

Towards a very low emissions electricity system

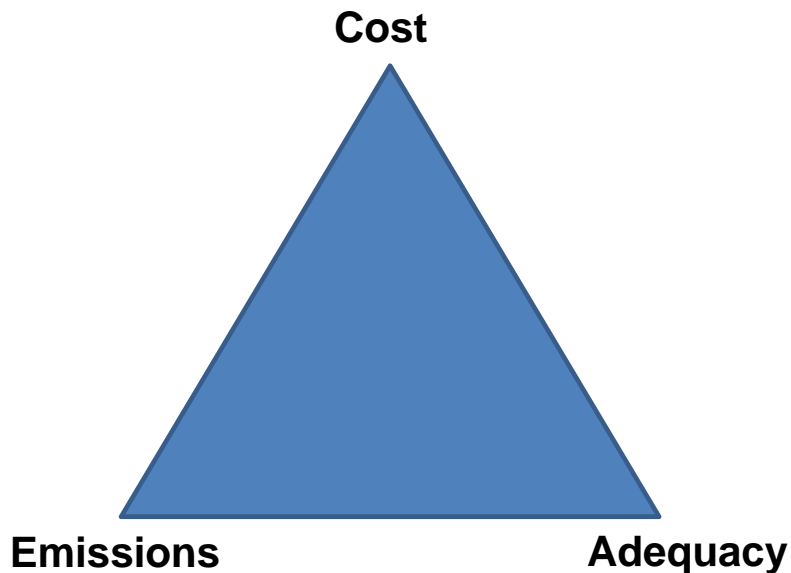
Toby Stevenson, Stephen Batstone, David Reeve, Corina Comendant, Matt Poynton

March 2018



sapere[®]
research group

Our Brief

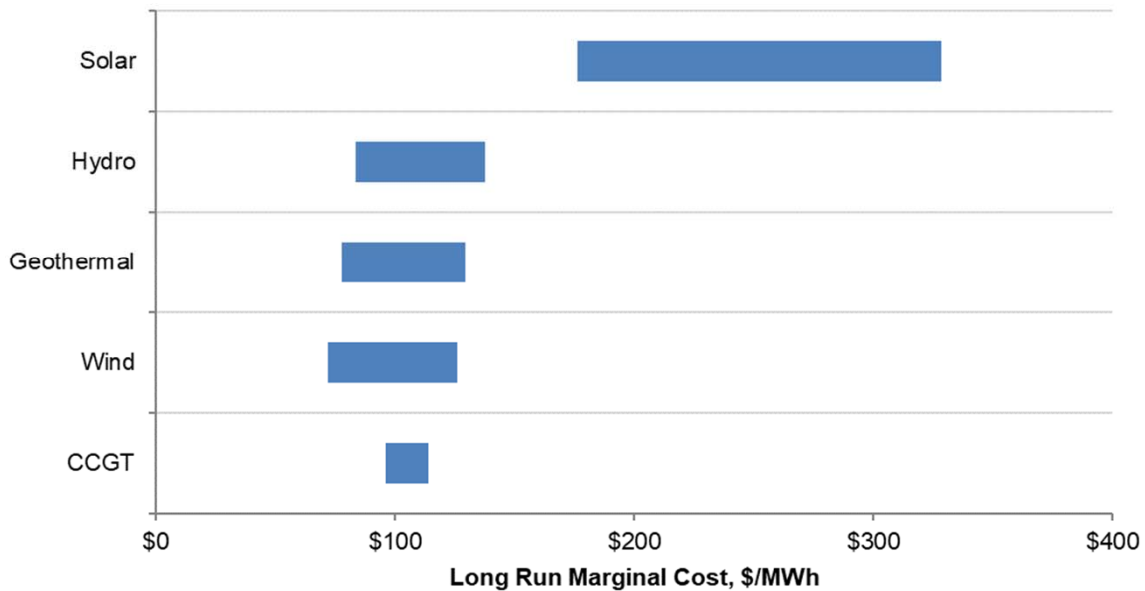


Based on what we know today, if an economy-wide carbon price is in place (reflecting our country's decarbonisation targets):

- Q1: In 2050 what is the lowest level of emissions that can be achieved in the New Zealand electricity sector technically and practicably while sustaining acceptable reliability and security standards?
- Q2: What is the cost of providing a flexible and resource adequate system with progressively lower emissions levels?
- Q3: Alongside the Emissions Trading Scheme (ETS), what other steps should regulators and policy makers consider with a view to accommodating a very low emissions electricity sector by 2050?

