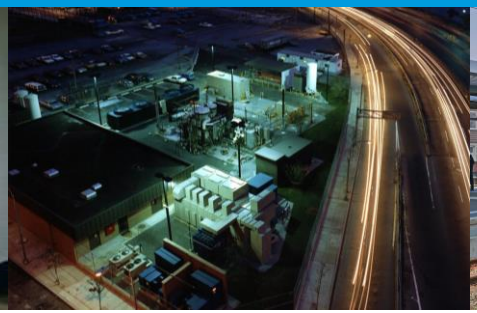
New Zealand Green Hydrogen Modelling Presentation to Business Energy Council

5 August 2020

Andreas Heuser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Key Questions for Hydrogen Modelling Project

Volume of Green Hydrogen Demanded New Zealand

Use Cases for Green Hydrogen and Key Assumptions

- Heavy vehicles
- Gas Pipeline Blending
- Electricity Storage and Generation
- Hydrogen in Niche Cases

Cost of Hydrogen Production in New Zealand

Selected Hydrogen Production Cost Assumptions

Will NZ import, export or produce for own consumption?

Future Directions of Work

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Castalia Green Hydrogen Model

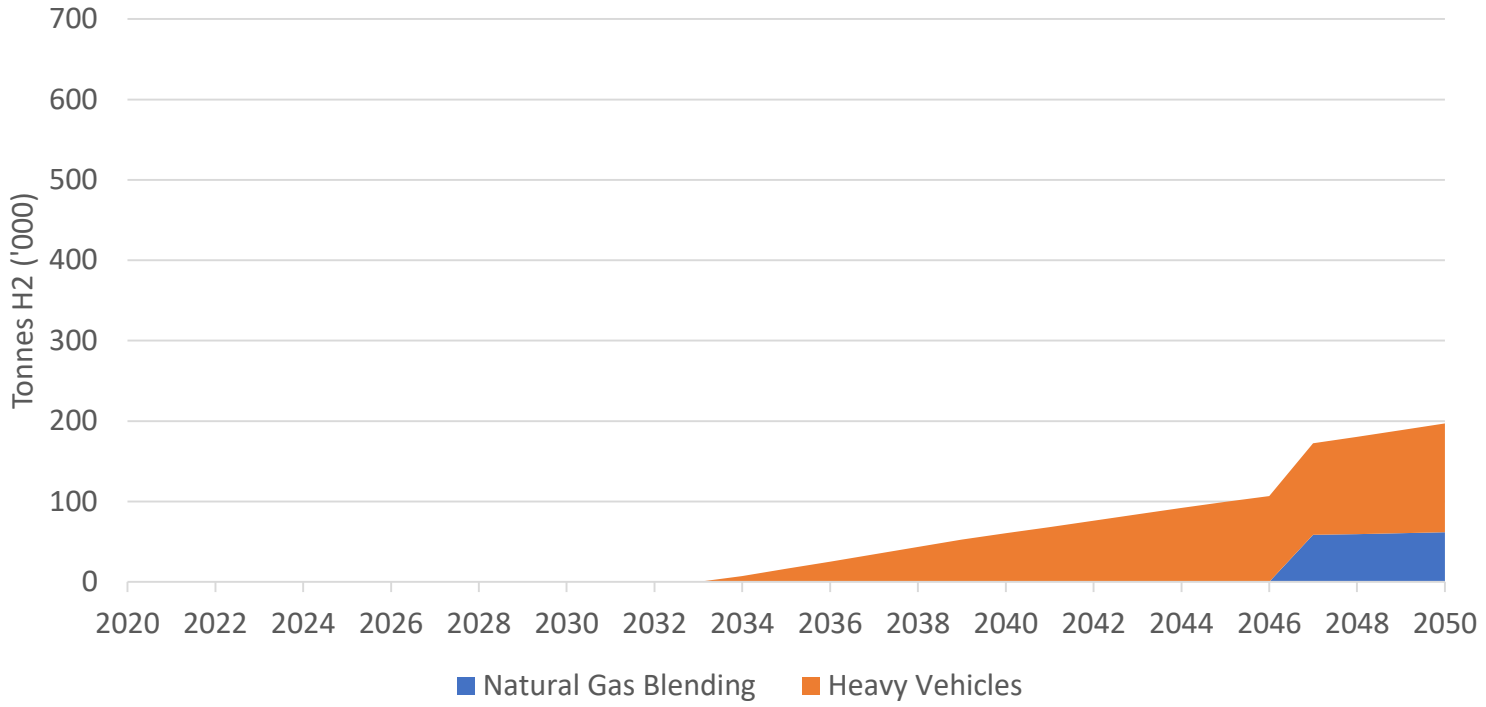
Key Questions for Hydrogen Modelling Project

- How much green hydrogen will be demanded in New Zealand?
- What are the resource implications?
- What are the domestic production costs for green hydrogen?
- How do New Zealand production costs compare to likely overseas producer countries?
- Is New Zealand likely to be an:
  - Exporter;
  - Importer;
  - Producer for domestic consumption only?

Demand for Green Hydrogen in New Zealand

Volume of Hydrogen Demanded in New Zealand

Base Case: 197,000 tonnes by 2050



Volumes depend on relative prices of:

- Green hydrogen and alternative energy sources
- Capital goods (for example, vehicles)

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Use Cases for Hydrogen and Key Assumptions

We modelled three main use cases. The economic viability of each use depends on relative prices and other key assumptions:

Heavy vehicles

- Diesel price
- Vehicle capital costs (Diesel, B-EV, HFC-EV)

Gas pipeline blending

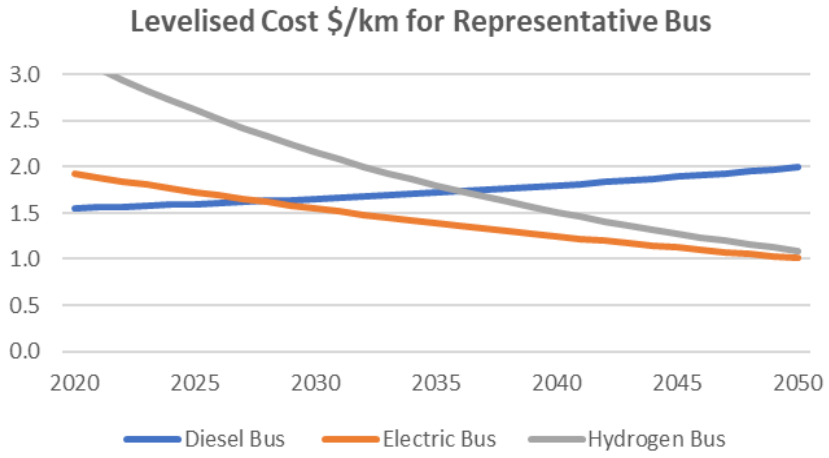
- Natural gas price
- Carbon cost
- Willingness to pay a “green premium” for hydrogen

