LCOE ($/MWh)	57	91	73	105	268
Max 2020 LCOE ($/MWh)	90	114	117	128	290
Rate of CAPEX reduction	0.8% p.a to 2035, 0.5% p.a 2035-2050	3.0% p.a to 2035, 1.8% p.a 2035-2050	NA	NA	NA

Other assumptions/settings

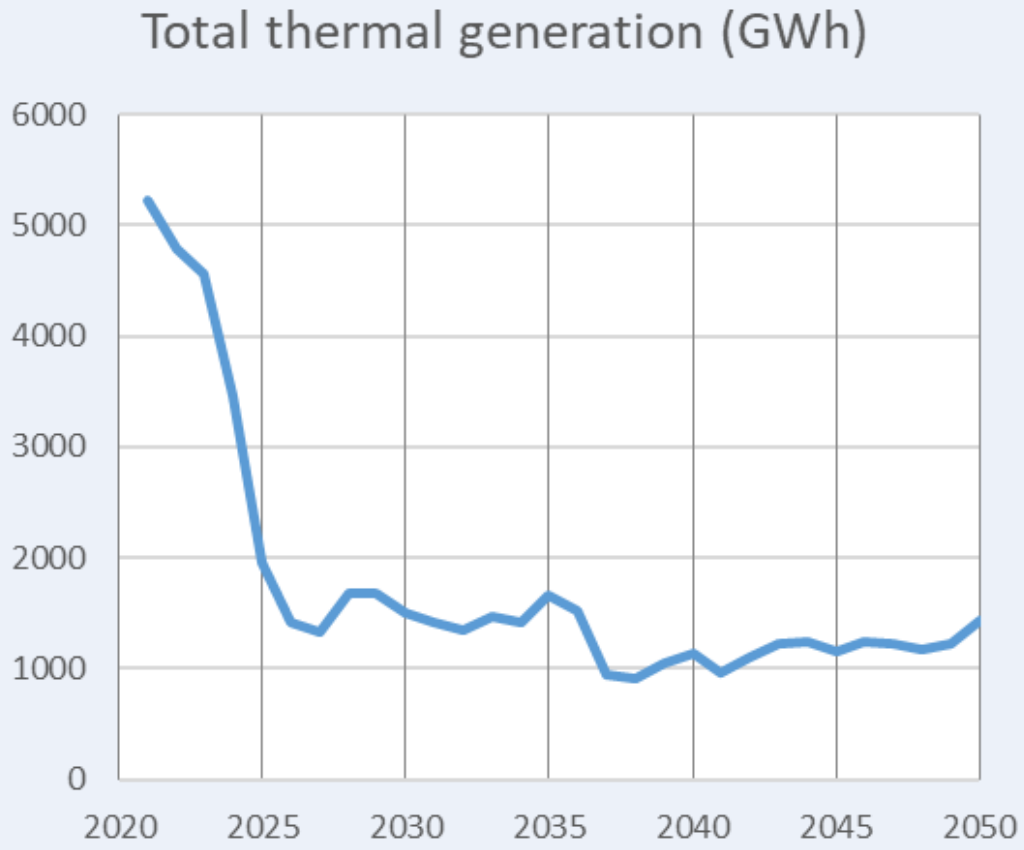
- Current market structure is unchanged.
- New projects are profitable.
- Networks are not a constraint.
- Emissions price rises to $250 by 2050.
- E-market mostly run in day night mode except for reference years (2035, 2050).
- Gas price rising from $8.6/GJ to $9.6/GJ by 2030.

