Towards a very low emissions electricity system

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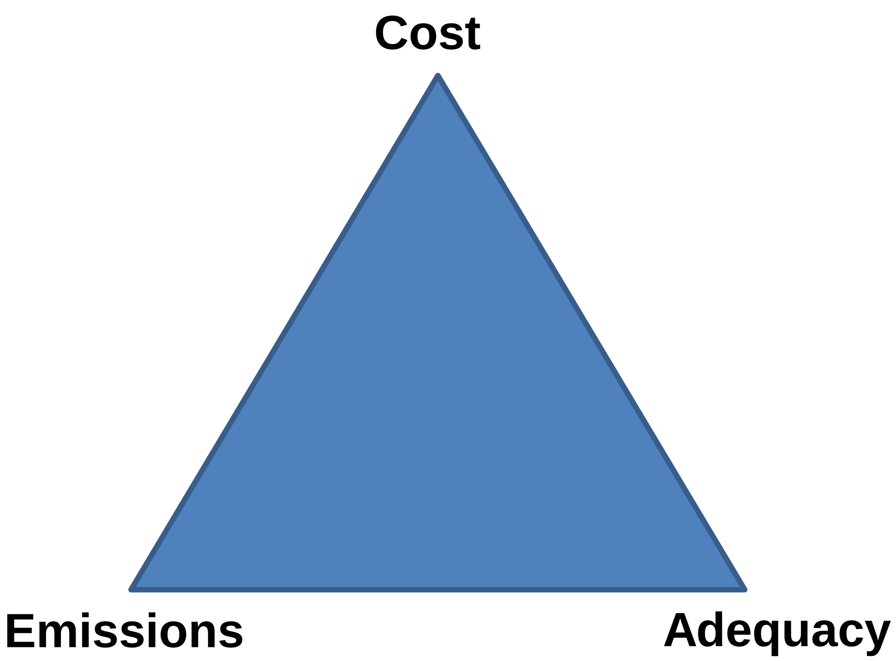
Our Brief



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?

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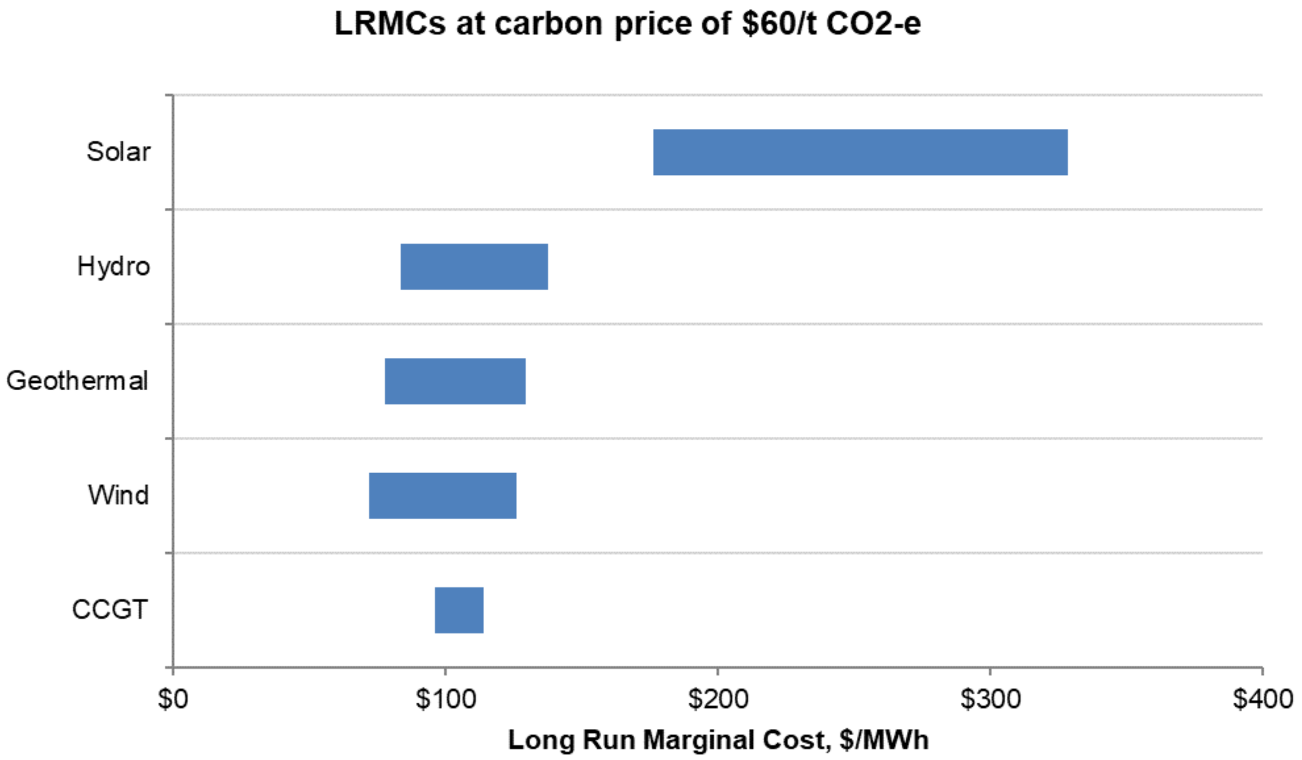
Decisions required to move to very low emissions



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.