Decisions required to move to very low emissions

LRMCs at carbon price of \$60/t CO₂-e



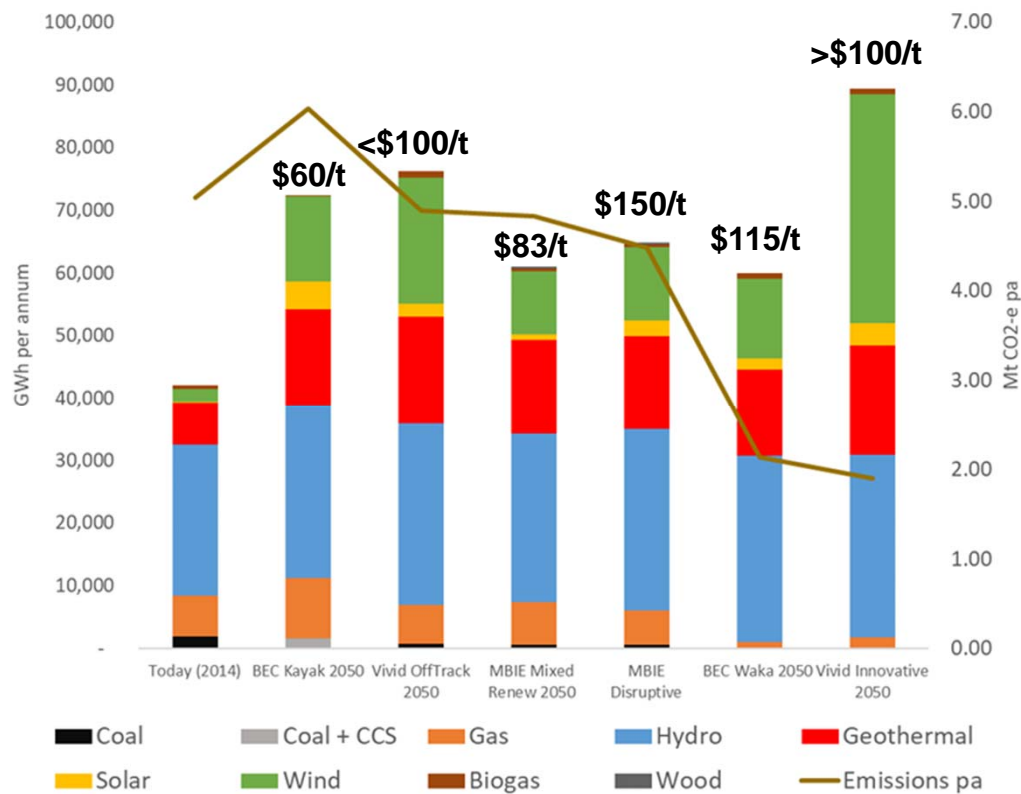
Reducing emissions requires us to:

- Removing some/all existing thermal
- Replacing this, and meeting any demand growth, with low-emissions generation

What we replace thermal with must do the same roles thermal does currently.

The possibilities open to us will be driven by technology, cost, carbon price and fuel – all highly uncertain over this timeframe.

Scenarios of emissions in 2050



Costs mostly as assumed in MBIE's 2016 EDGS

A doubling of geothermal in all scenarios

A variety of solar uptakes

Modest investments in hydro

Wind as a the swing fuel...and up to 5,000MW?