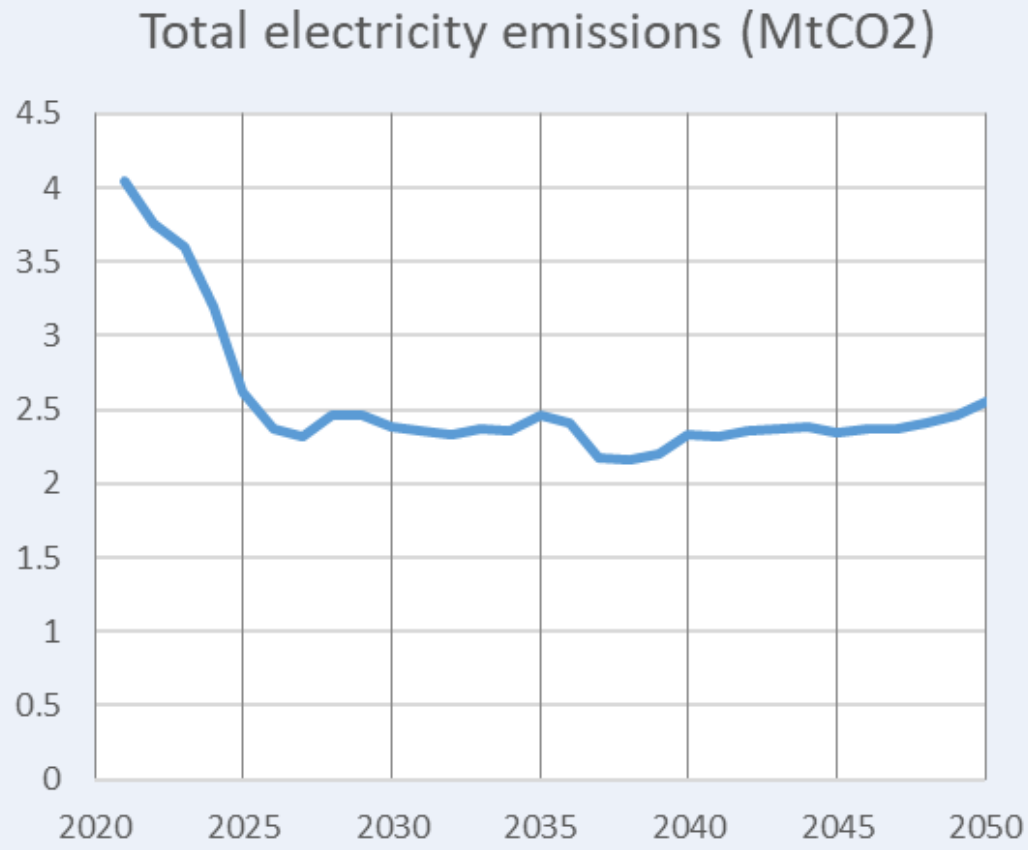
Results

Generation build and thermal retirement



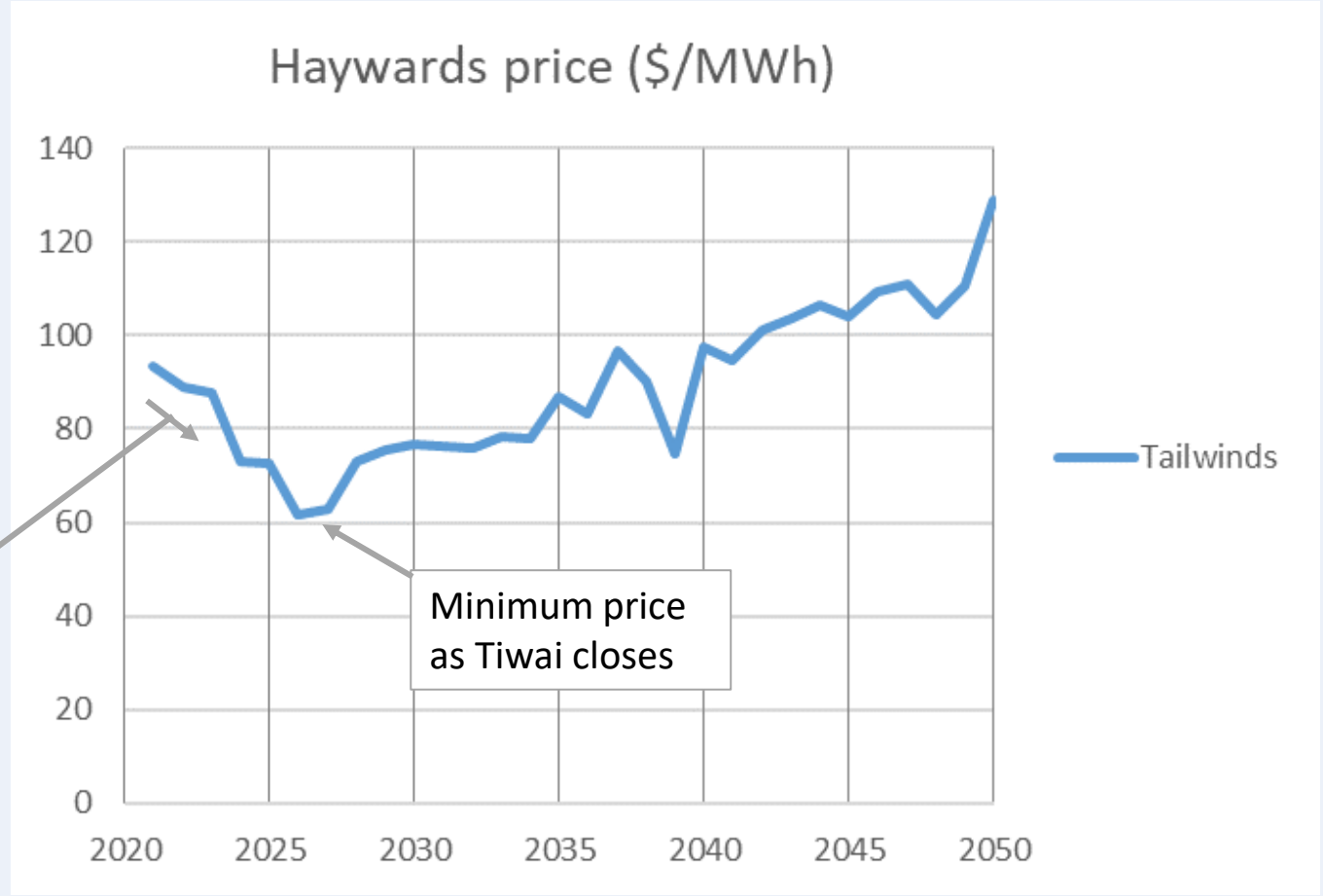
System emissions and thermal generation



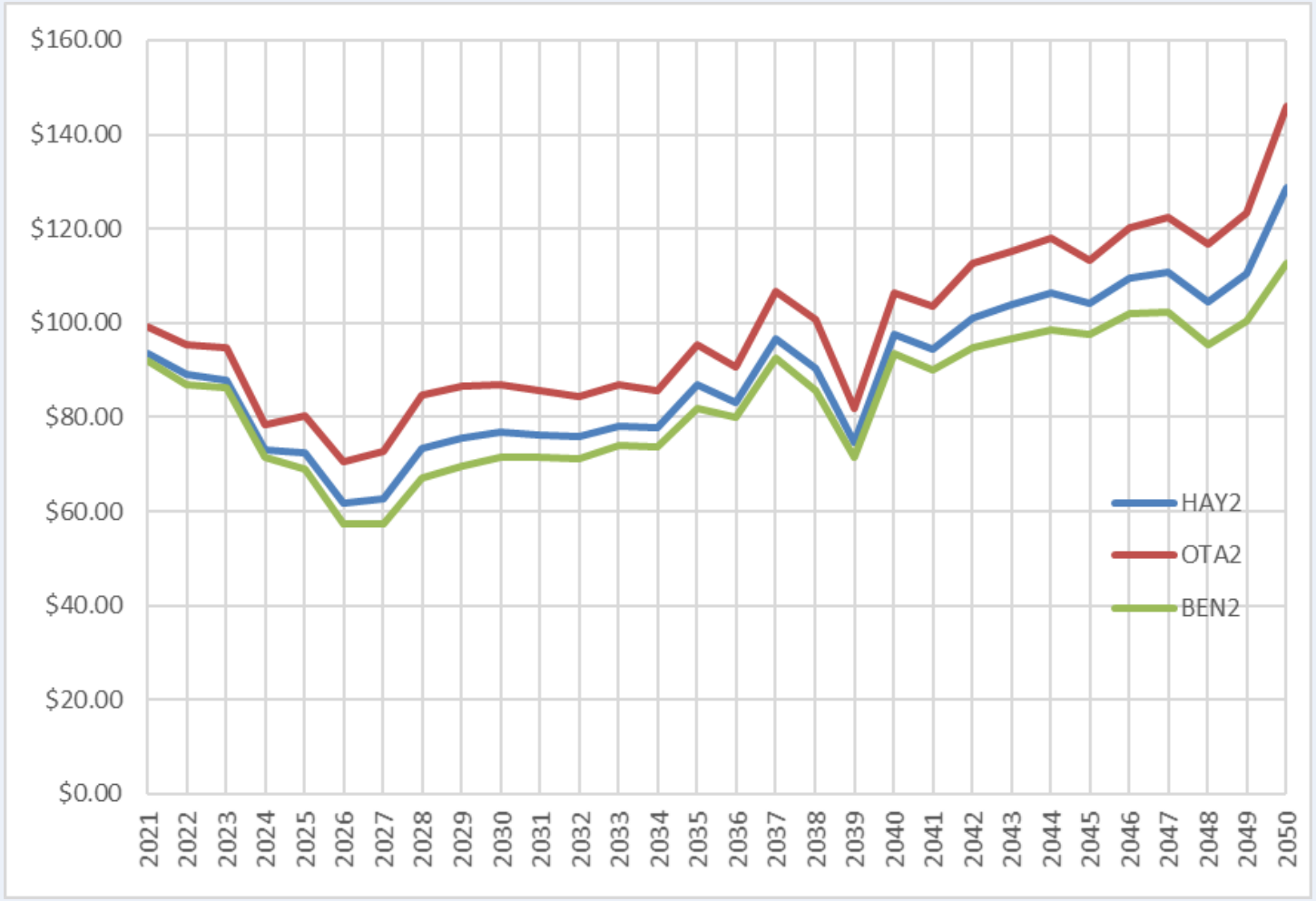


Questions?