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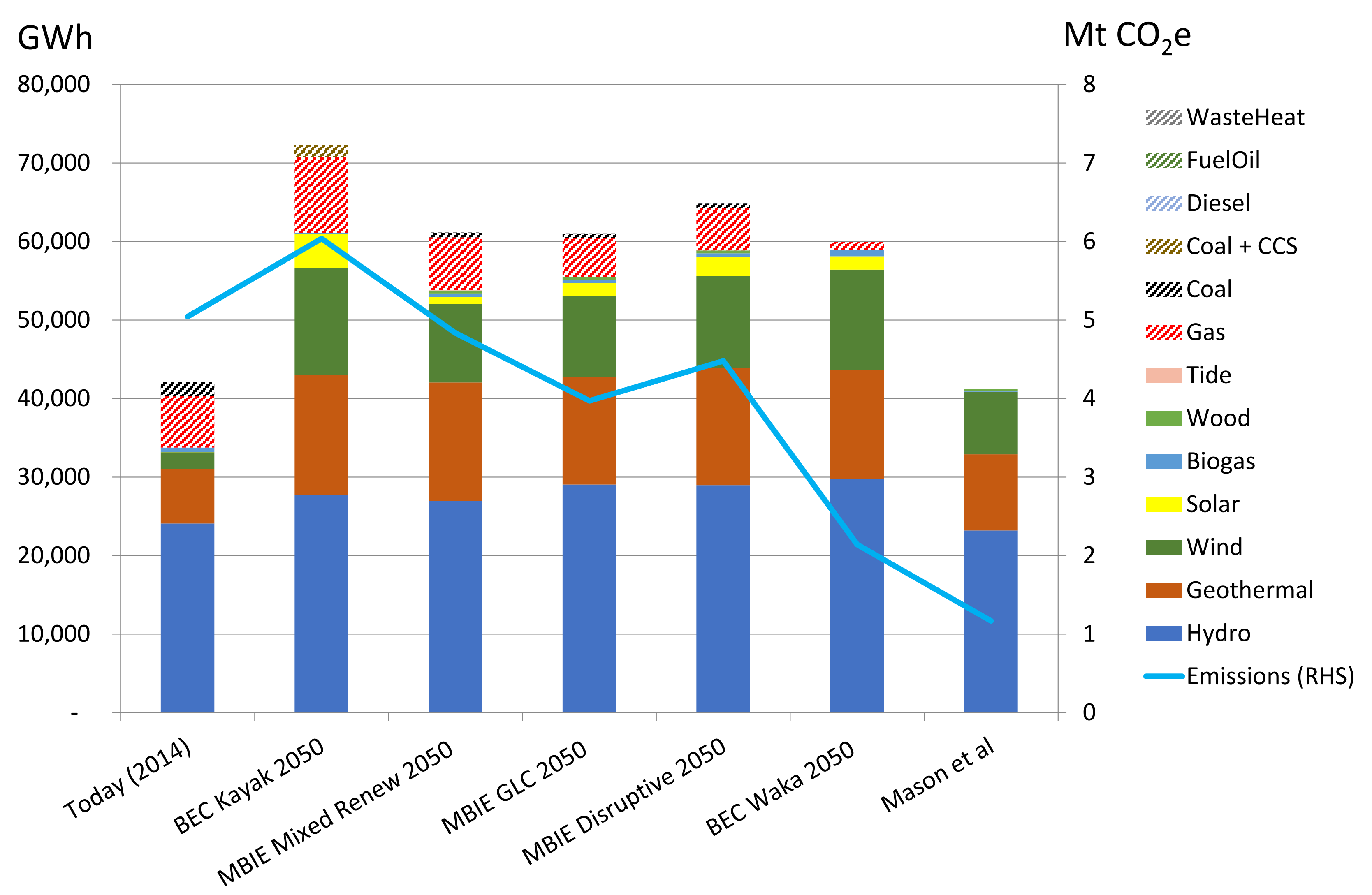
Scenarios of emissions in 2050



A doubling of geothermal in all scenarios

Modest investments in hydro

Wind as the swing fuel. 10 -12 TWh pa, 2500 – 3500 MW installed capacity excl. Vivid)

