Exploration of offshore wind and green hydrogen in New Zealand

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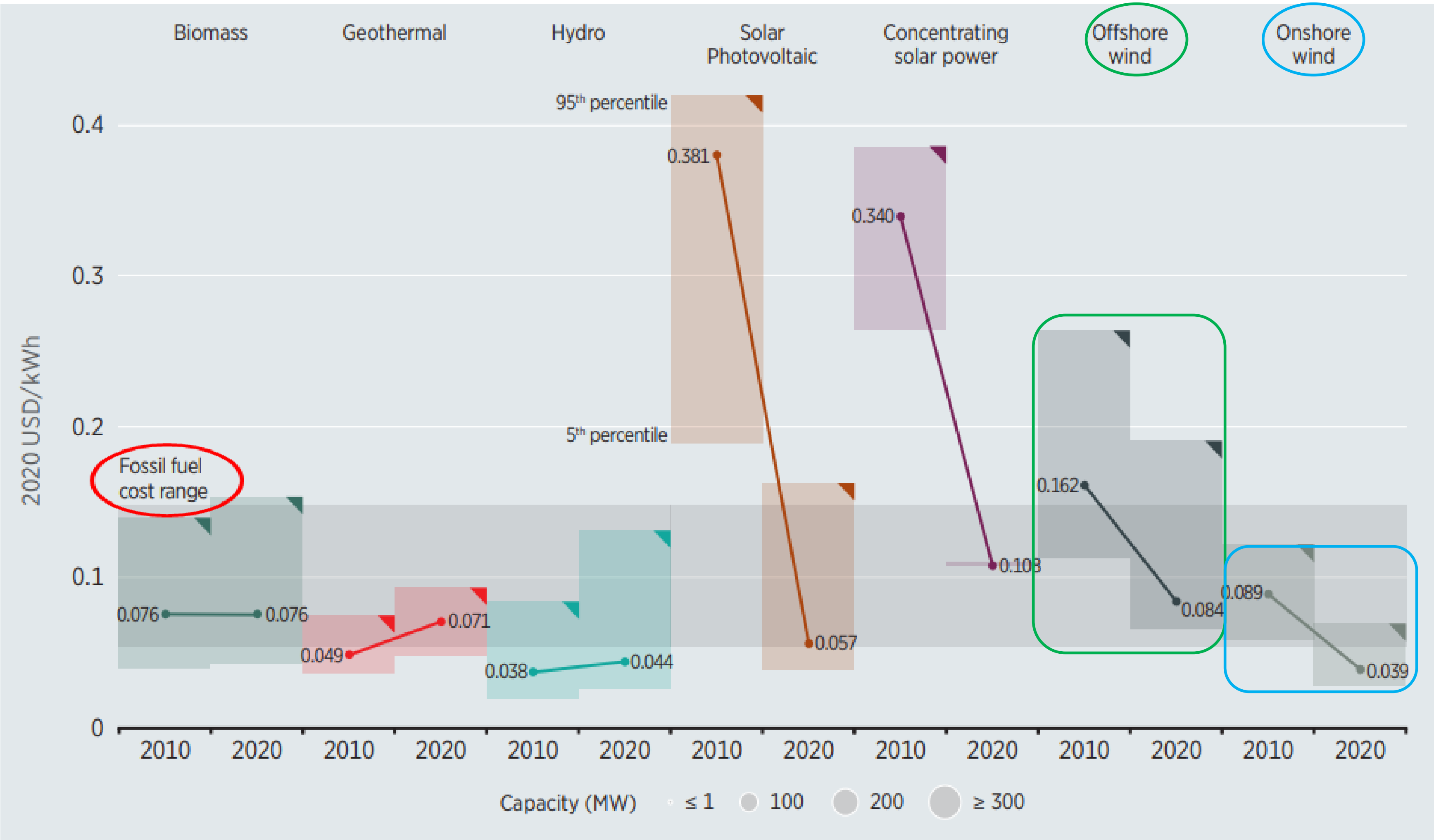
Overview

- Goal of the study:
  - Provide an understanding as to why these technologies are so important in the role of decarbonization.
  - Compare developmental progress overseas to NZ.
  - Provide insight into what New Zealand can learn and implement these technologies.

- Motivations:
  - NZ's target: Net-zero carbon by 2050.
  - 100% renewable electricity by 2035
  - Electricity demand is expected to double up annually by 2050.
  - Offshore wind will play a significant role in the decarbonization/electrification of economies.
  - Due to battery storage limitations, hydrogen can act as a 'green' energy source and storage option.
  - NZ's ideal use would be to combat dry years through these technologies.