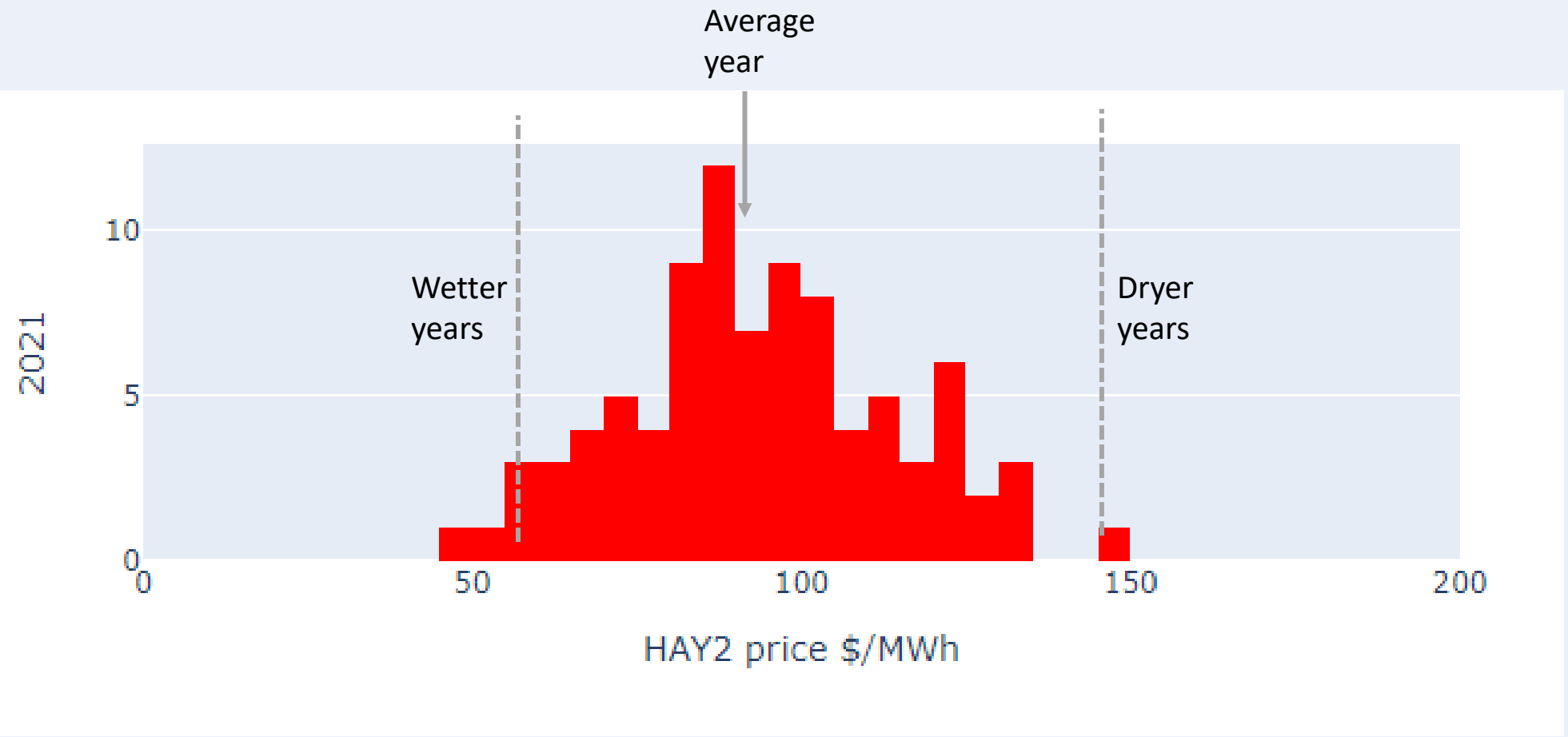
Wholesale market price



Regional pricing variation

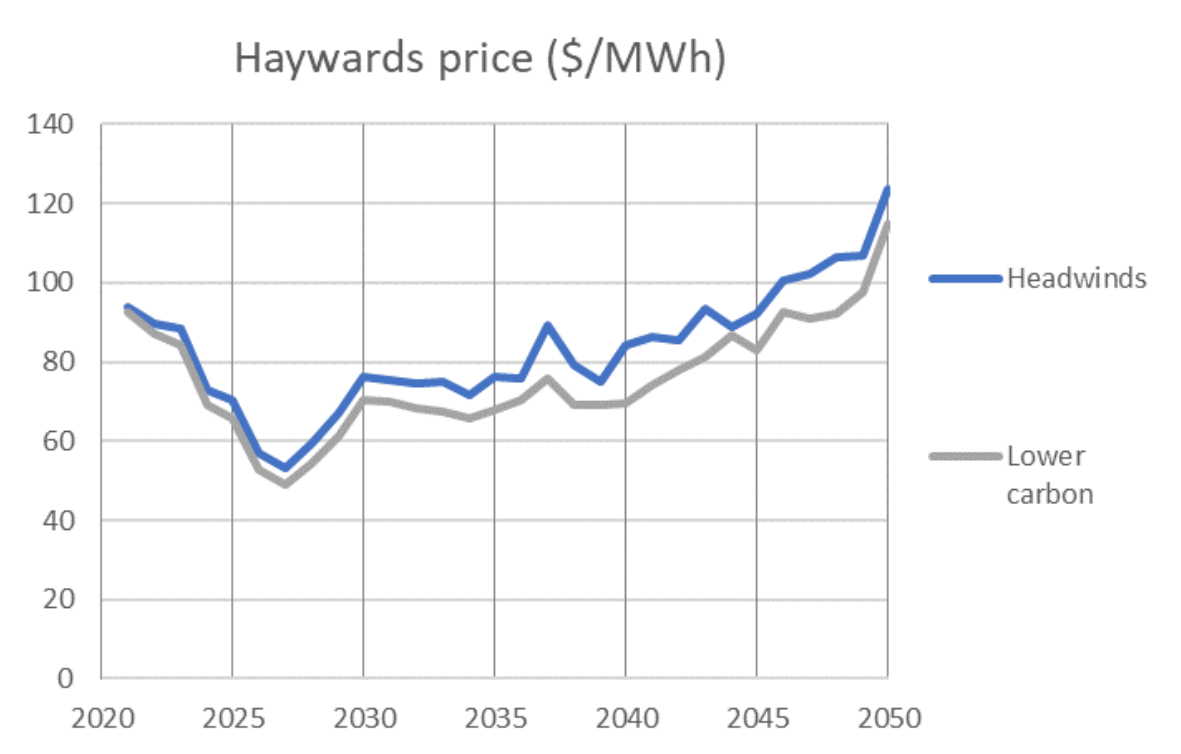


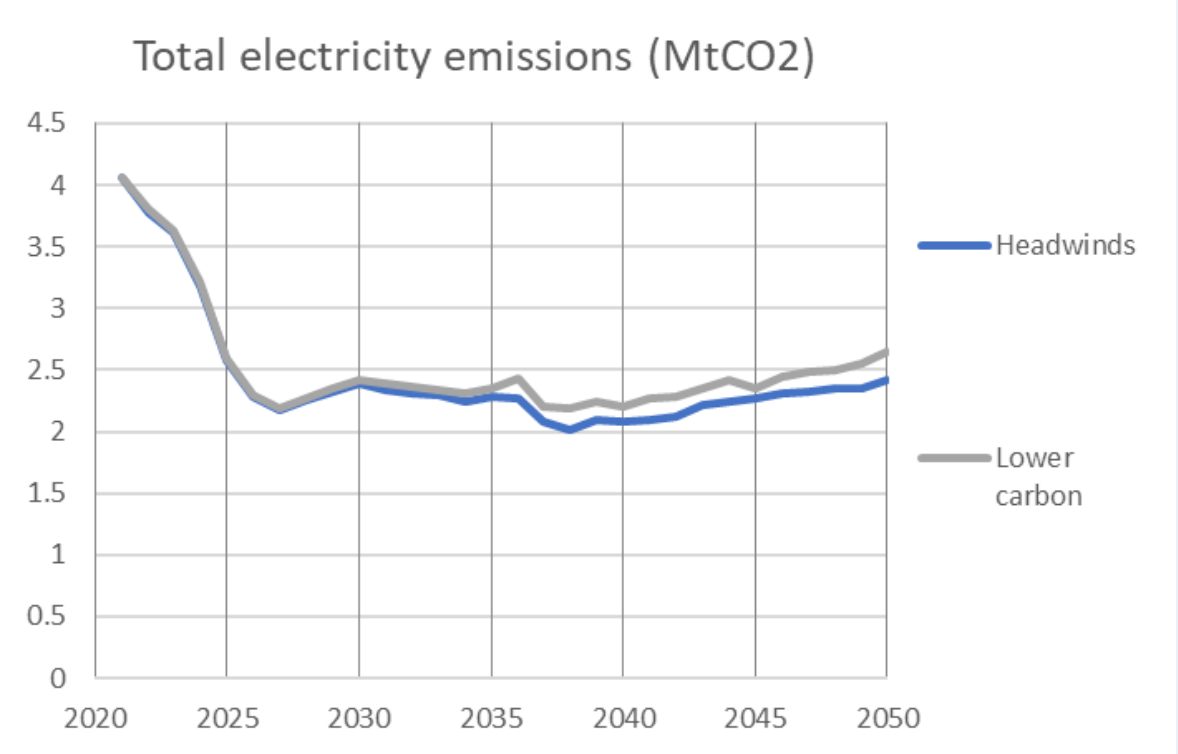
Distribution of prices



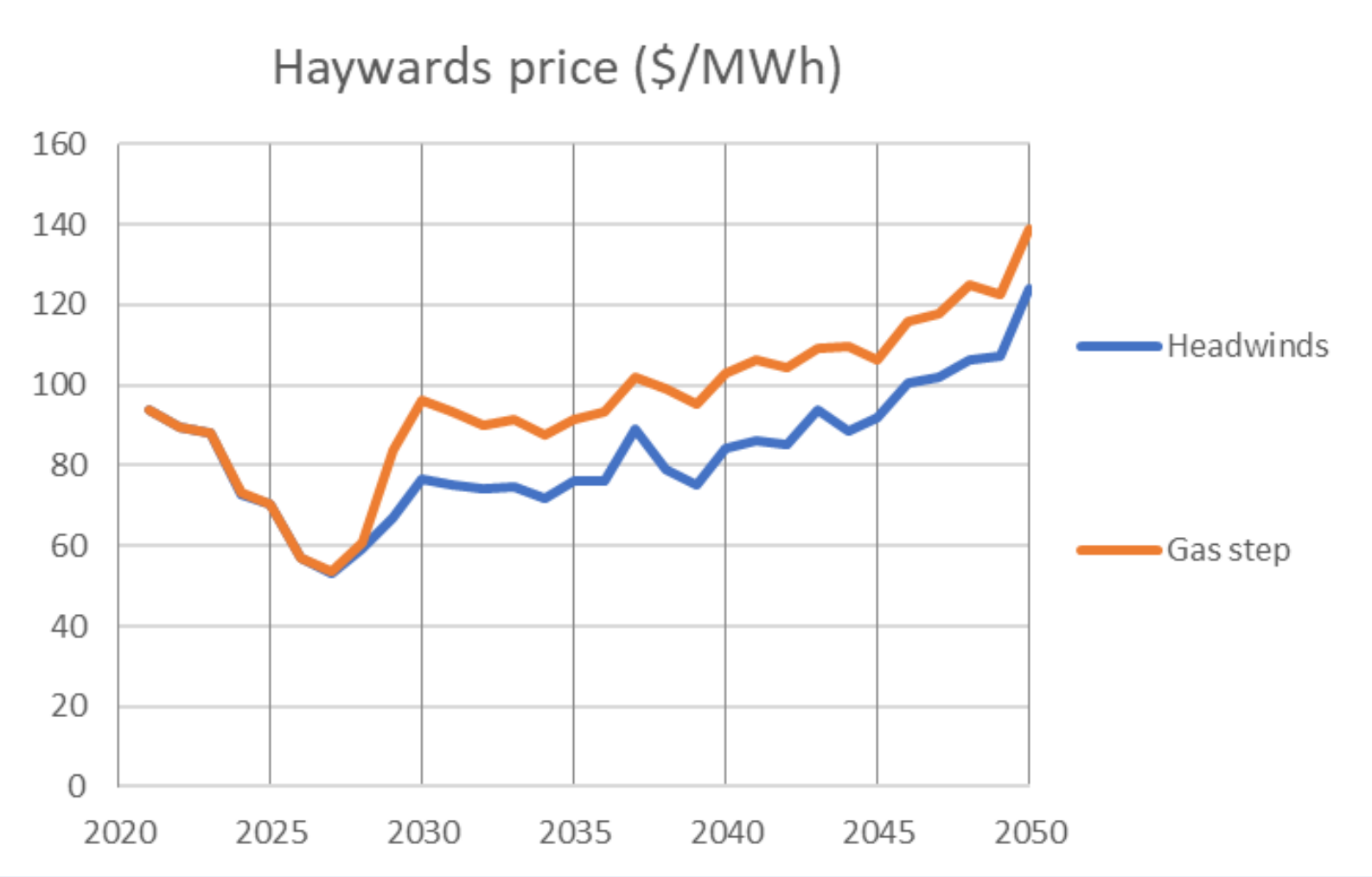
Questions?

Sensitivity - Carbon price effects





Gas price step sensitivity



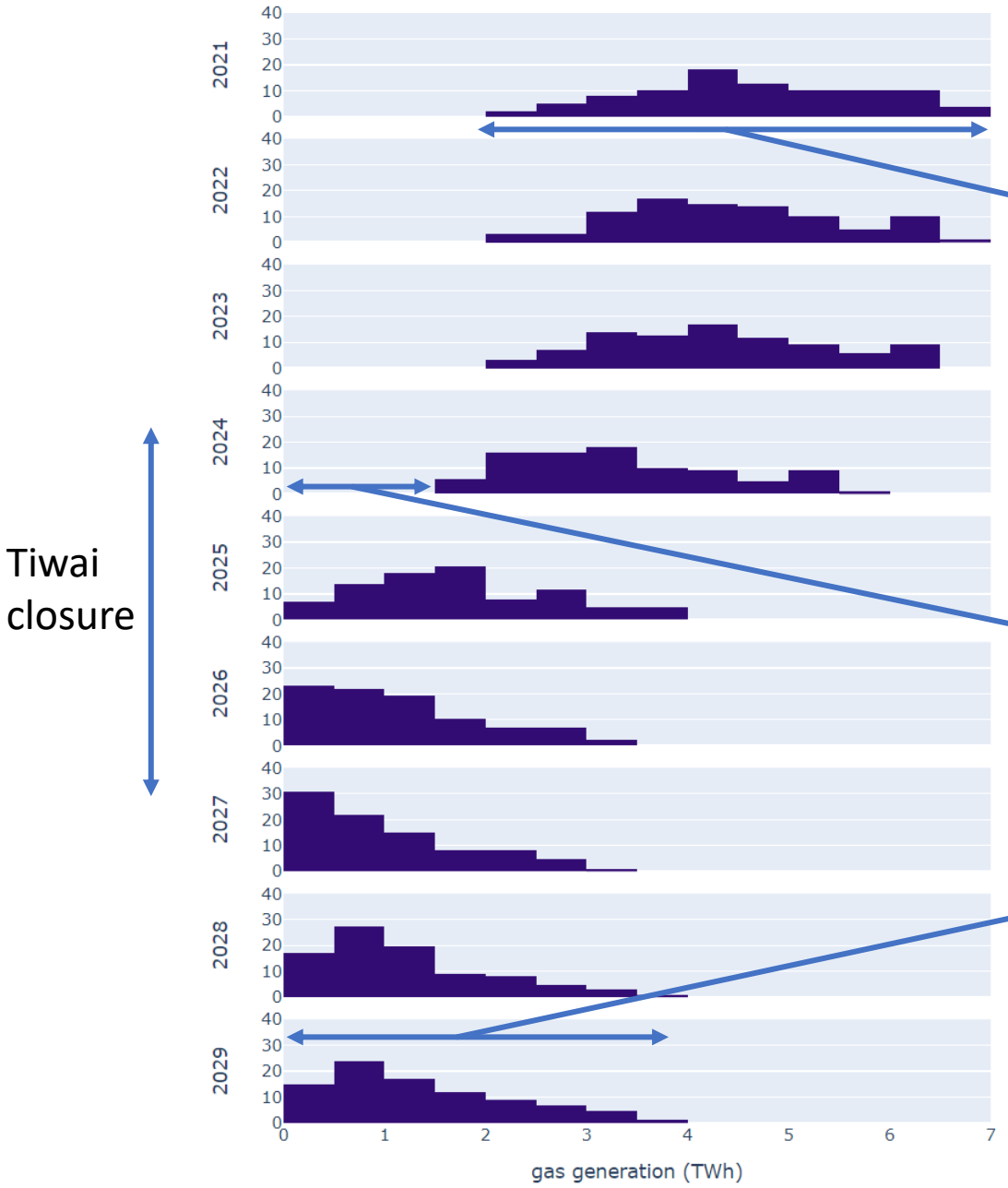
Questions?

Investigating a pumped hydro storage scheme

- Modelled a ~5,000GWh scheme at Lake Onslow as a sensitivity
- The scheme becomes operational at around 2033.
- Runs at a 70% efficiency (pumping losses).
- Participates in market by purchasing electricity and on-selling later.
- Water values are assigned to resource to manage scarcity.
- Operates intra-day, intra-season and intra-year.
- Covers costs of operating but doesn't try to pay for CAPEX.

Does it solve the dry year problem?