MBIE and BEC scenarios substantively resource adequate

Most significant differences in emissions driven by thermal decommissioning

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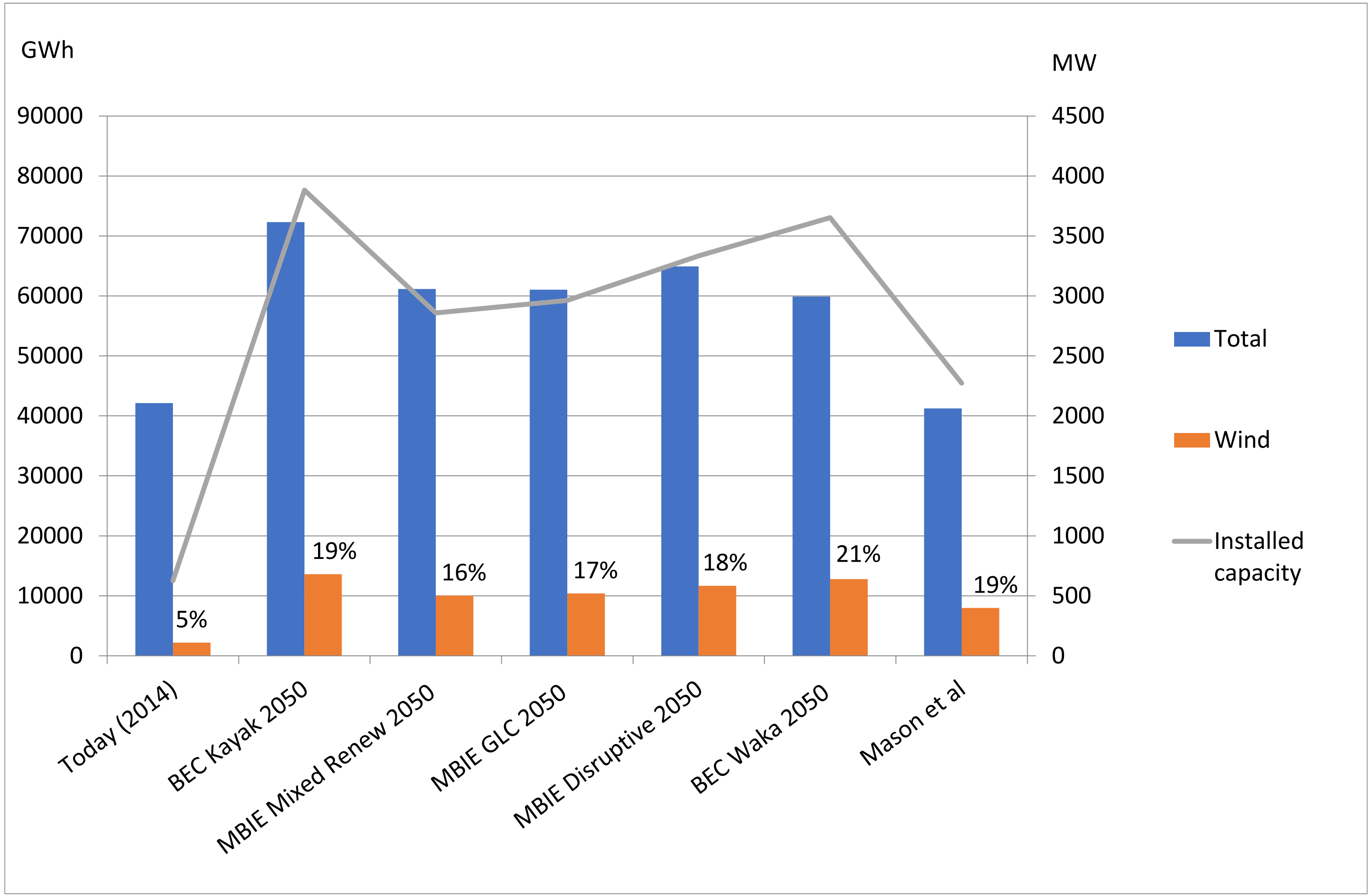
GWh
MW
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5%
19%
16%
17%
18%
21%
19%
Today (2014)
BEC Kayak 2050
MBIE Mixed Renew 2050
MBIE GLC 2050
MBIE Disruptive 2050
BEC Waka 2050
Mason et al
Total
Wind
Installed capacity

Consented wind farm projects (Source NZWEA)

Developer	Project	Region	Capacity (MW)
Contact Energy	Waitahora	Southern Hawkes Bay	156
Genesis Energy	Castle Hill	Northern Wairarapa	800
Mercury	Turitea	Manawatu	180
Mercury	Puketoi	Tararua District	317
Meridian	Central Wind	Ruapehu & Rangatikei	130
Meridian	Hawkes Bay	Hastings	225
Meridian	Titiokura	Hastings	48
Meridian	Hurunui	Hurunui	76
Tilt Renewables	Mahinerangi	Clutha	160
Tilt Renewables	Kaiwera Downs	Gore	240
Tilt Renewables	Awhitu	Franklin	18
Tilt Renewables	Waverley	South Taranaki	130
MainPower	Mt Cass	Hurunui	78
Taharoa C and PowerCoast	Taharoa	Kawhia	54
Ventus	Taumatatotara	Waikato	27
Windflow	Long Gully stage 2	Wellington	12
TOTAL			**2521**