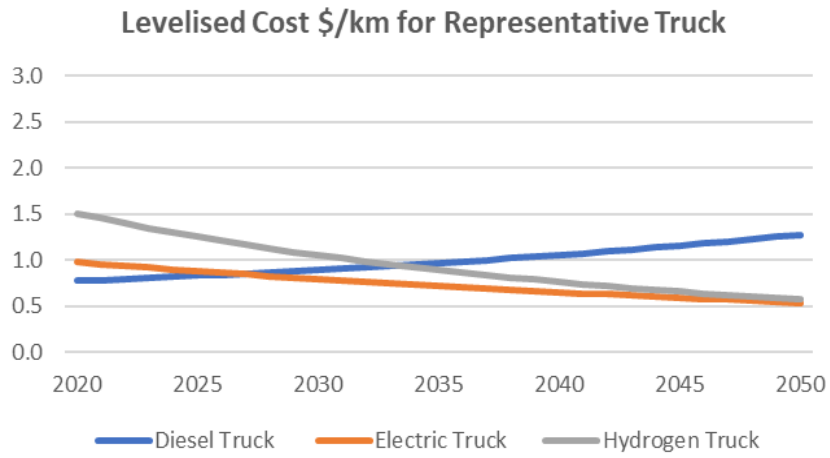
Electricity storage and generation

- Battery capital costs
- Costs of stored hydro electricity

Hydrogen for Heavy Vehicles

Base





Key assumptions:

- Diesel Prices Rise Three Percent Annually (High Case – Five Percent, Low Case – Zero Percent)
- Hydrogen Prices at Optimised New Zealand Price (2020 Base Case – $3.96)
- Hydrogen capital cost decline five percent annually (high and low case changes 2020 starting cost), electric capital cost declines three percent annually

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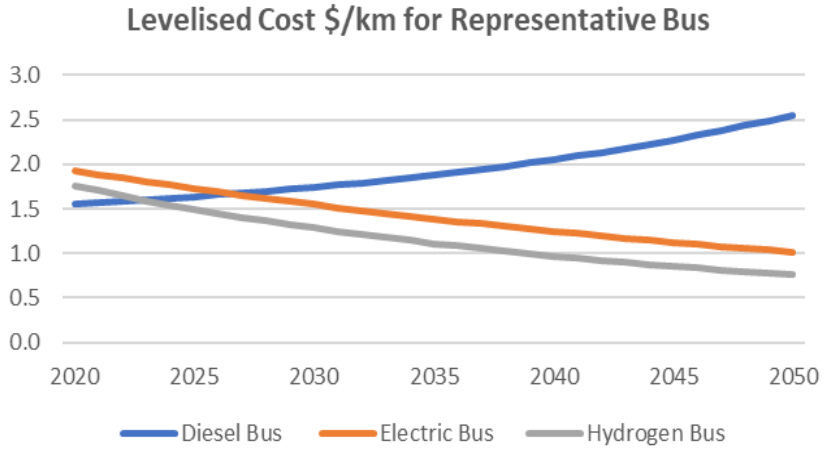
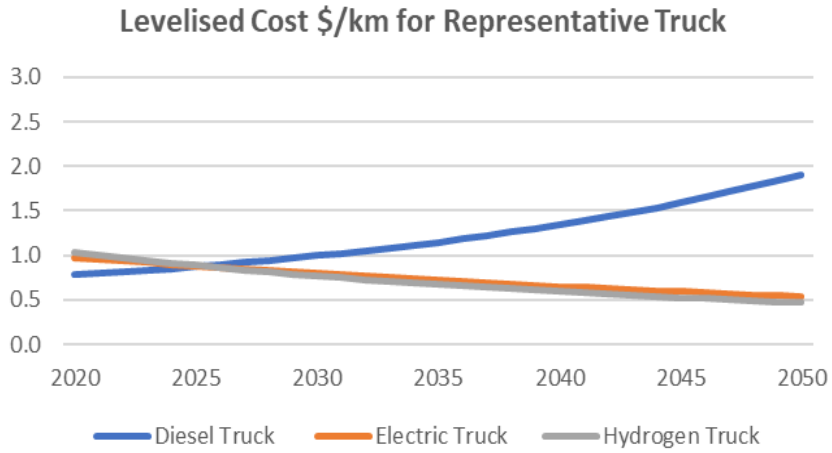
Hydrogen for Heavy Vehicles

High





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Hydrogen for Heavy Vehicles

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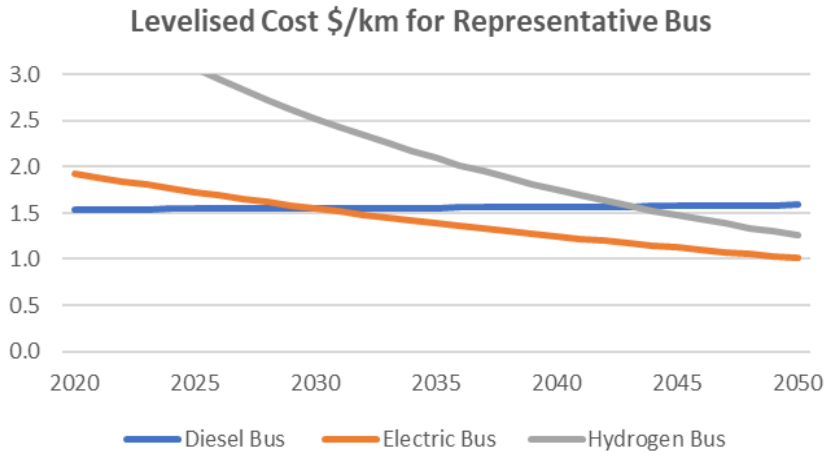