Thermal generation **2020-2029** across 90 year record of hydro flows



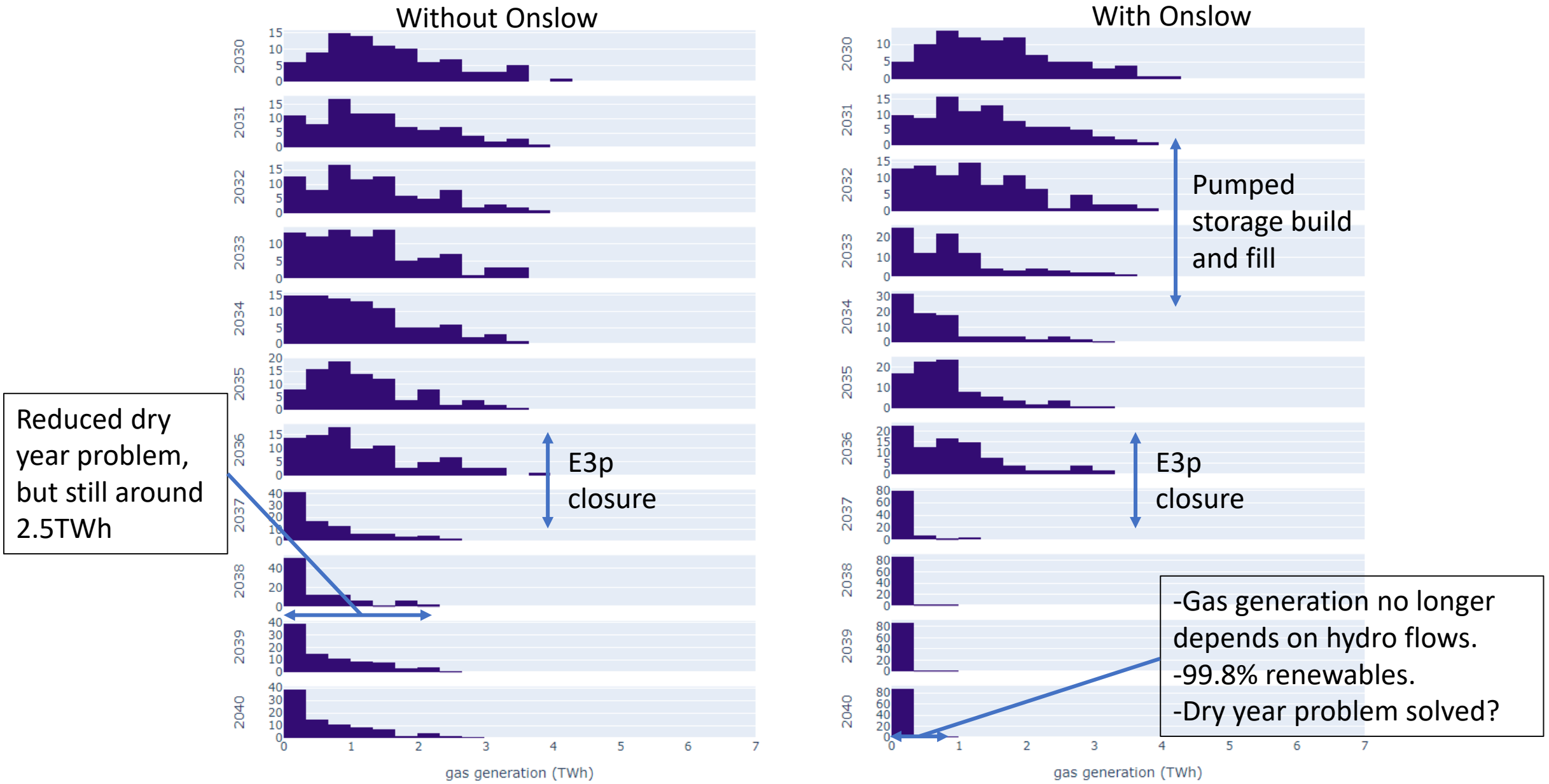
Tiwai closure

Variation in modelled thermal generation across 90 hydro inflows shows the ‘Dry year problem’

Tiwai closure + Tauhara geothermal displace baseload gas

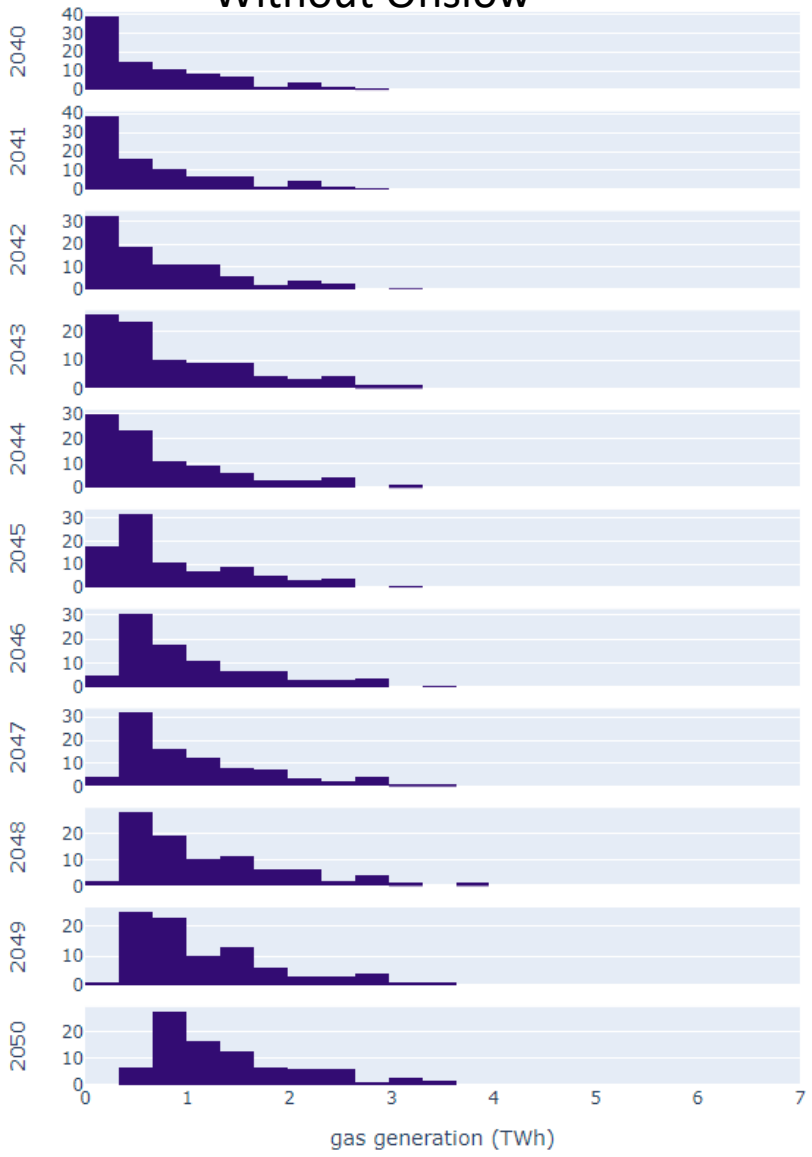
Dry year problem still around 4TWh, but average shortage is smaller