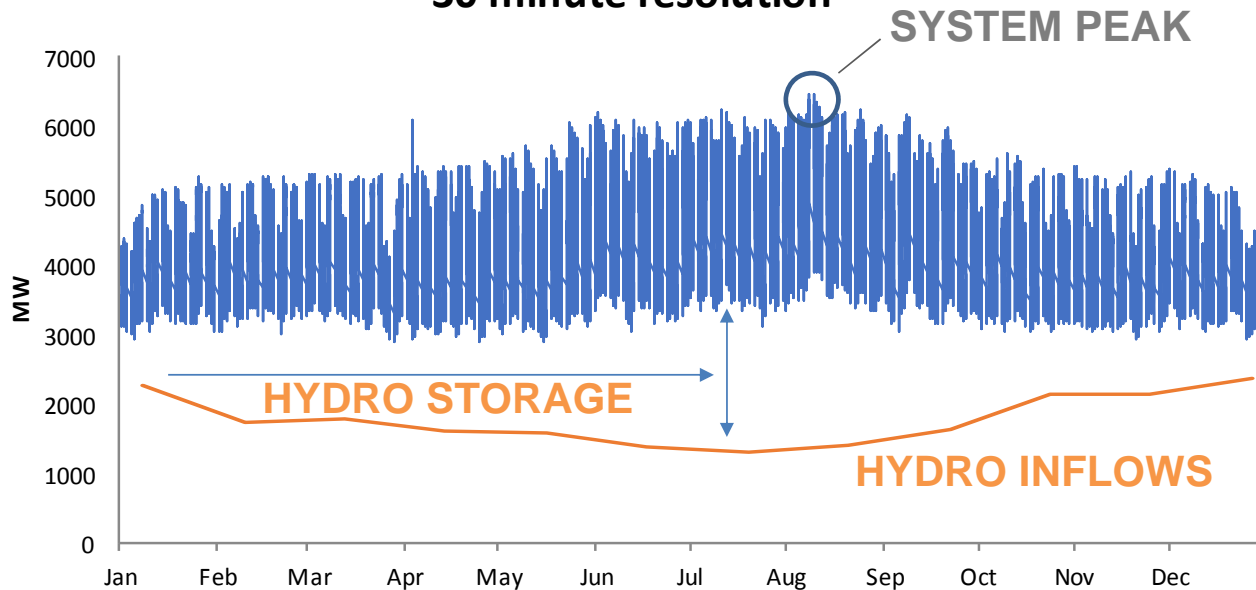
Most significant differences in emissions driven by thermal decommissioning

Underpinned by assumed carbon prices



Maintaining resource adequacy

NZ Electricity Demand
30 minute resolution



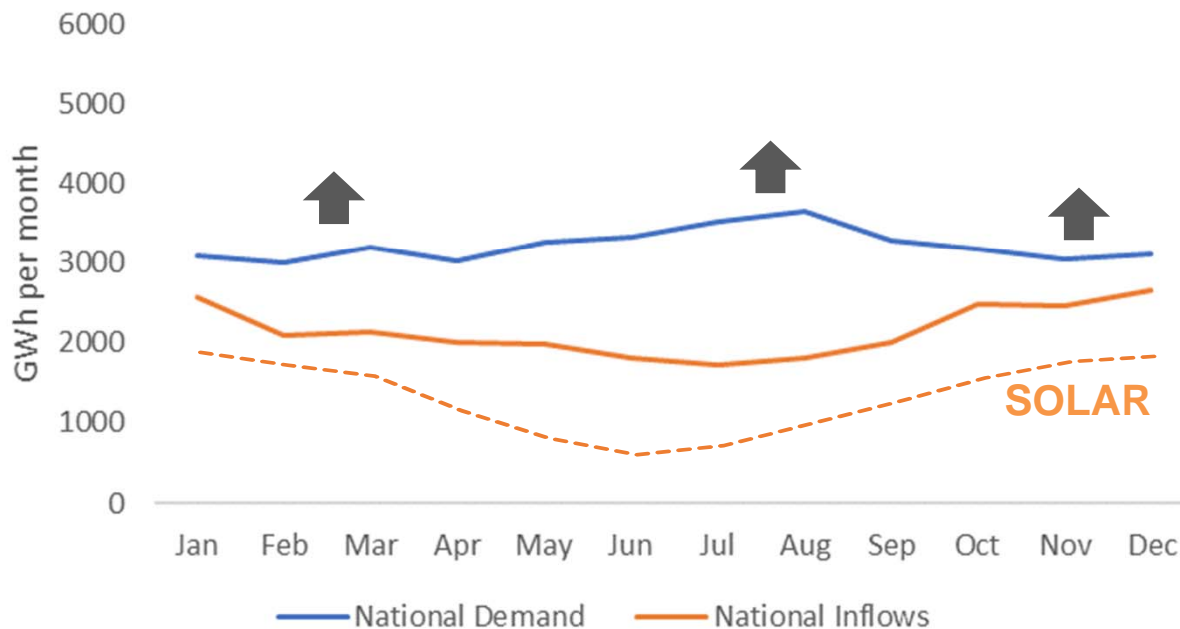
Resource adequacy – the ability to meet demand at every point in time