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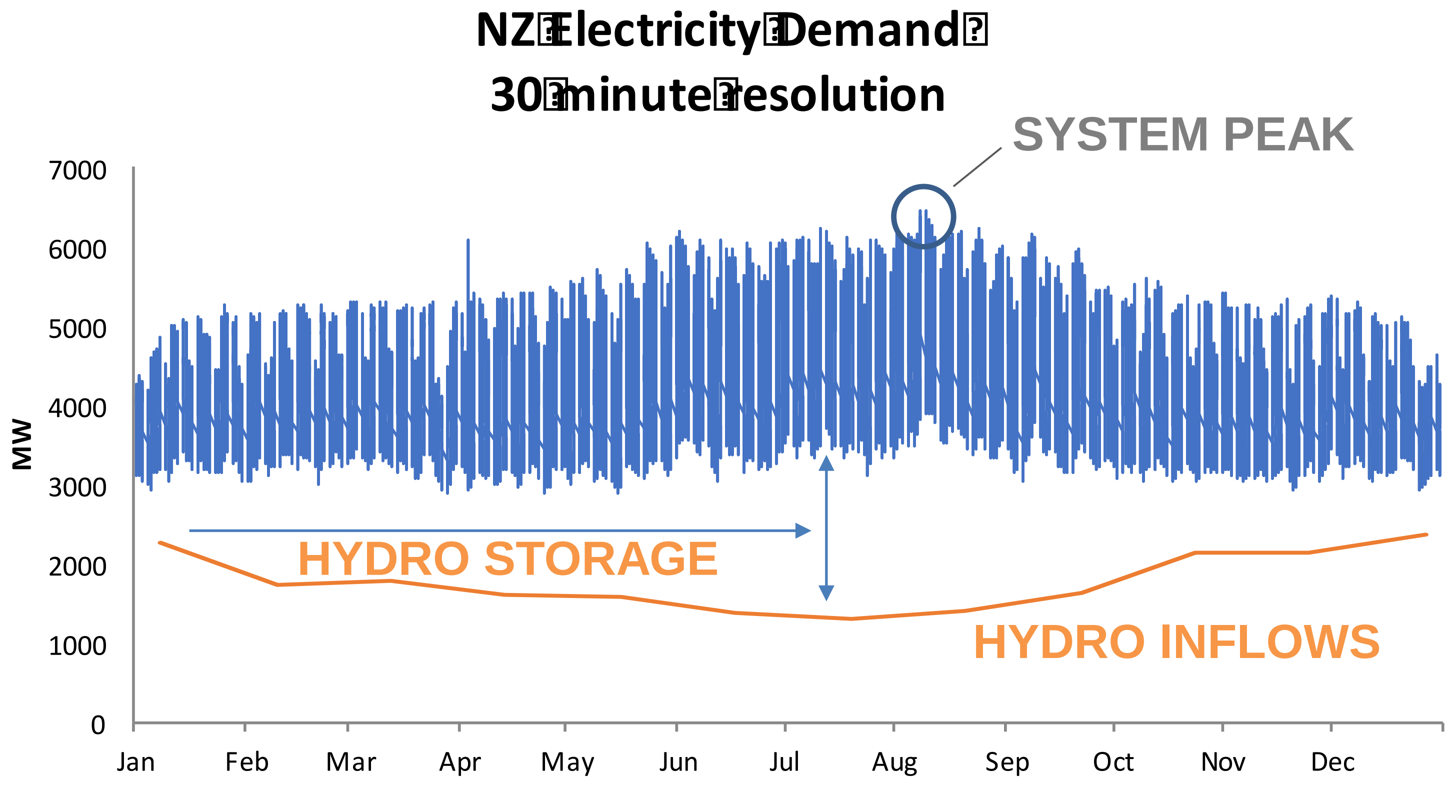
Maintaining resource adequacy