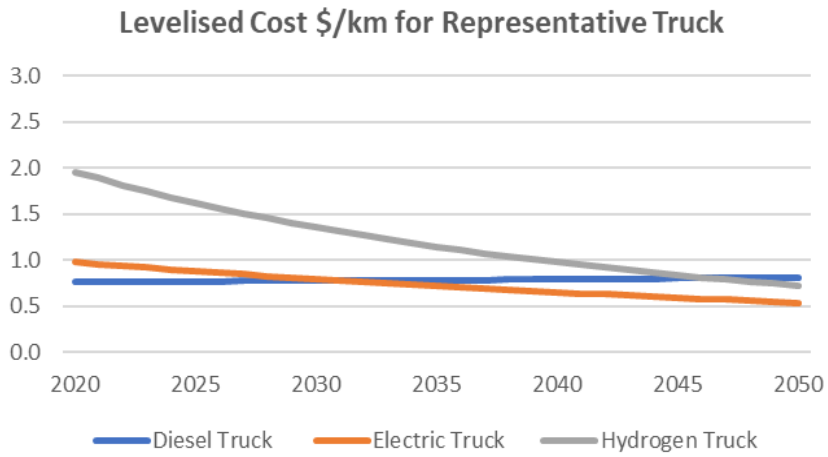

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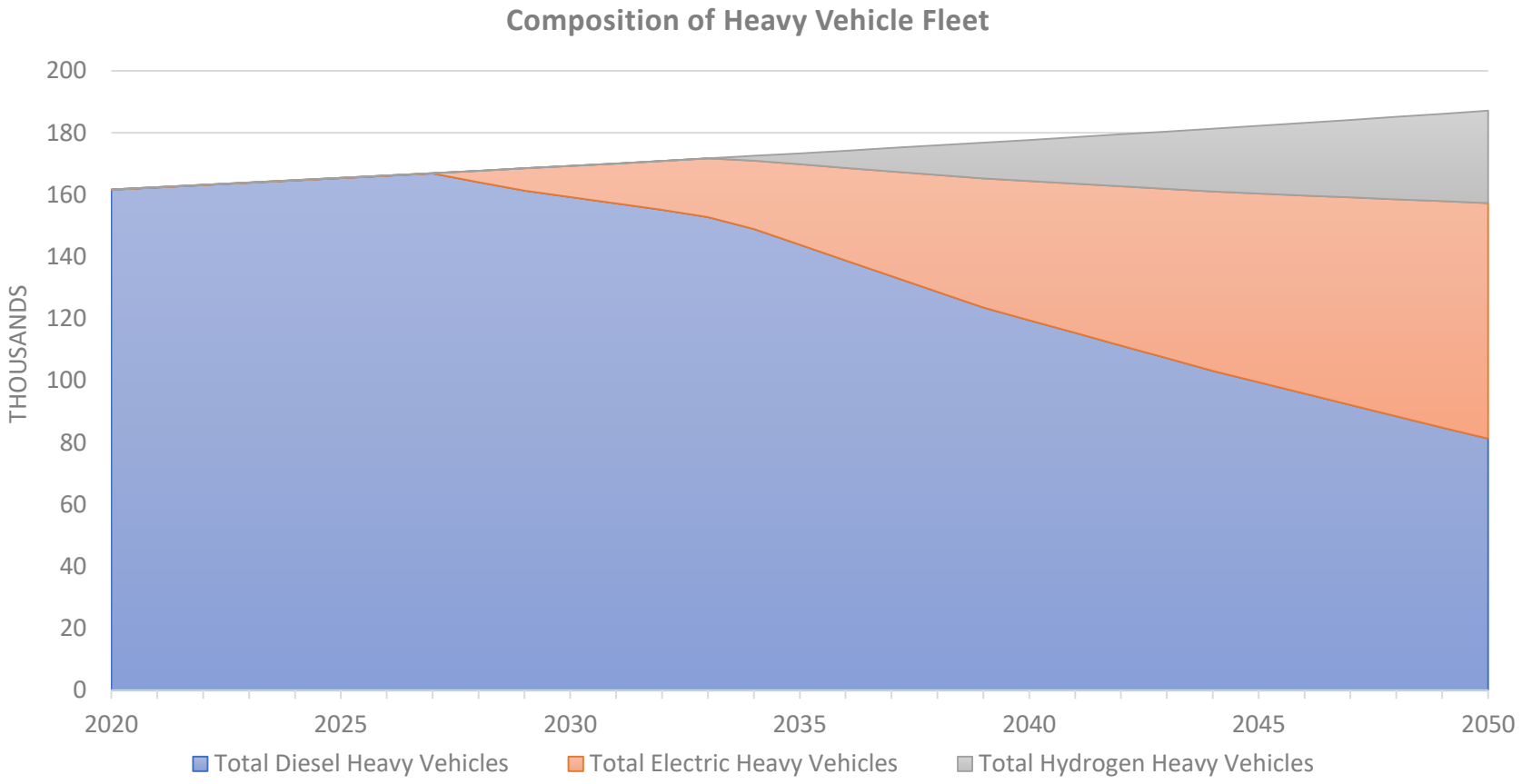

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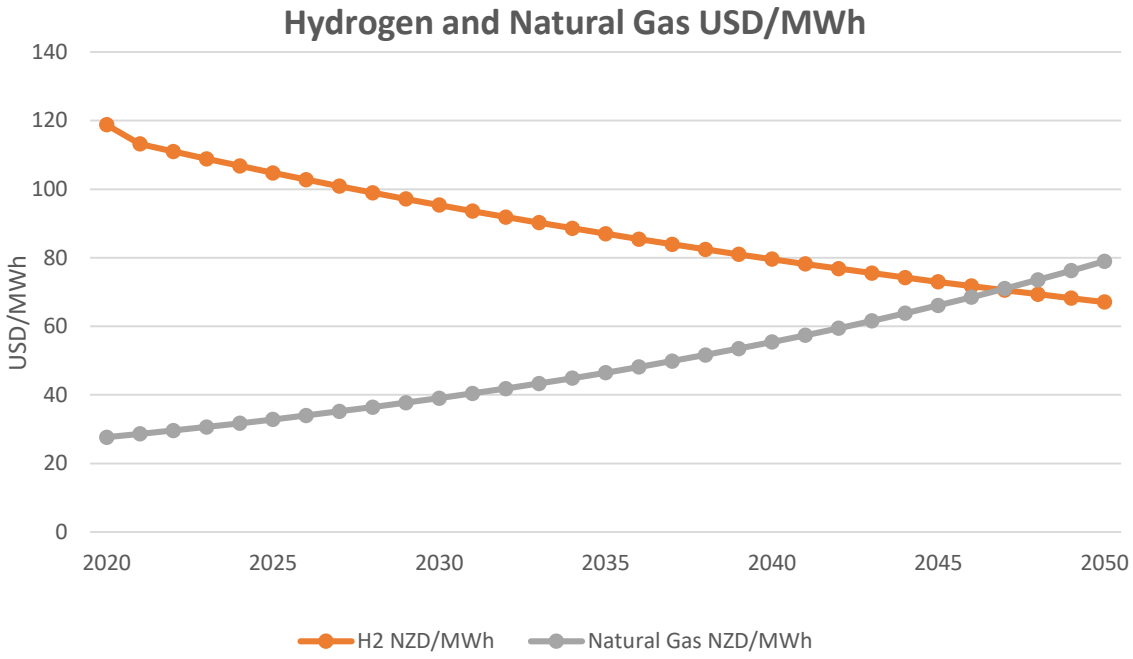
Hydrogen for Gas Pipeline Blending

Base



Key assumptions:

Natural gas prices

- Base case: rise at 3 percent p.a.
- High case: rise at 5 percent p.a.
- Low case: no change over time

Hydrogen Prices at Optimised New Zealand Price (2020 Base Case – $3.96)

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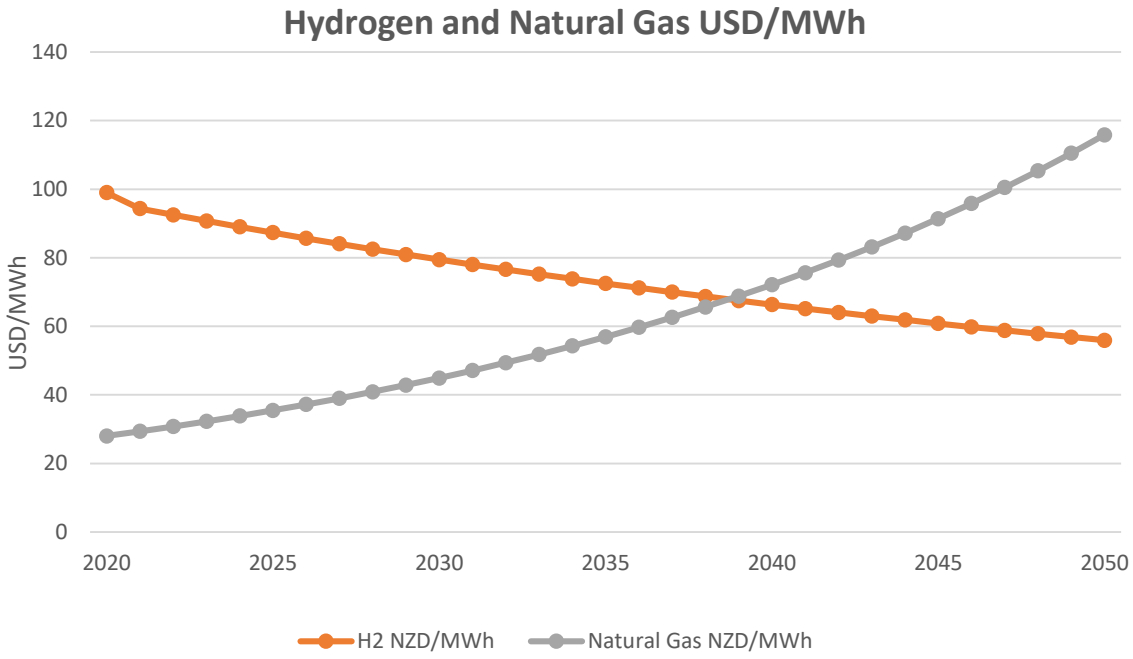