Our system requires this flexibility:

- Across short time periods (minutes-days), which can be provided by hydro, gas turbines, demand response and batteries
- Across medium time periods (weeks-months) provided by hydro storage and thermal fuel flexibility
- Across longer time periods (years)

The ongoing importance of storage and fuel flexibility

Average National Inflows vs National Electricity Demand



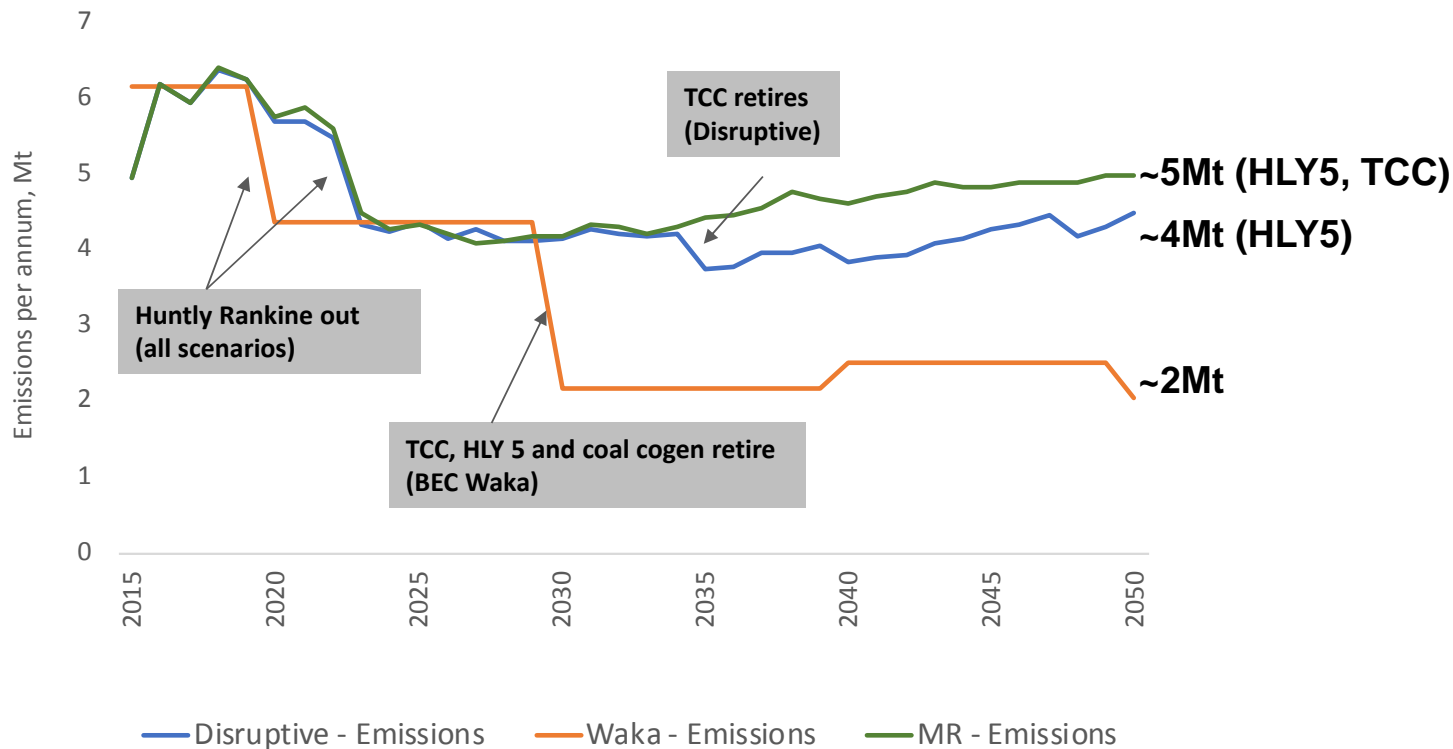
Variability in inflows over the year, and between years will always need storage and flexible fuel.