Thermal generation **2030-2039** across 90 year record of hydro flows

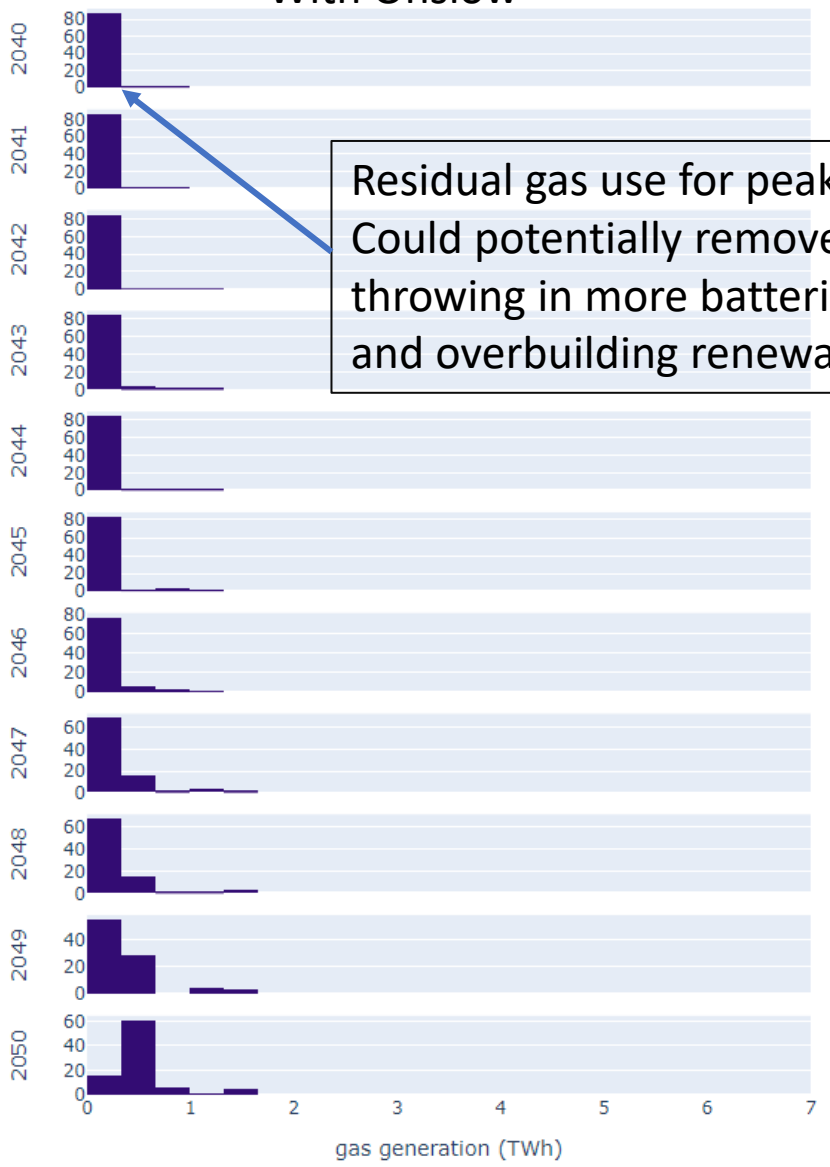


Thermal generation **2040-2050** across 90 year record of hydro flows

Without Onslow



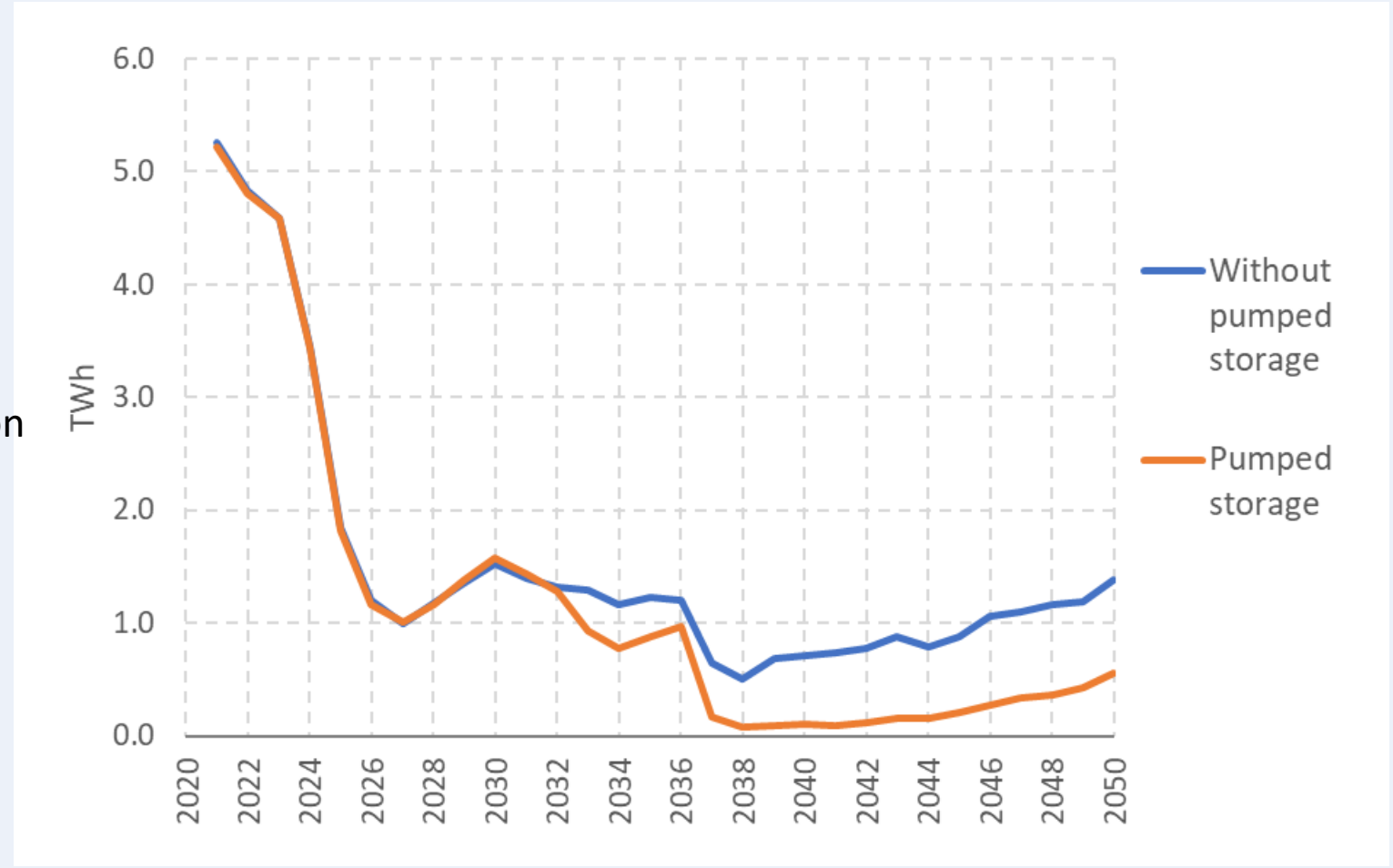
With Onslow



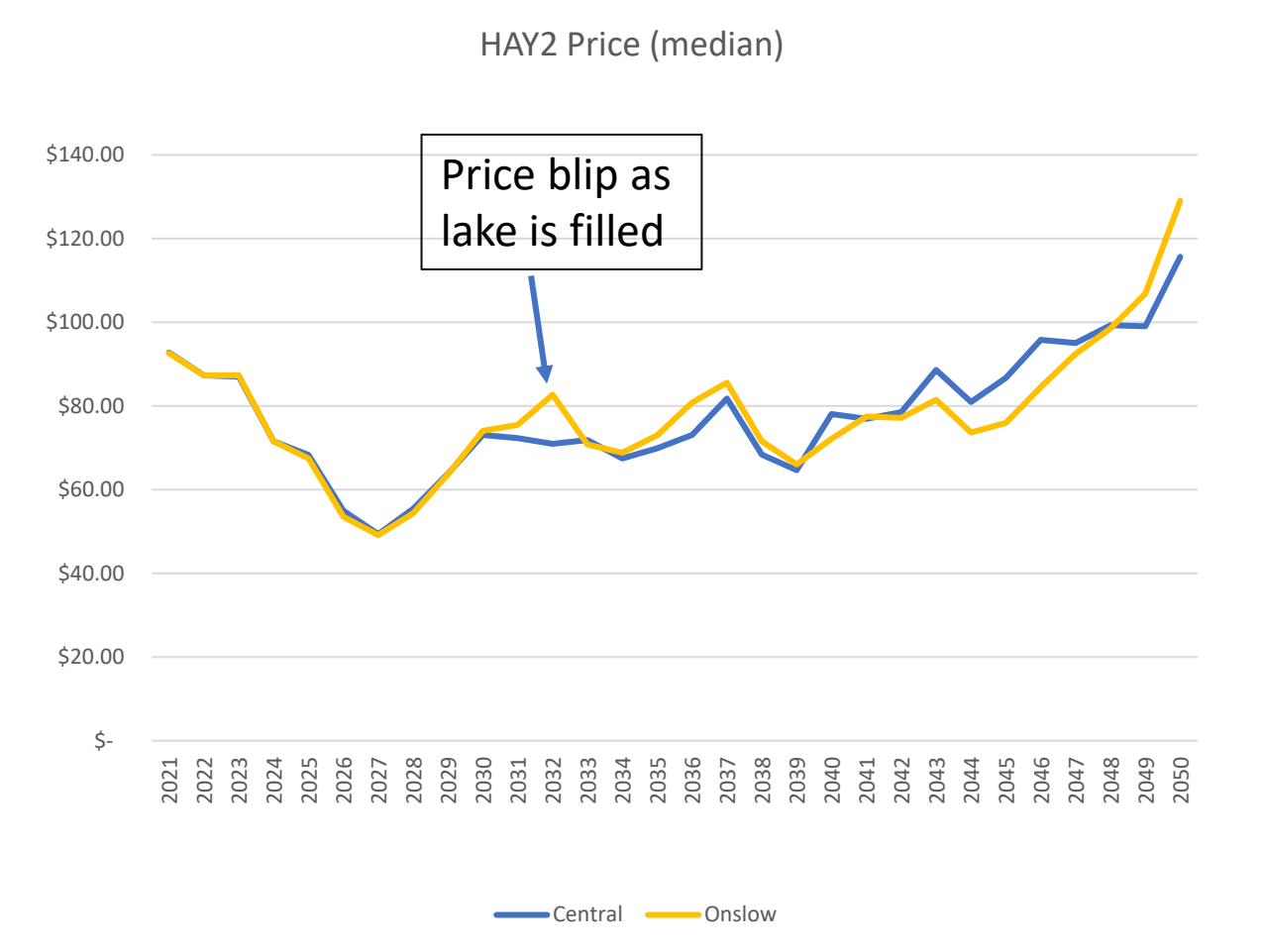
Residual gas use for peaking. Could potentially remove by throwing in more batteries and overbuilding renewables.