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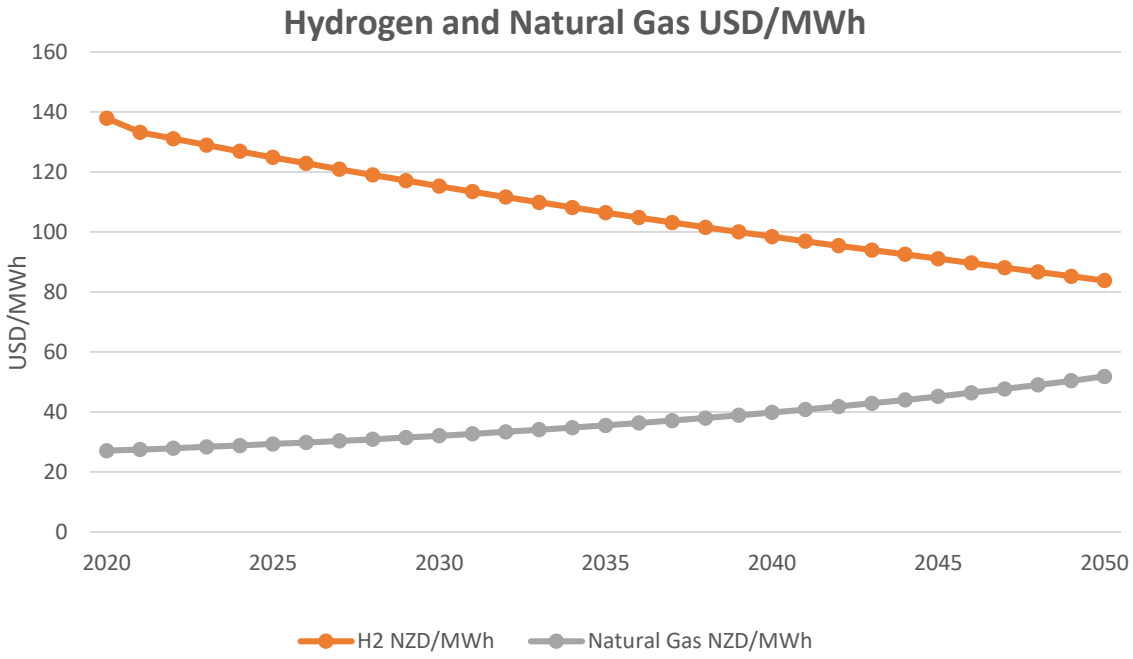

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Hydrogen Prices at Optimised New Zealand Price (2020 Base Case – $3.96)

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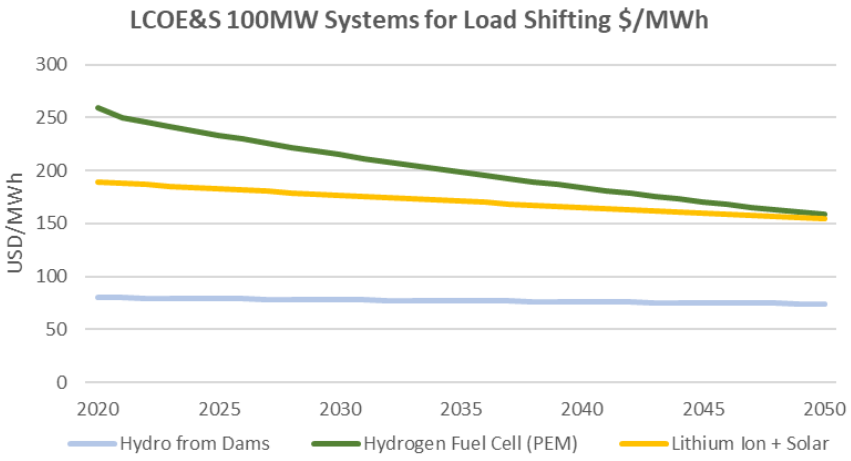
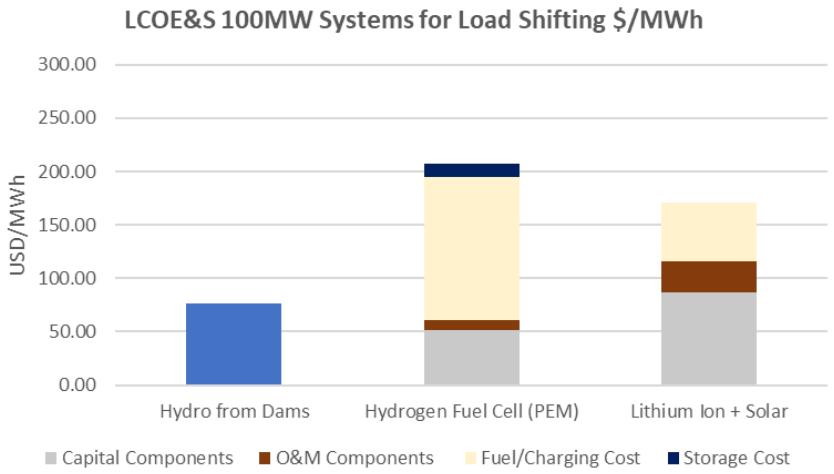
Hydrogen for Electricity Storage and Generation

Base





Key assumptions:

- Capital costs of hydrogen fuel cells (Base: decline at -1%, High: Decline at -2%, Low: Flat Price)
- Capital costs of alternative technology (-0.25% for hydro, -1% for batteries)

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Hydrogen for Electricity Storage and Generation

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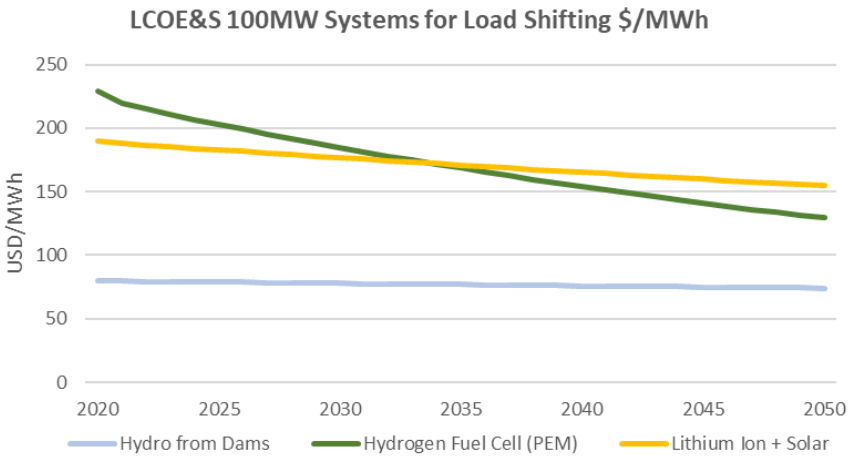