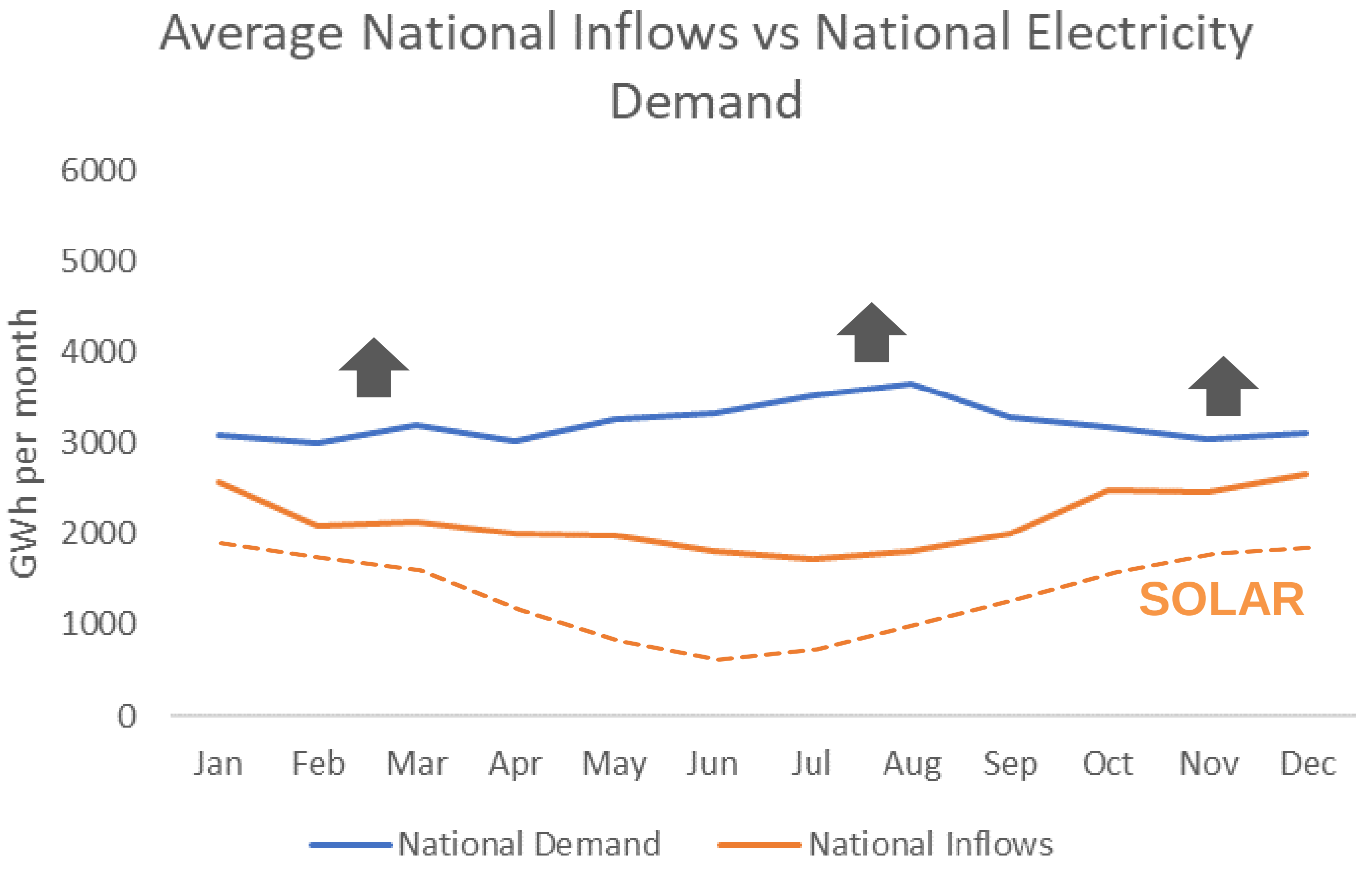


Resource adequacy – the ability to meet demand at every point in time

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

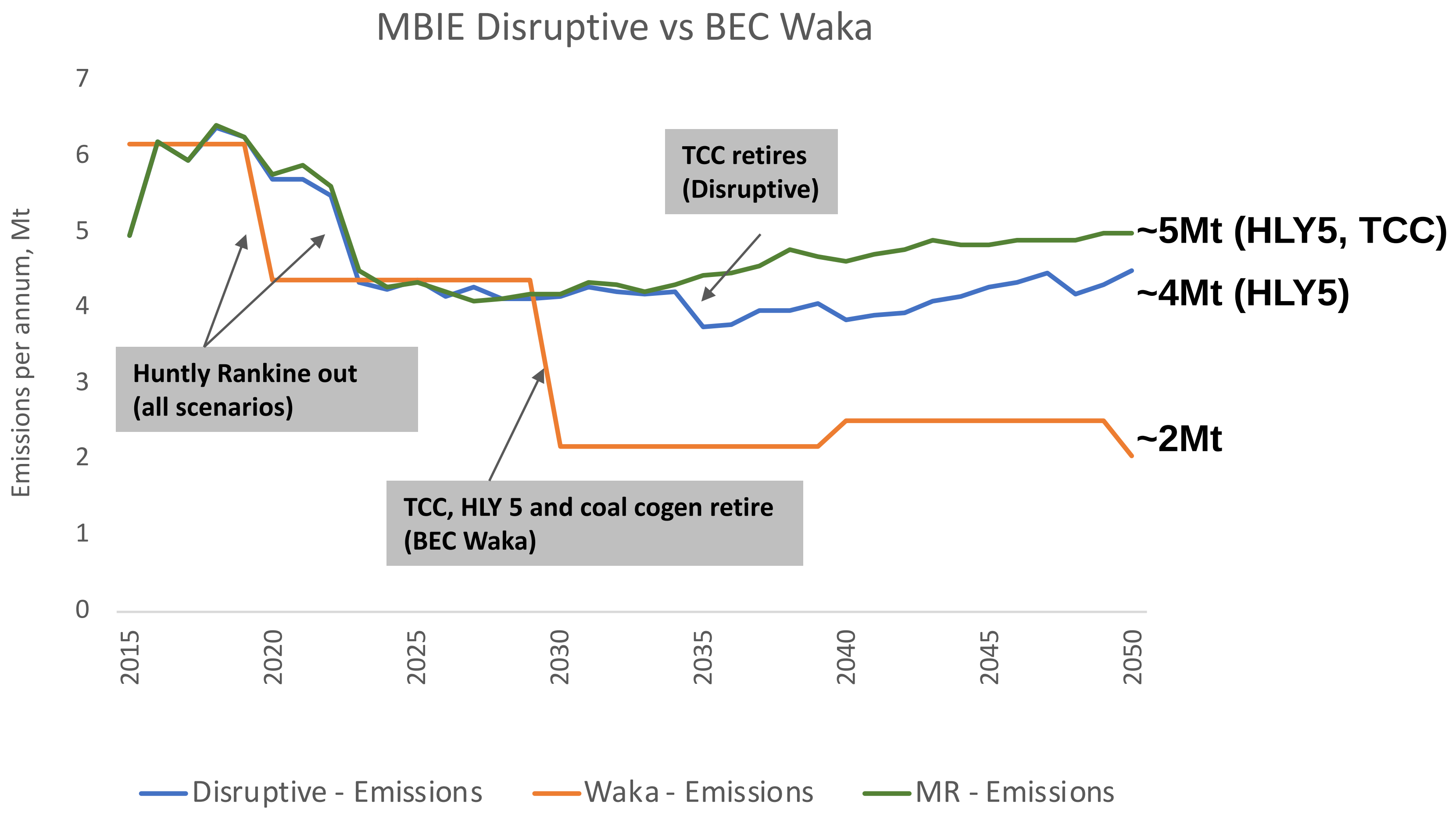


Variability in inflows over the year, and between years will always need storage and flexible fuel.

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

Solar exacerbates the issue

Transitioning away from Rankines and CCGTs…



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**