The way in which demand grows may help reduce the seasonal shifting required.

Solar exacerbates the issue

Transitioning away from Rankines and CCGTs...

MBIE Disruptive vs BEC Waka



Emissions outcomes heavily influenced by retirement vs refurbishment decisions

A function of the carbon price, but other factors too.

Models transitioned away from 'baseload' thermals to renewables plus:

- Flexible peakers, demand response + batteries for short term management
- Flexible peakers for medium term/dry year

Deeper cuts (towards 100% renewable)

Energy Policy 60 (2013) 324–333



Contents lists available at SciVerse ScienceDirect

Energy Policy

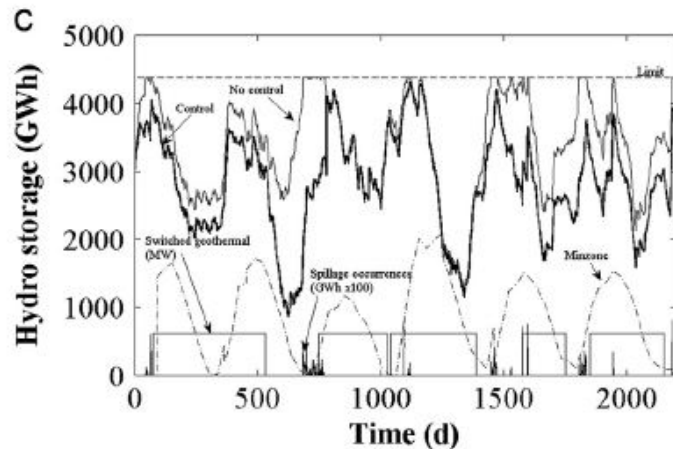
journal homepage: www.elsevier.com/locate/enpol



Security of supply, energy spillage control and peaking options within a 100% renewable electricity system for New Zealand