Investigating a pumped hydro storage scheme

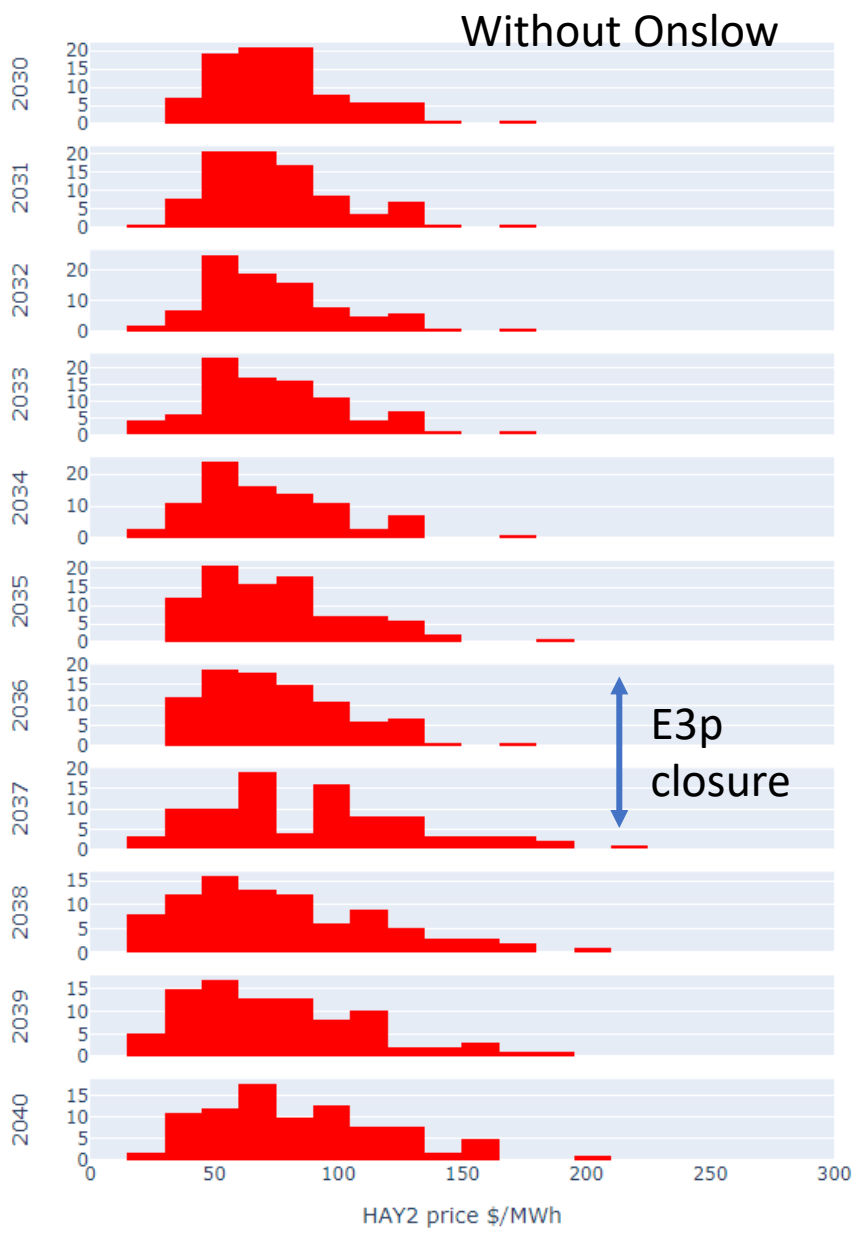
Thermal generation

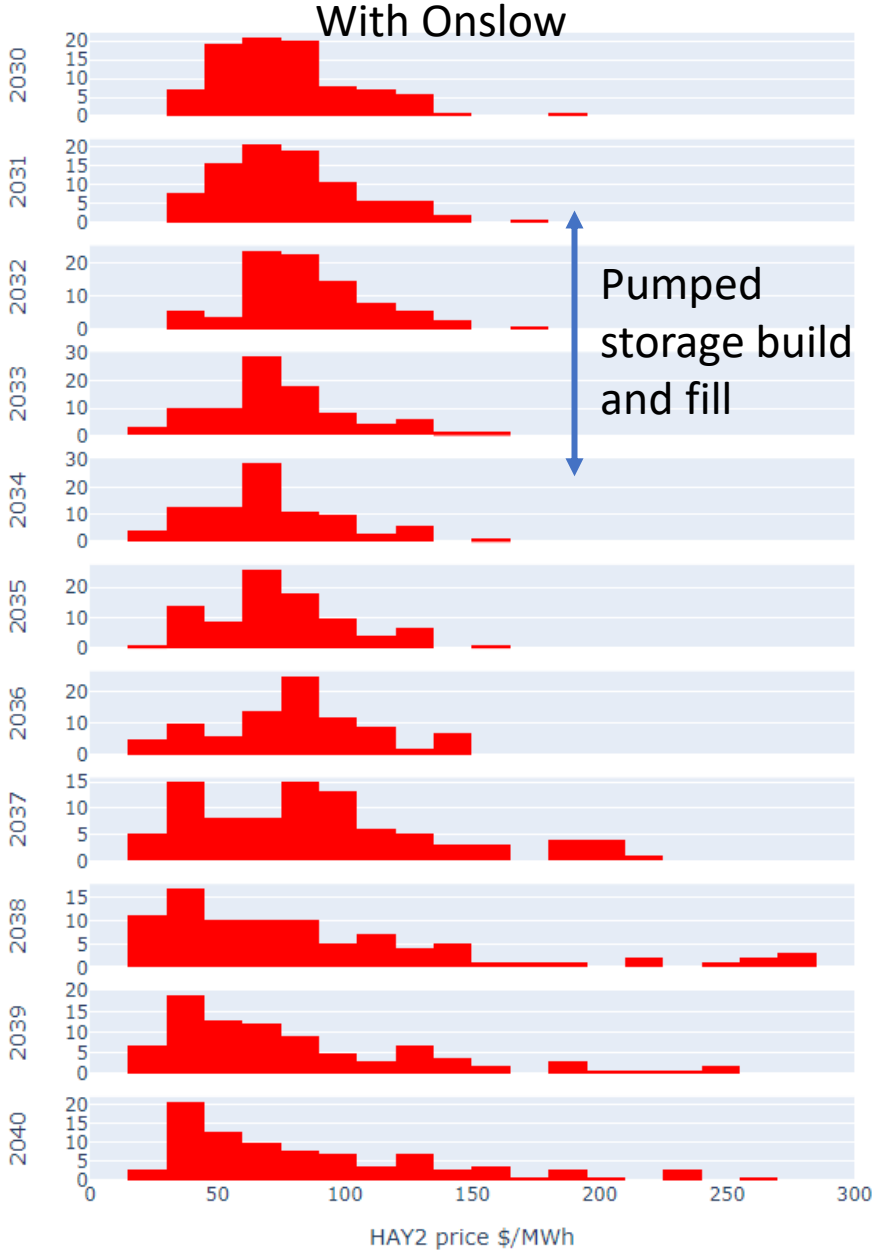


Market price effects



Market prices **2020-2029** across 90 year record of hydro flows





Investigating a pumped hydro storage scheme

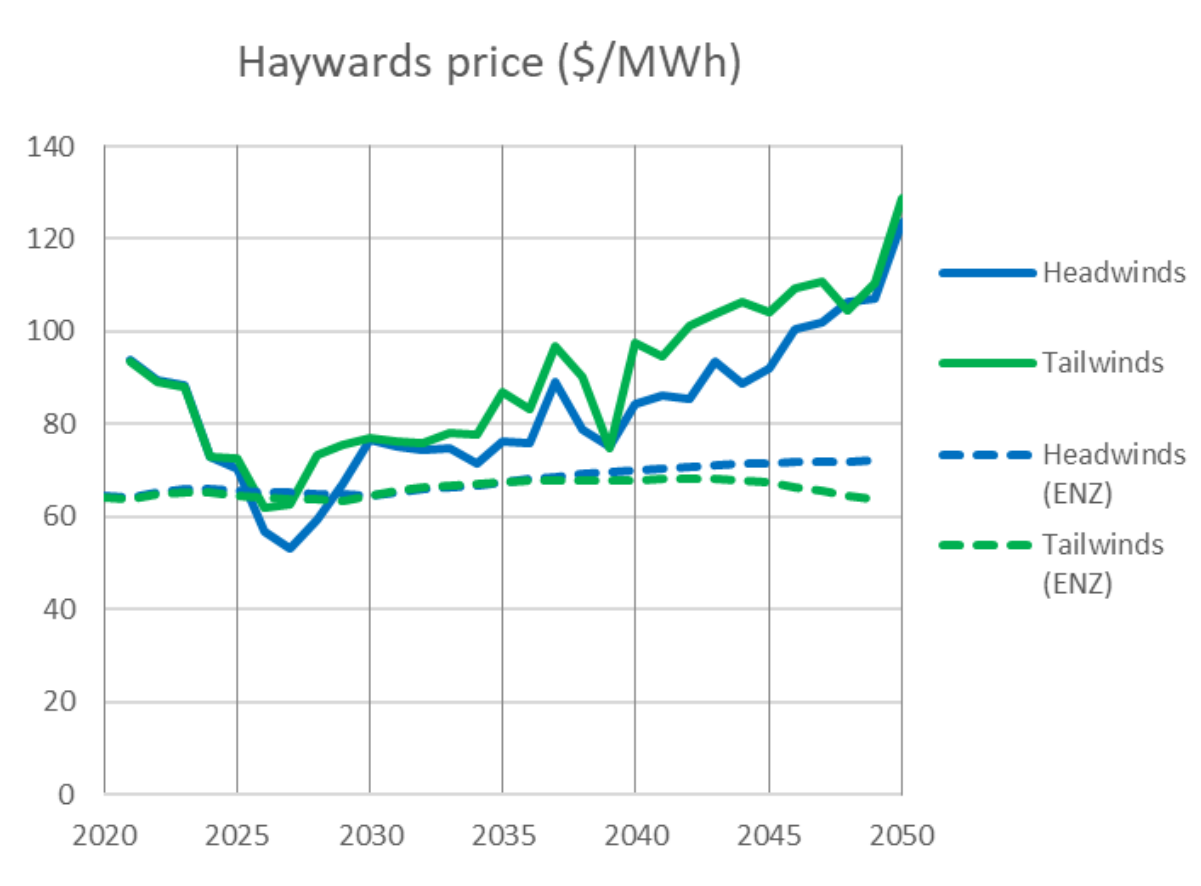
Summary:

- Model shows that a 5,000GWh pumped storage scheme largely decouples thermal generation from lake inflows (and wind and solar seasonal variation later).
- Gas is still in system for peaking purposes. Eliminating gas was not the purpose of this exercise. But have reached 99.8% renewables average.

Questions?

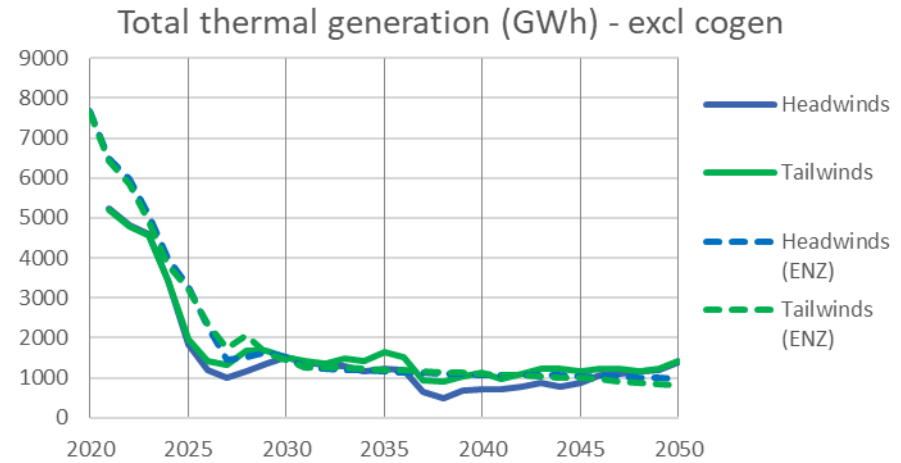
Comparison with ENZ (Headwinds and tailwinds)

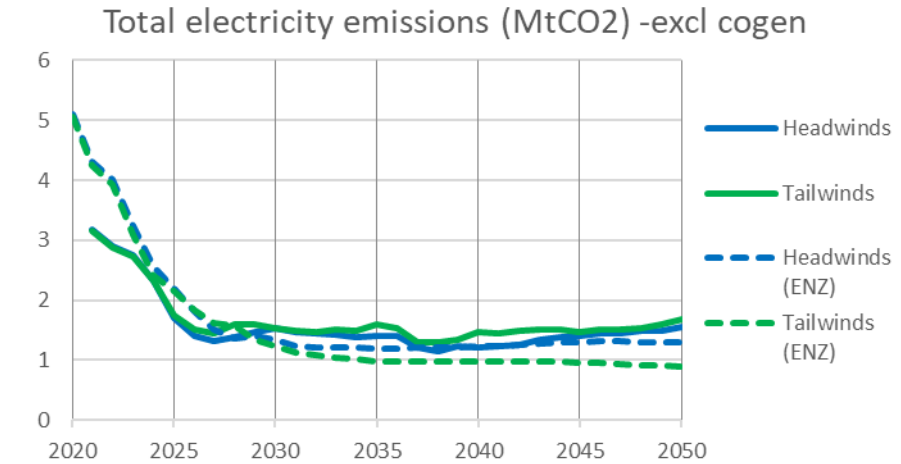
- ENZ market price is determined by LCOE of next cheapest project on idealised supply curve. Penalties are applied as renewables increase penetration and a short term correction is made (not shown) based on futures market.
- E-market model has a much more detailed generation stack with location and weather factors.
- Builds are manually deployed and revenue thresholds are checked.