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Deeper cuts (towards 100% renewable)

Energy Policy 60 (2013) 324–333

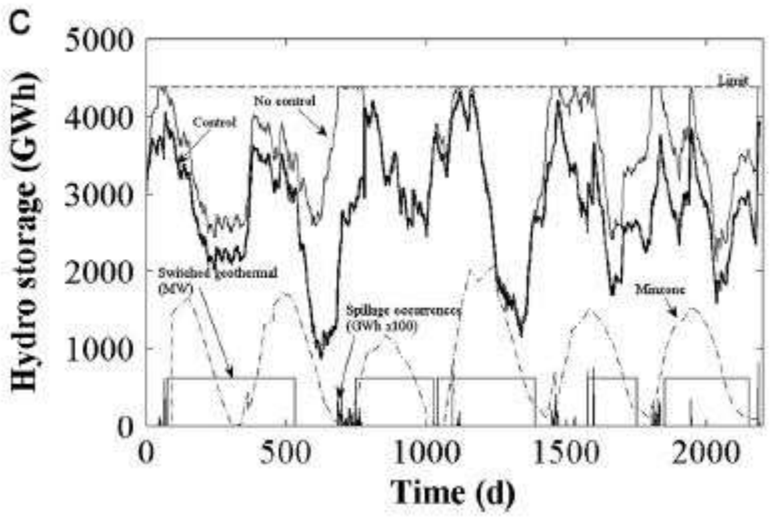
Contents lists available at SciVerse ScienceDirect

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?**

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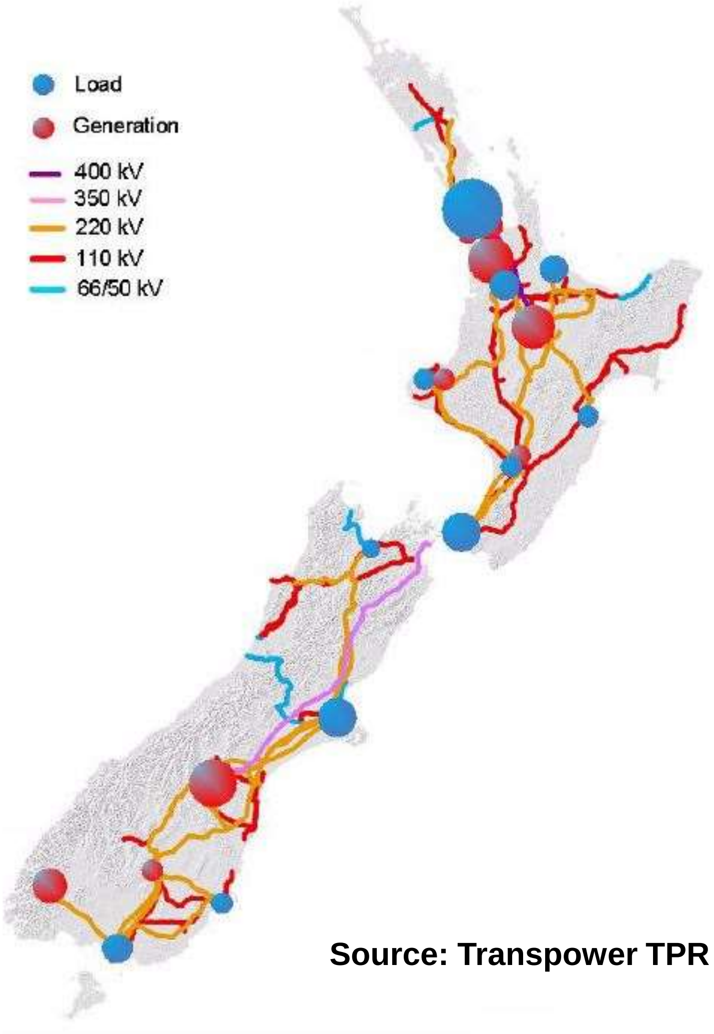
Implications: Transmission and Ancillary Services



Source: Transpower TPR 2015

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

But prospect of 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?