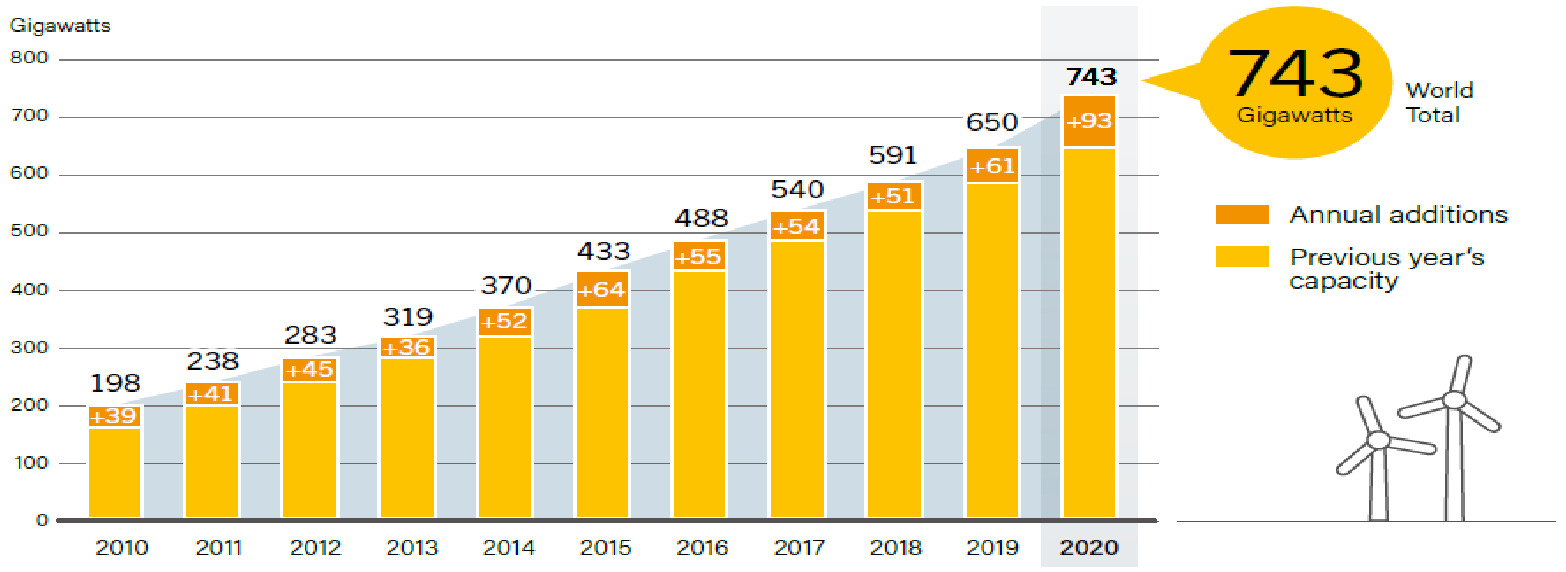
Wind Power Potential

LCOE from utility-scale renewable power generation technologies, 2010 -2020

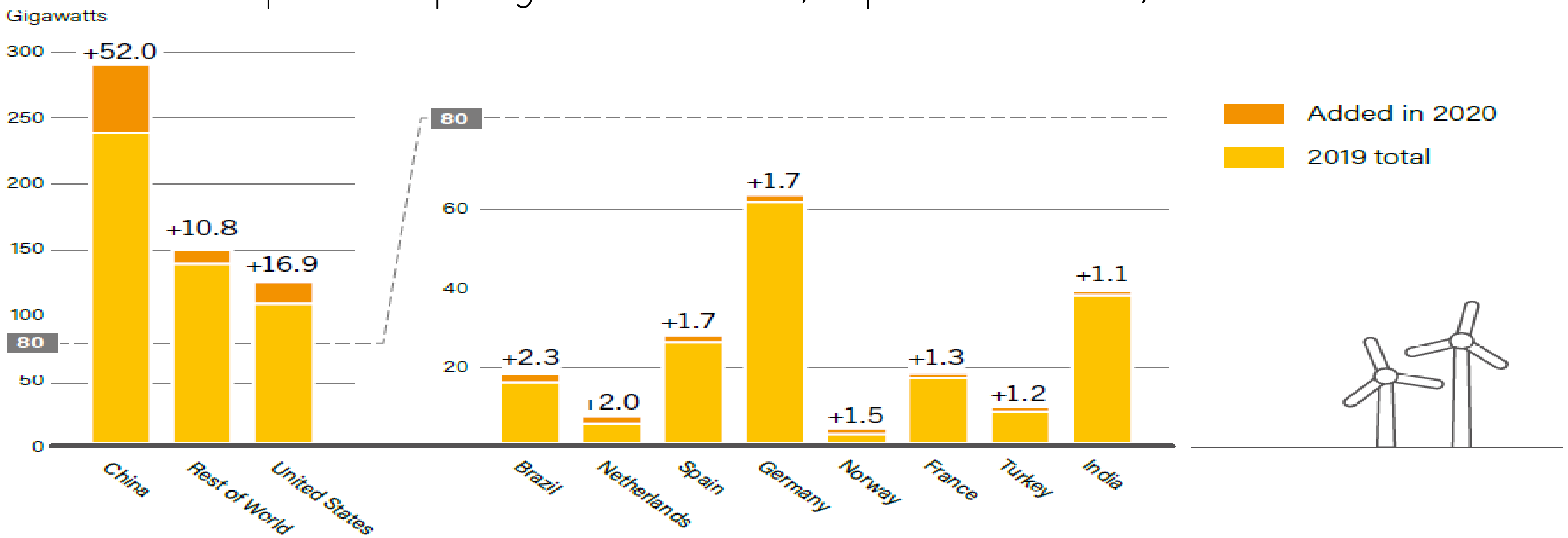


Source: IRENA, 2021.