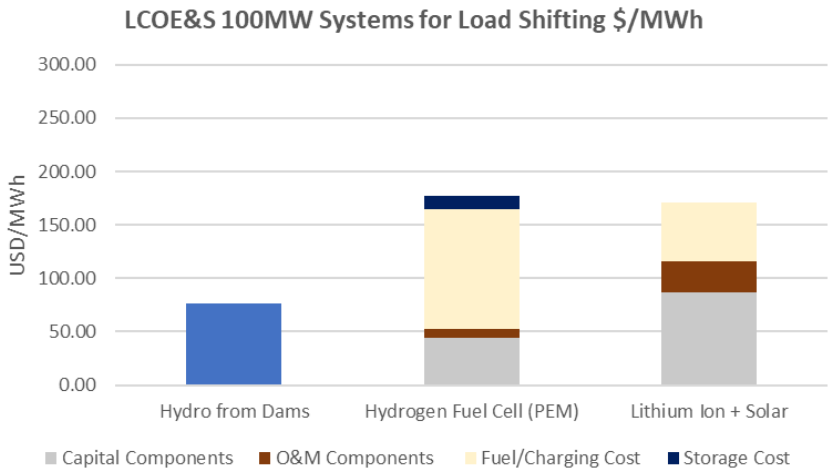

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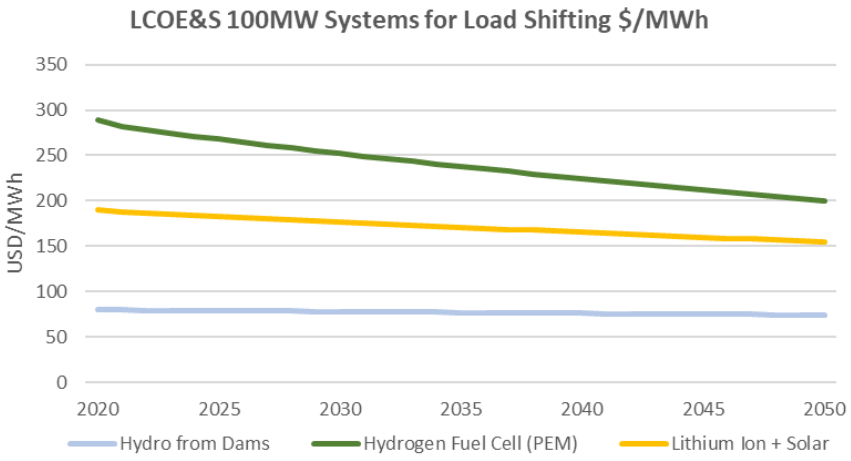

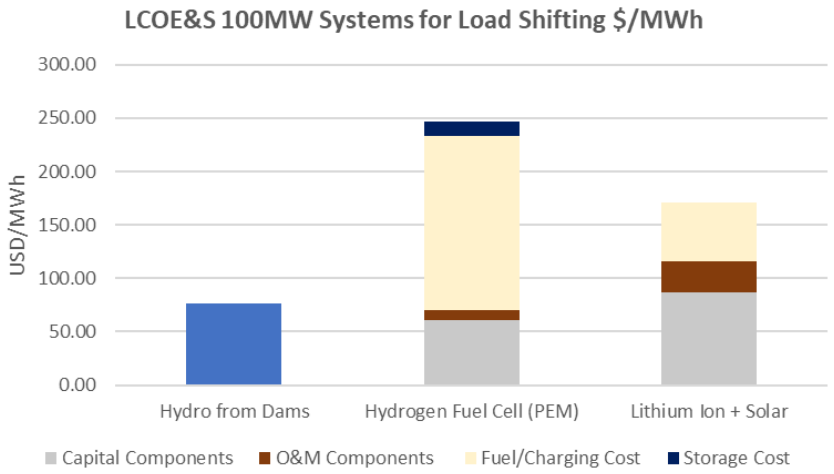

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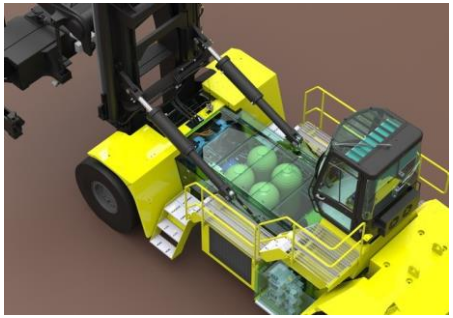
Hydrogen in Niche Use Cases

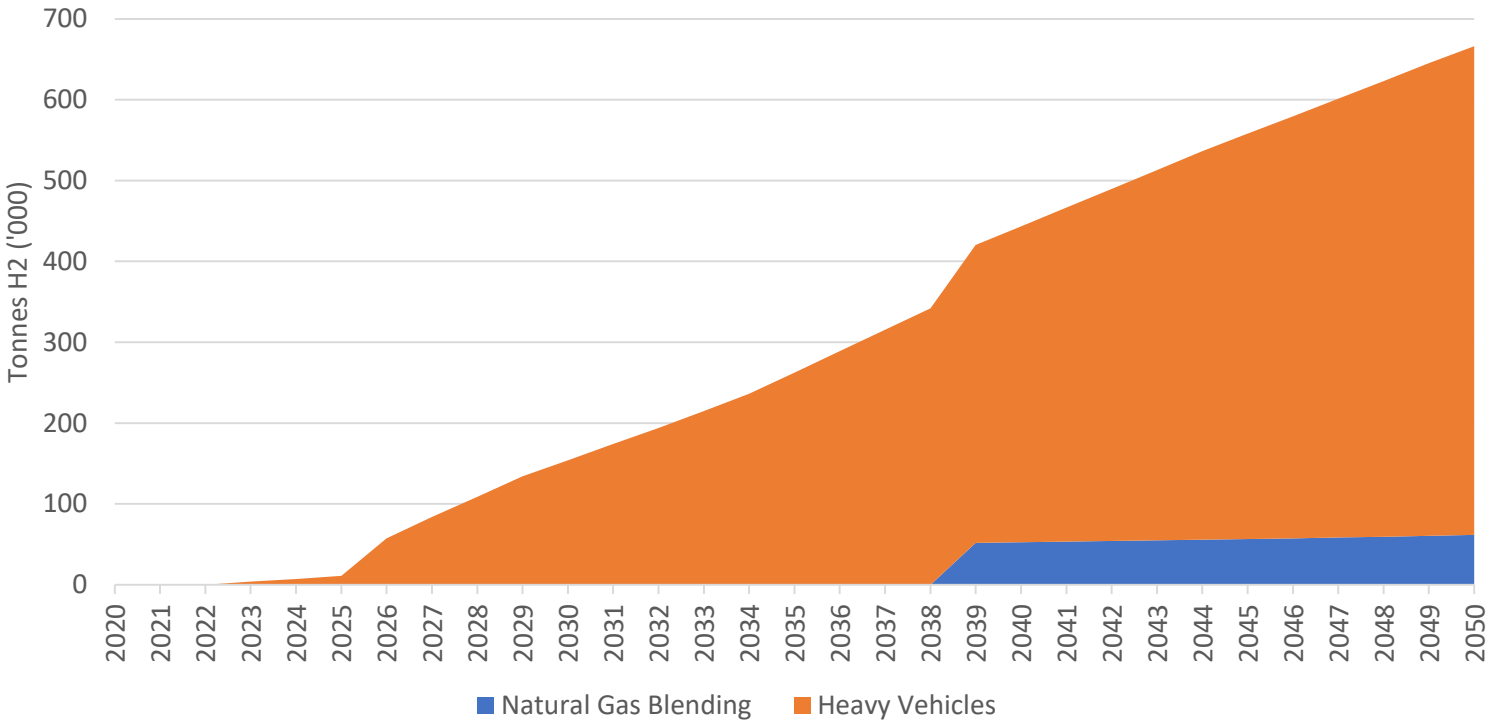
There are many niche use cases which may emerge. We did not model these in our national-level model. Niche uses could include:

- Long-range buses
- Port vehicles
- Other industrial vehicles
- Isolated community energy storage or fuel source



Summary of Hydrogen Demand

High Case: 605,000 tonnes by 2050



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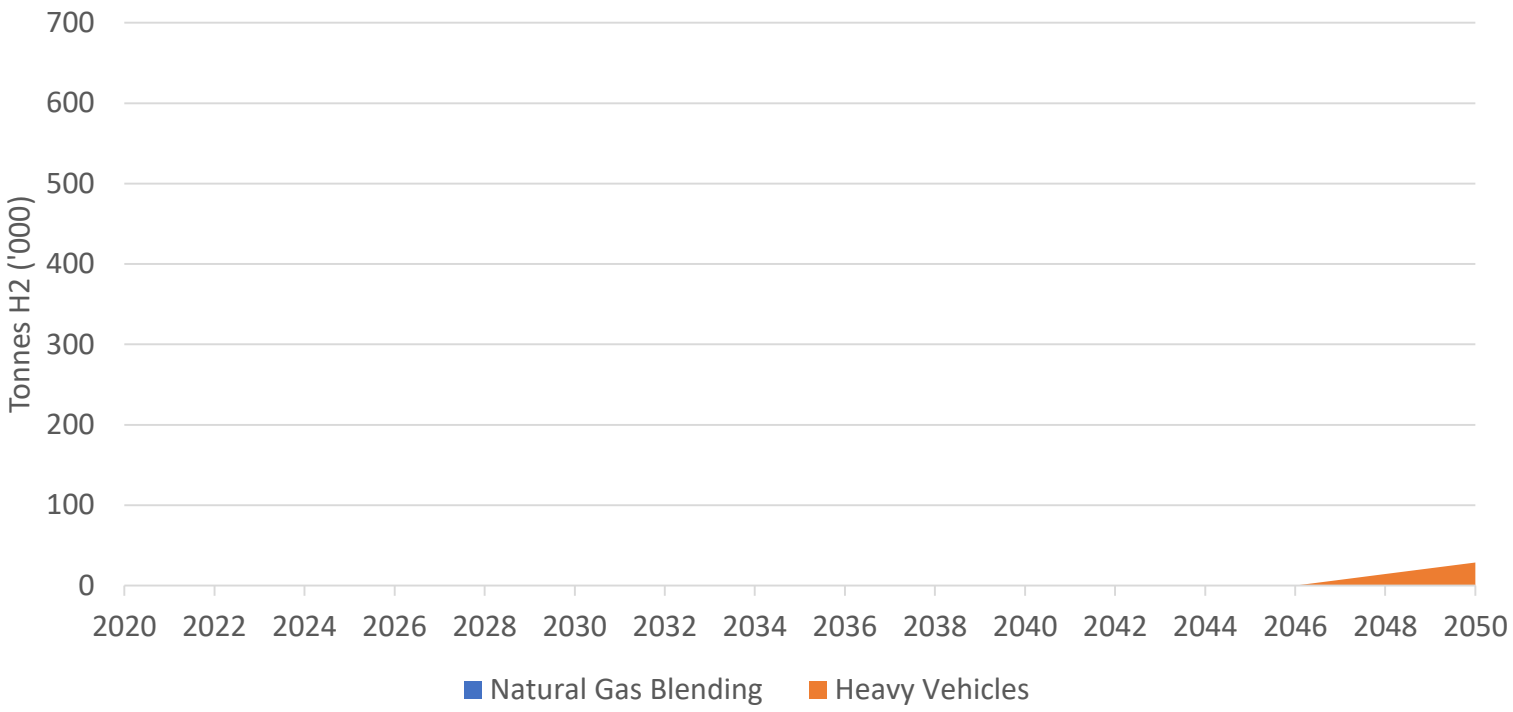
Summary of Hydrogen Demand

Low Case: 29,000 tonnes by 2050



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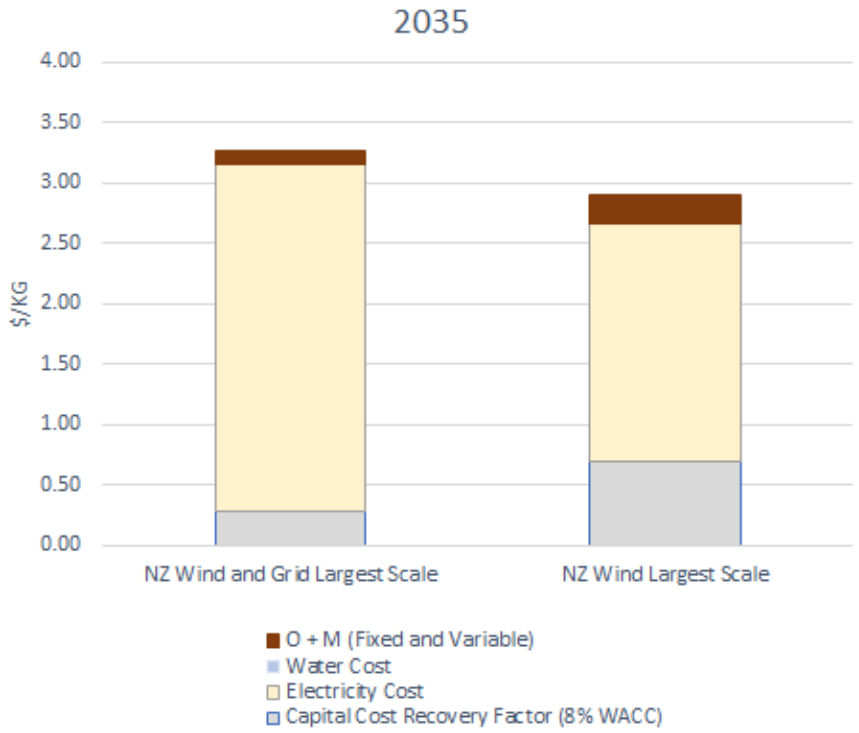
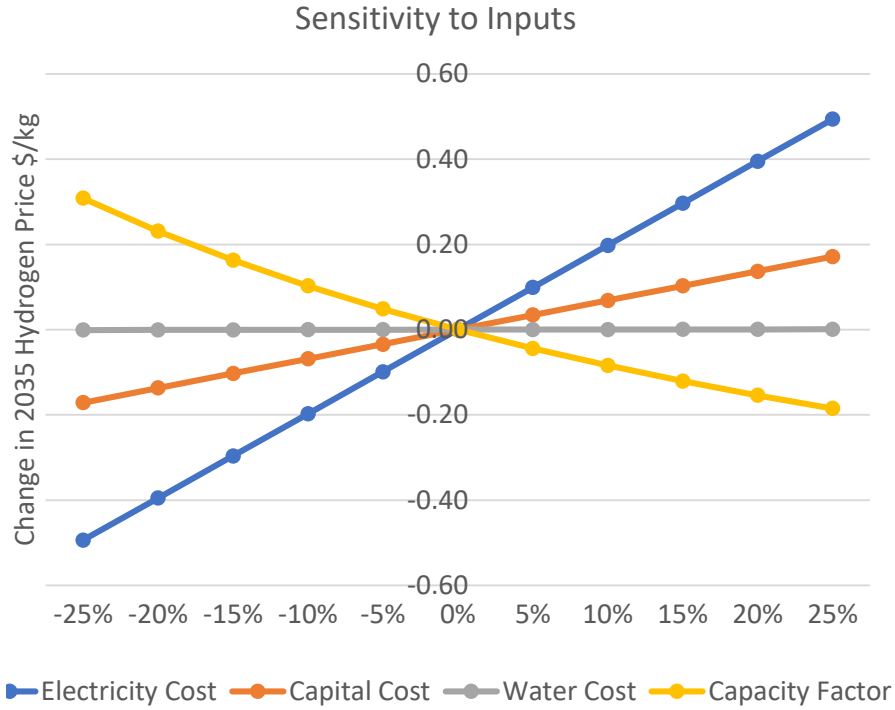
Supply of Green Hydrogen in New Zealand