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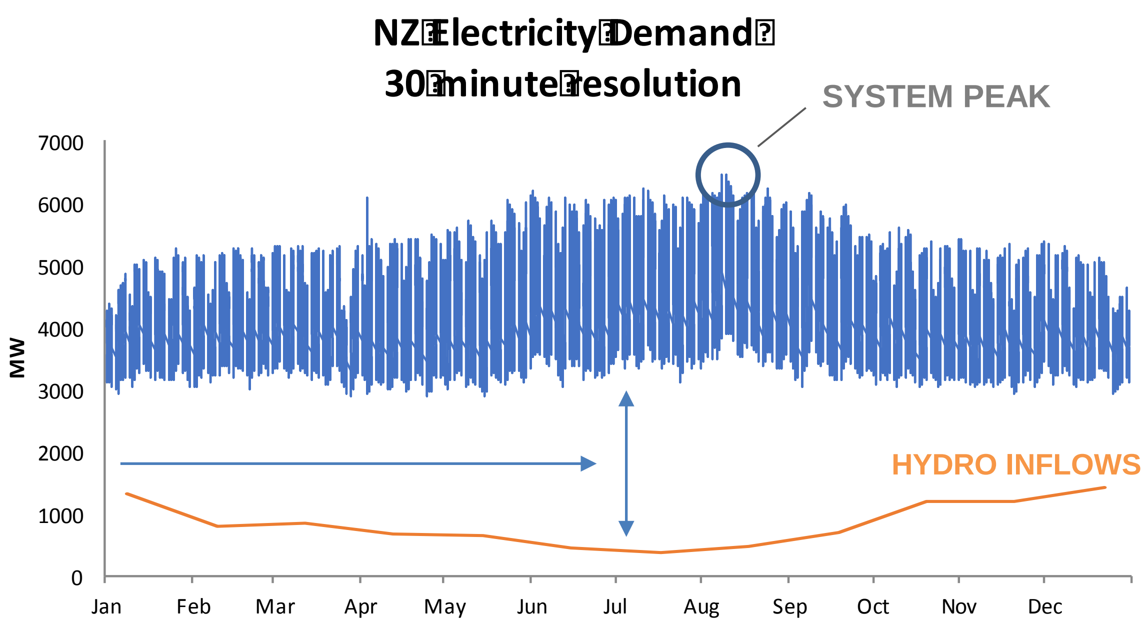
Demand side options more opaque



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?

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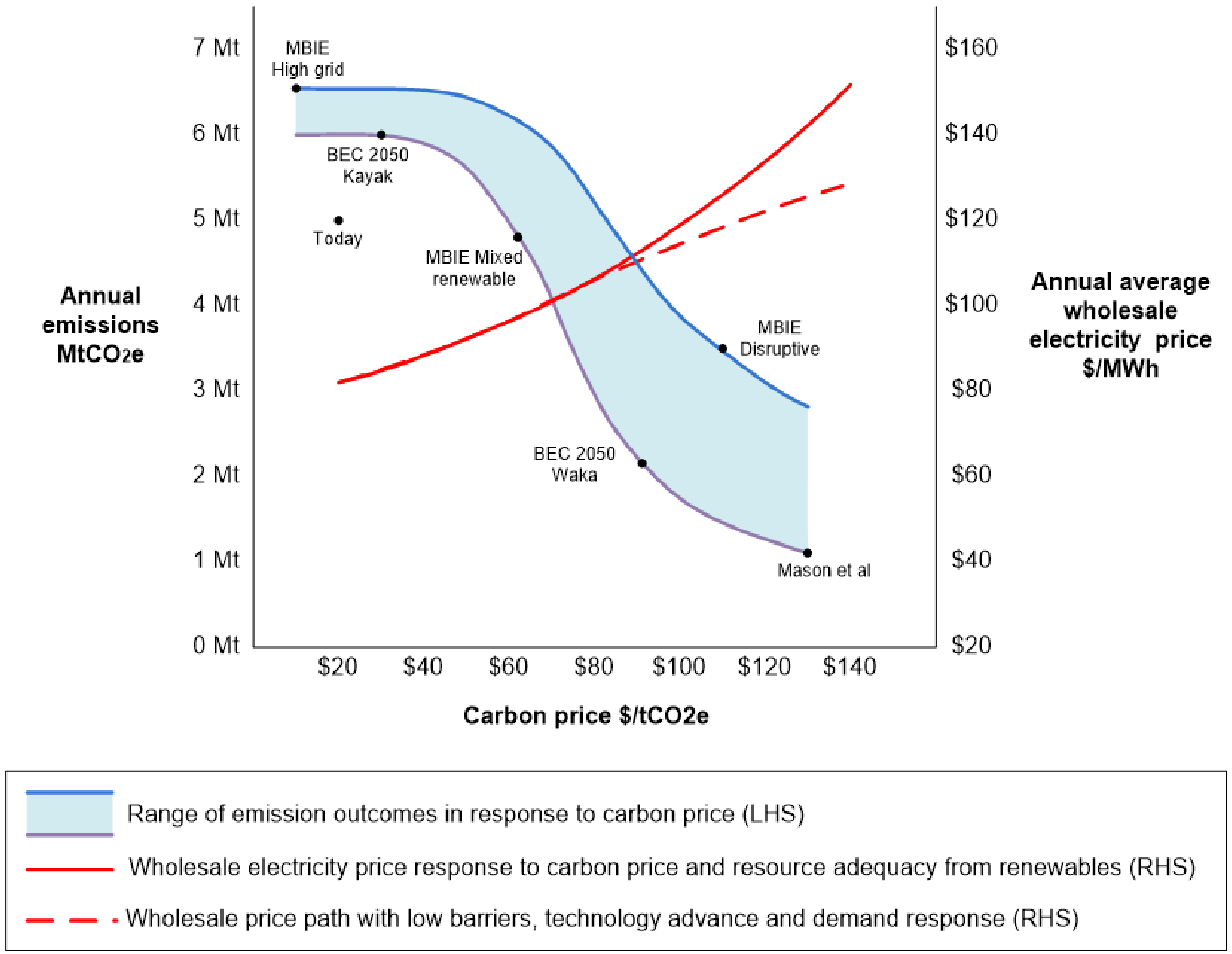
Costs for a cross-sector comparison