I.G. Mason ^{a,*}, S.C. Page ^c, A.G. Williamson ^b

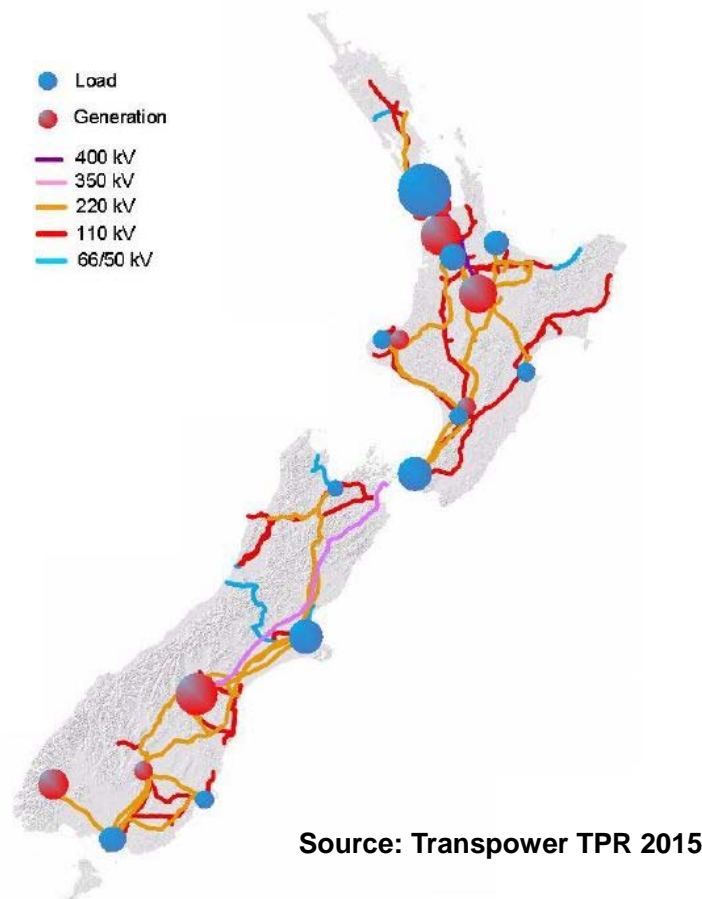


Based on the mature technologies we use today, we think minimum **emissions of around 1Mt is possible**, but only by using partially loaded geothermal for hydro firming (Mason *et al*).

But by 2050, anything is possible:

- Zero-emission geothermal systems?
- Biomass-fuelled peakers?
- Hydrogen storage?
- Pumped storage?
- [Industrial] Demand response?
- Carbon capture and storage?

Implications: Transmission and Ancillary Services



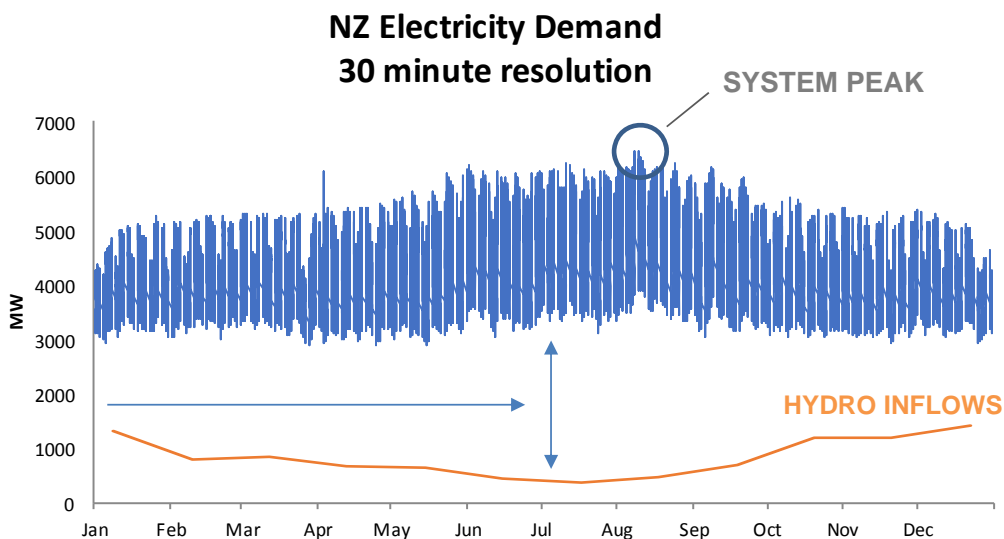
Transpower's current grid plans for next 10-15 years robust to most of the scenarios.

But prospect of Vivid/Waka wind takeup, if concentrated, raises prospect of HVDC re-think to enable volatile power transfer in normal and dry years.

Low levels of spinning plant in Auckland raises voltage questions.

High renewables (esp solar and wind) creates need for synthetic inertia, as well as different ramping needs to manage frequency – new AS products needed?

Demand side options more opaque



Models do not capture the demand side in as much detail as the supply side. This has to change.