- Higher prices in E-market beyond 2040 in part due to assumed generation stack running out of low-cost renewable projects. Comparison is of limited usefulness at this point.

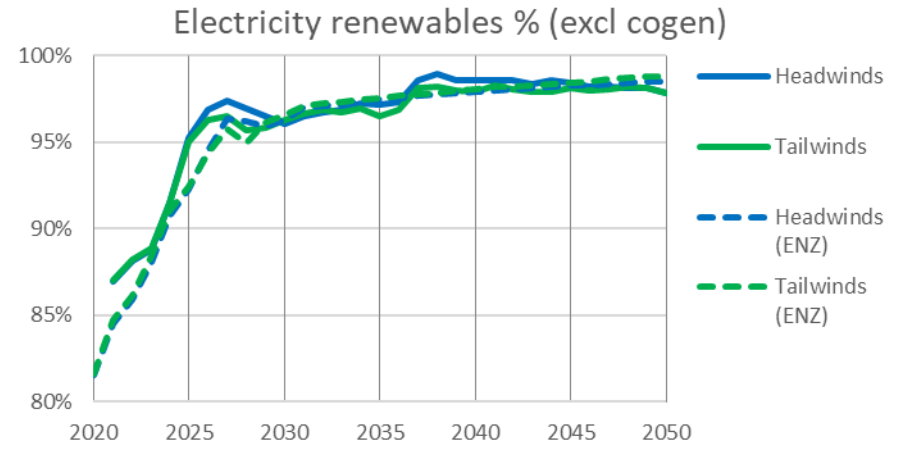


Comparison with ENZ (Headwinds and Tailwinds)

- ENZ estimates higher levels of thermal generation in short term. This is due to differences in base year generation and immediate build schedule.
- ENZ has lower total emissions beyond 2030. This is because high emissions geothermal fields close and geothermal re-injection is applied (Tailwinds).
- Setting aside cogeneration, both models give similar projection of renewables % (above 96% by 2030 and peaking at around 98%).







Scenarios and sensitivities

Headwinds and Tailwinds were modelled as scenarios.

- The modelled results of electricity demand from ENZ are used as inputs to the Energy Link models.
- This alignment was as of Nov 2020
- Regional demand profile provided for process heat electrification.
- Sensitivities to Headwinds scenario are:
  - a lower carbon price,
  - step increase in gas price and
  - integration of pumped hydro storage scheme.