Cost of Hydrogen Production in New Zealand

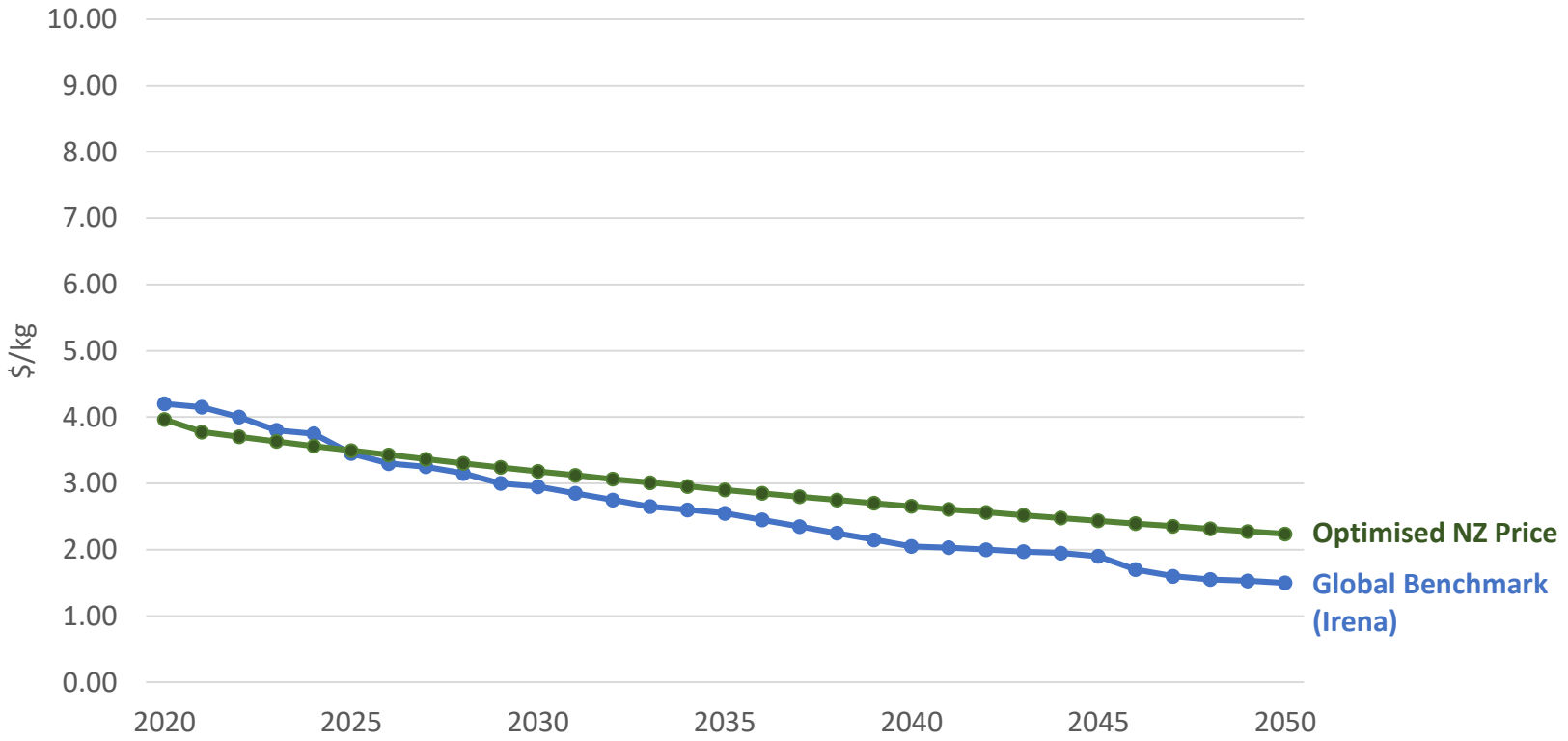
Domestic production of hydrogen is likely to come from either captive wind-only or captive wind plus grid powered electrolysis