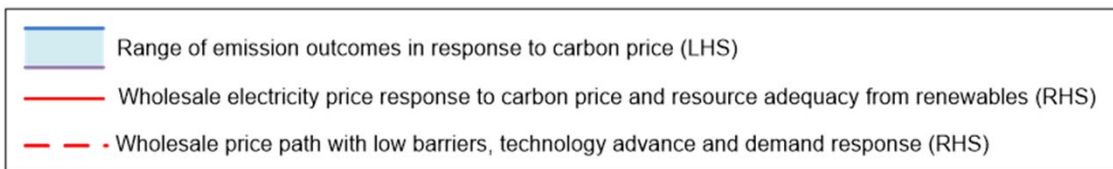
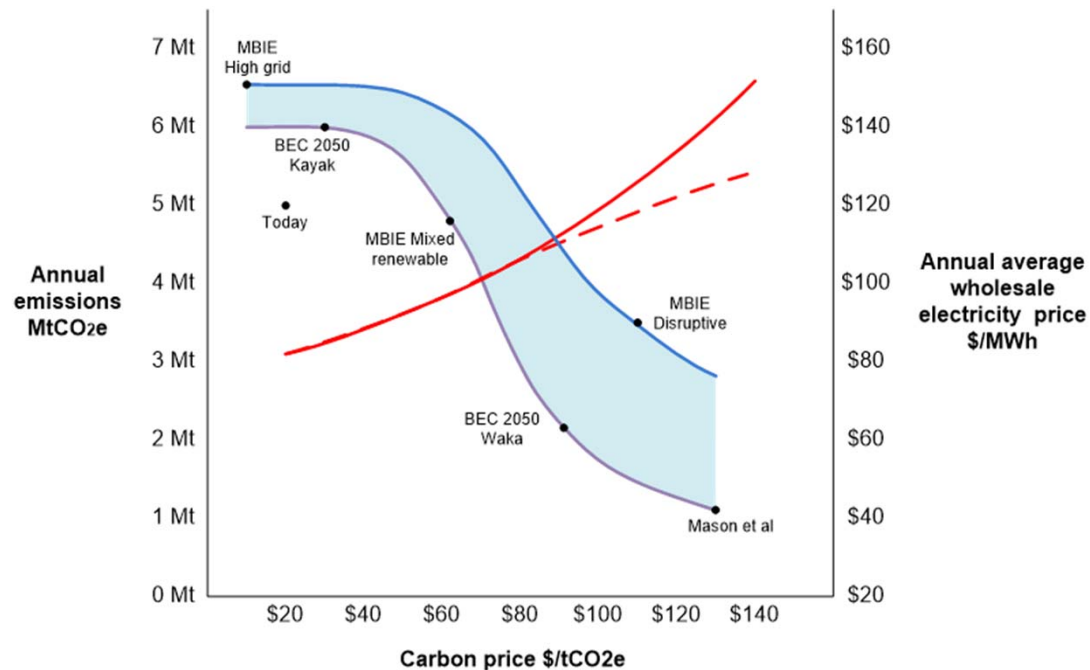
Distributed Energy Resources (DER) can provide:

- low emissions generation, and
- some of the flexibility services a low-emissions system requires (esp AS).

But some services are not currently priced at the grid level, let alone demand side; this limits the role that DER could play in assisting a transition to low emissions.

And a need for coordination: A role for a Distribution System Operator?

Costs for a cross-sector comparison



Given the time frame, it is simply not sensible to discuss “marginal abatement cost” curves with any precision or accuracy

Beyond the next 5-10 years, significant uncertainty in:

- Technology
- Cost
- (dis)investment decisions
- Demand
- Consumer response to price

Static analyses are indicate only, dynamic analyses are hard

Market evolution



Enabling mass participation in the electricity market

How can we promote innovation and participation?

While not targeted at decreasing emissions, Electricity Authority and Commerce Commission workstreams underway re competition, innovation, pricing and participation will enable better, more efficient engagement by DER.

Flexibility may become a prized commodity as we transition away from thermal. We see the need for potential market design evolutions to support a high-renewable future:

- Market-based procurement of ancillary services (inertia, voltage)
- New ramping/standby reserve products targeted at the flexibility needed
- Consideration of the role of a DSO in efficient coordination of DER



Summary

Q1: Based on technology we are familiar with today, we believe that the industry could potentially reach ~1Mt of emissions by 2050.

Q2: But it would be expensive (based on what we know today). While today's new technology (batteries, DR) could provide short term resource adequacy, replacing the role of thermal for hydro firming would be costly.

Q3: A number of regulatory and policy initiatives underway today, while not targeted at lowering emissions, would help facilitate this. But we believe there are market design evolutions that may be required to ensure a transition to higher renewables future is achieved at the lowest cost.