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


ELECTRICITY AUTHORITY
TE MANA HIKO

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.

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Thank you

Figure 1 – New Zealand's 2030 target and provisional carbon budget for 2021-2030

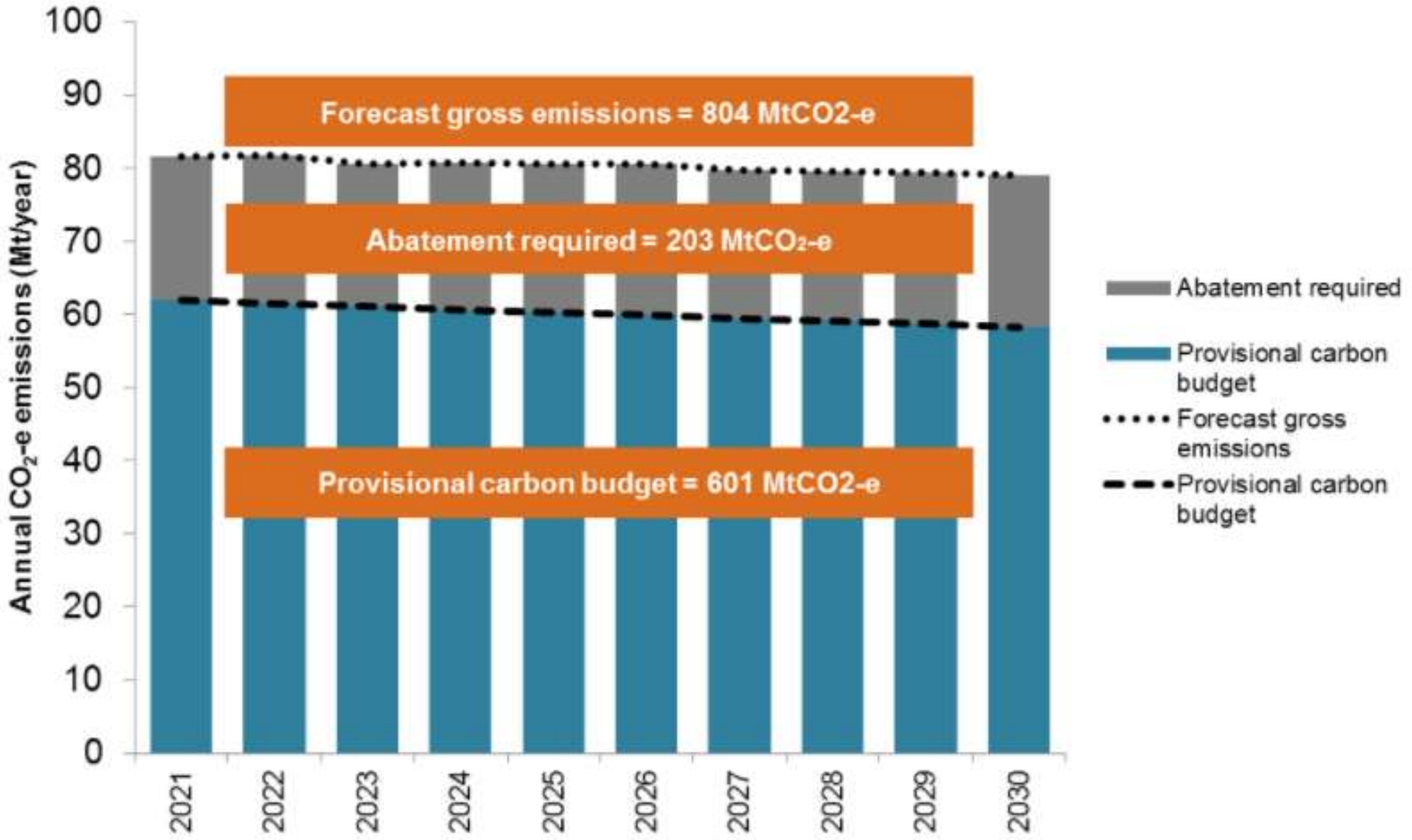

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Figure 2 Distribution of the carbon budget under current policies and NZ ETS settings (as of April 2018)