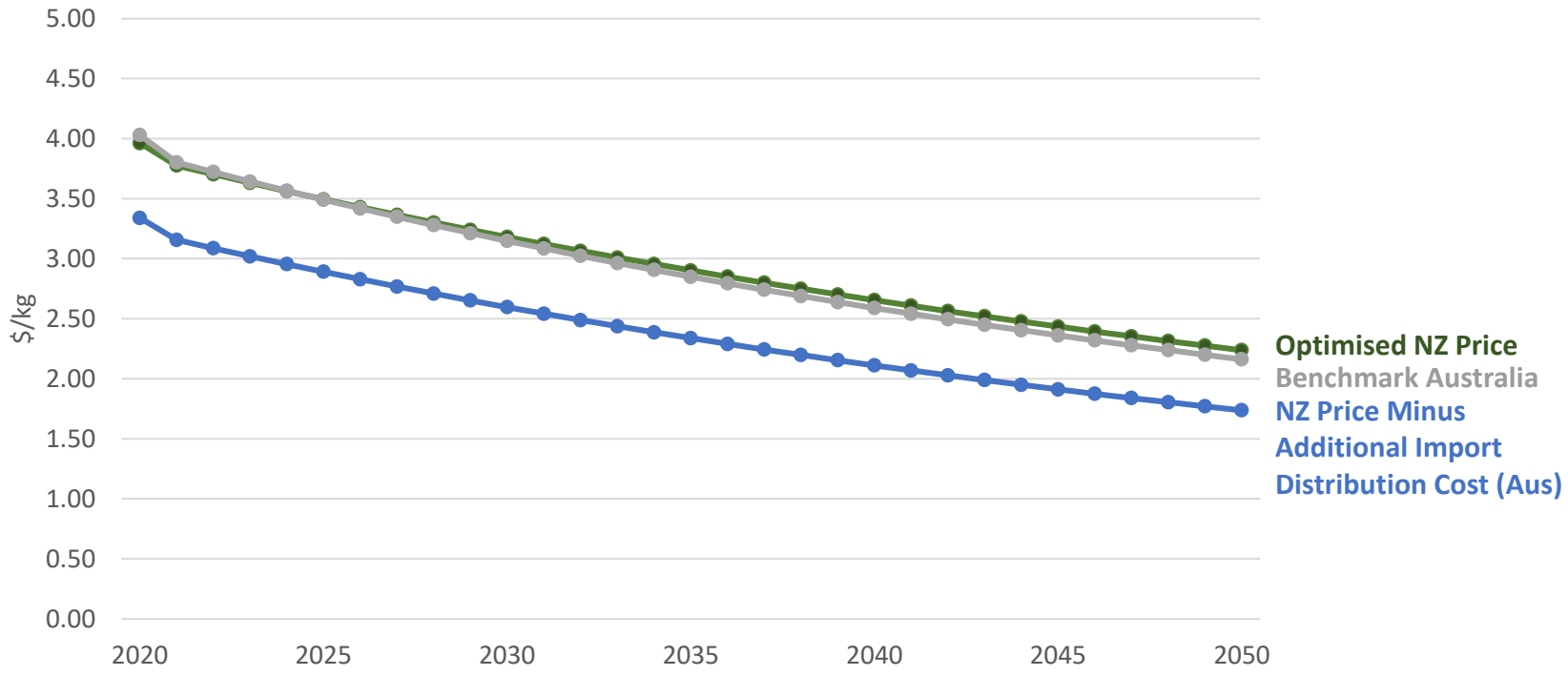


Cost of Hydrogen Production in New Zealand

Domestic production of hydrogen will depend on the relative costs of production

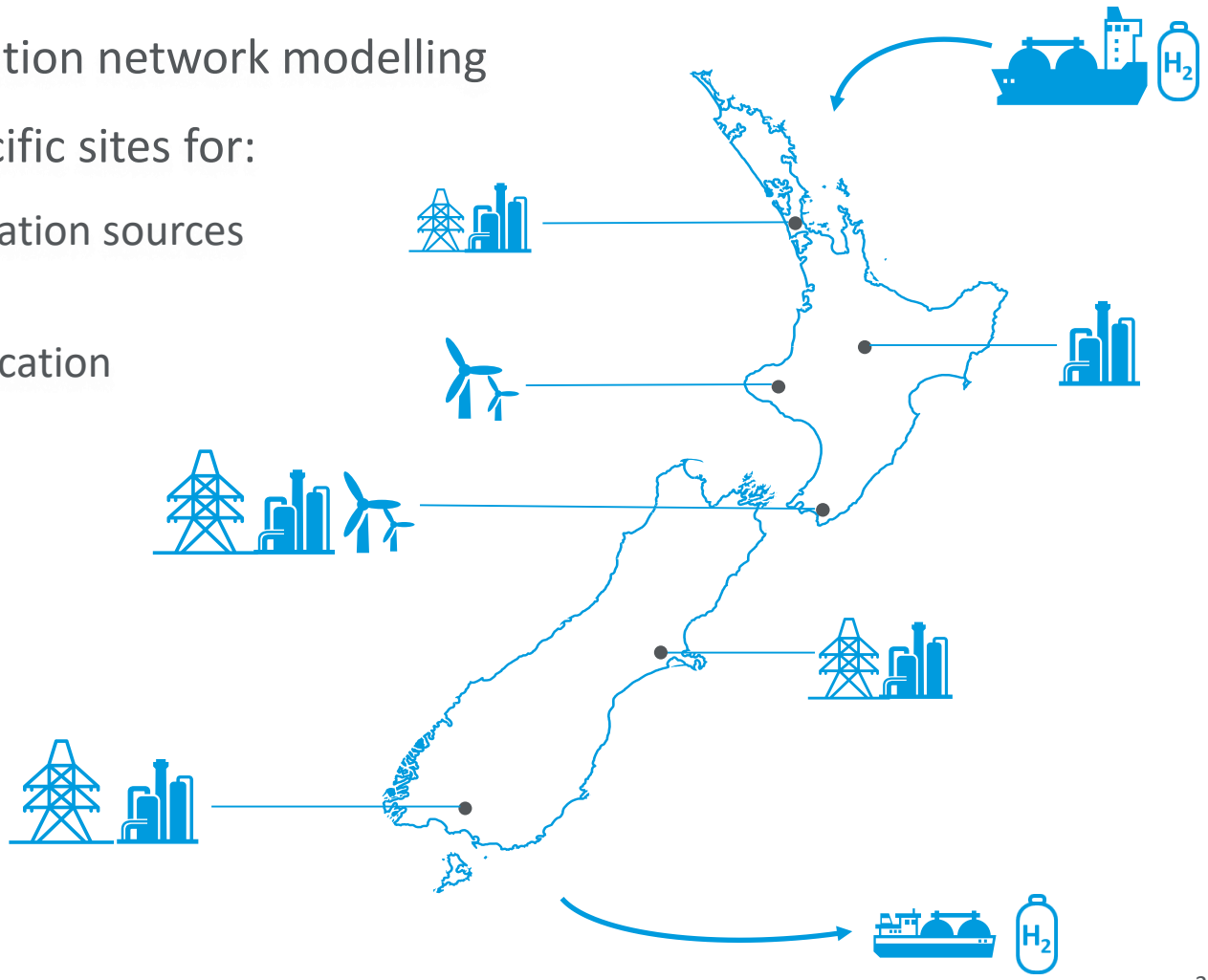


Export or import depends on transport prices



What are Logical Next Steps for this Work?

- Domestic distribution network modelling
- Modelling at specific sites for:
  - Electricity generation sources
  - Optimal scale
  - Nodal pricing/location



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Castalia – About Us

Castalia is a global strategic advisory firm. We design innovative solutions to the world's biggest infrastructure, resource, and policy challenges.

We are active in the global energy shift to renewables and are excited by the possibilities of hydrogen for extending use of renewable energy.

Castalia in numbers

We have a global presence	We have a deep bench of experts	Energy	We have decades of experience
6	**54**	**159**	**40**
Offices around the world	People on our team	Power projects	Years of infrastructure experience

CASTALIA

Andreas Heuser
Andreas.Heuser@castalia-advisors.com

Level 2, 88 The Terrace
PO Box 10-225
Wellington 6011

www.castalia-advisors.com

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WASHINGTON, DC
1747 Pennsylvania Avenue NW
Suite 1200
Washington, DC 20006
USA

SYDNEY
Suite 19.01, Level 19
227 Elizabeth Street
Sydney NSW 2000
Australia

AUCKLAND
74D France Street
Newton South
Auckland 1010
New Zealand

WELLINGTON
Level 2, 88 The Terrace
PO Box 10-225
Wellington 6011
New Zealand

PARIS
64-66 Rue des Archives
Paris 75003
France

BOGOTÁ
Calle 81 #11-08
Piso 5, Oficina 5-127
Bogotá
Colombia