Wind power global capacity and annual additions, 2010-2020

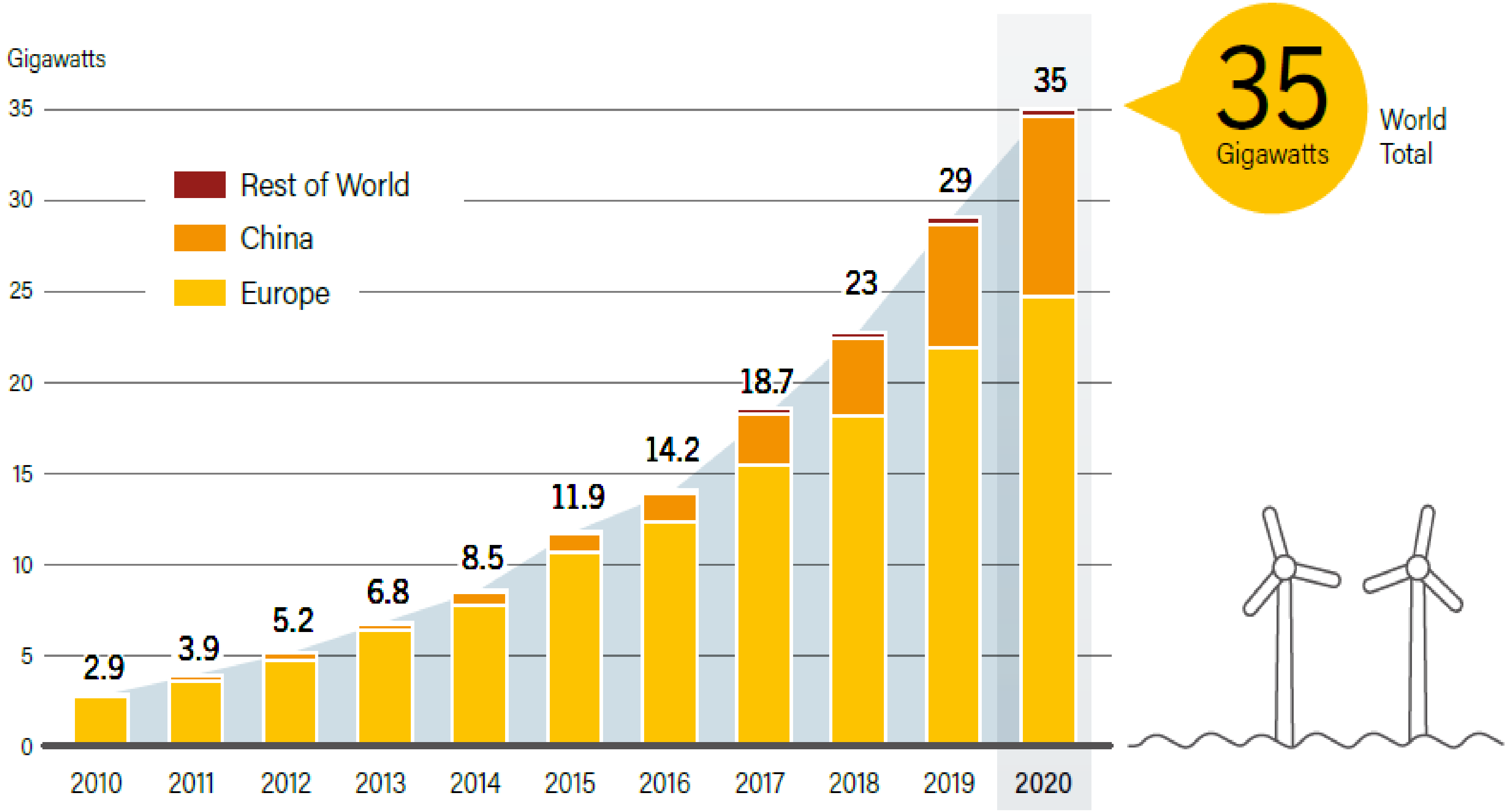


Wind power capacity and additions, top 10 countries, 2020



Source: REN21, 2021

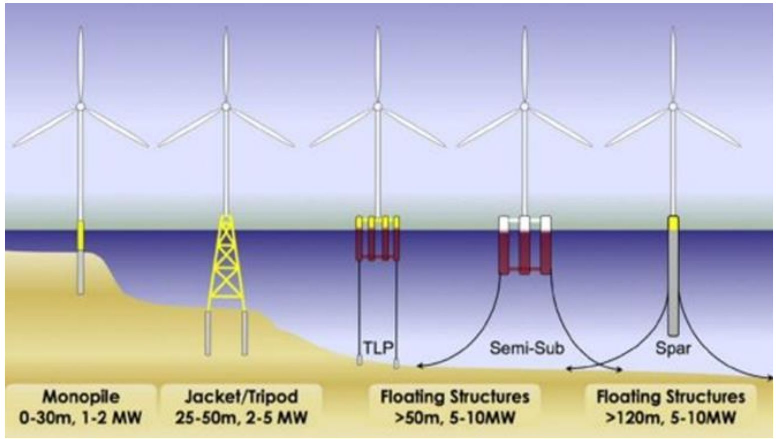
Offshore wind energy global capacity, 2010-2020



Source: REN21, 2020

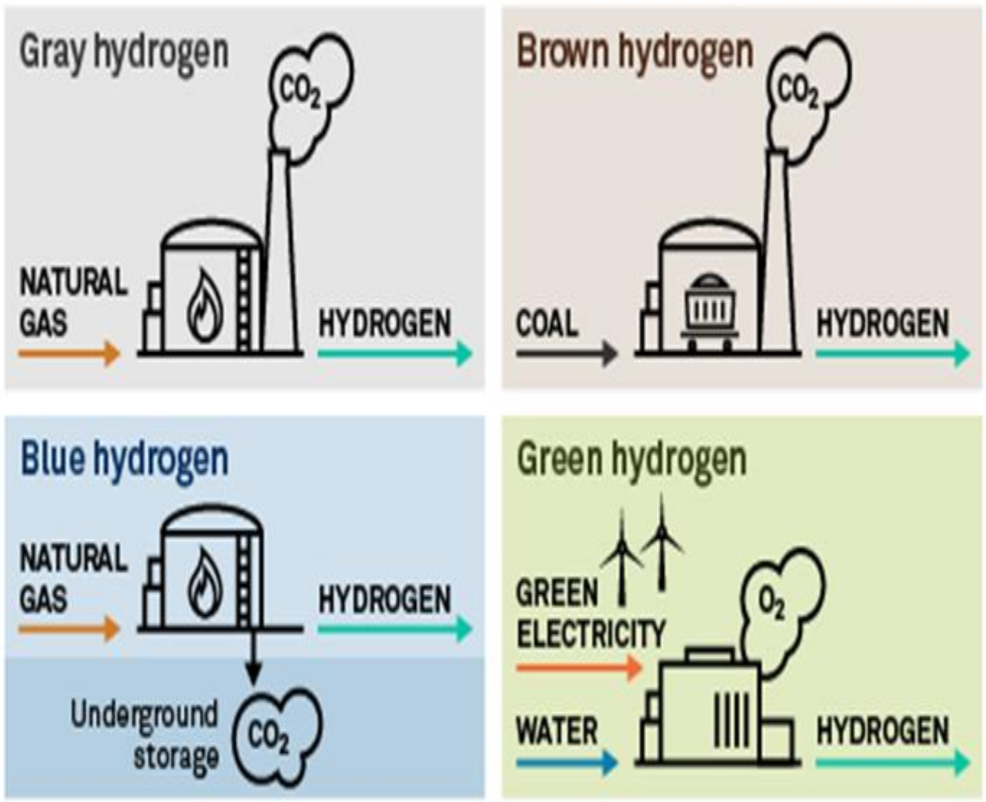
- IEA forecasts (forecasting period of 2021-2026):
  - onshore wind growth of about 75GW annually
  - offshore wind growth of about 21GW annually, with a total capacity of 120GW in 2026

Onshore vs Offshore Wind



- Onshore wind is relatively inexpensive (LCOE: US$30-60/MWh) (Gondal, 2019)
  - Turbine capacity at 2.5-3MW
- Offshore wind is expensive (LCOE: US$120-140/MWh in the current UK and US projects)
  - Alleviates social acceptance problems
  - Higher capacity than onshore (8-12MW)
  - Offshore wind is stronger and more uniform than onshore, larger capacity factor
  - 15% of total costs attributed to the electrical system
  - Projected declining costs of 25-30% by 2030
  - Possibility of moving further offshore (floating turbines)

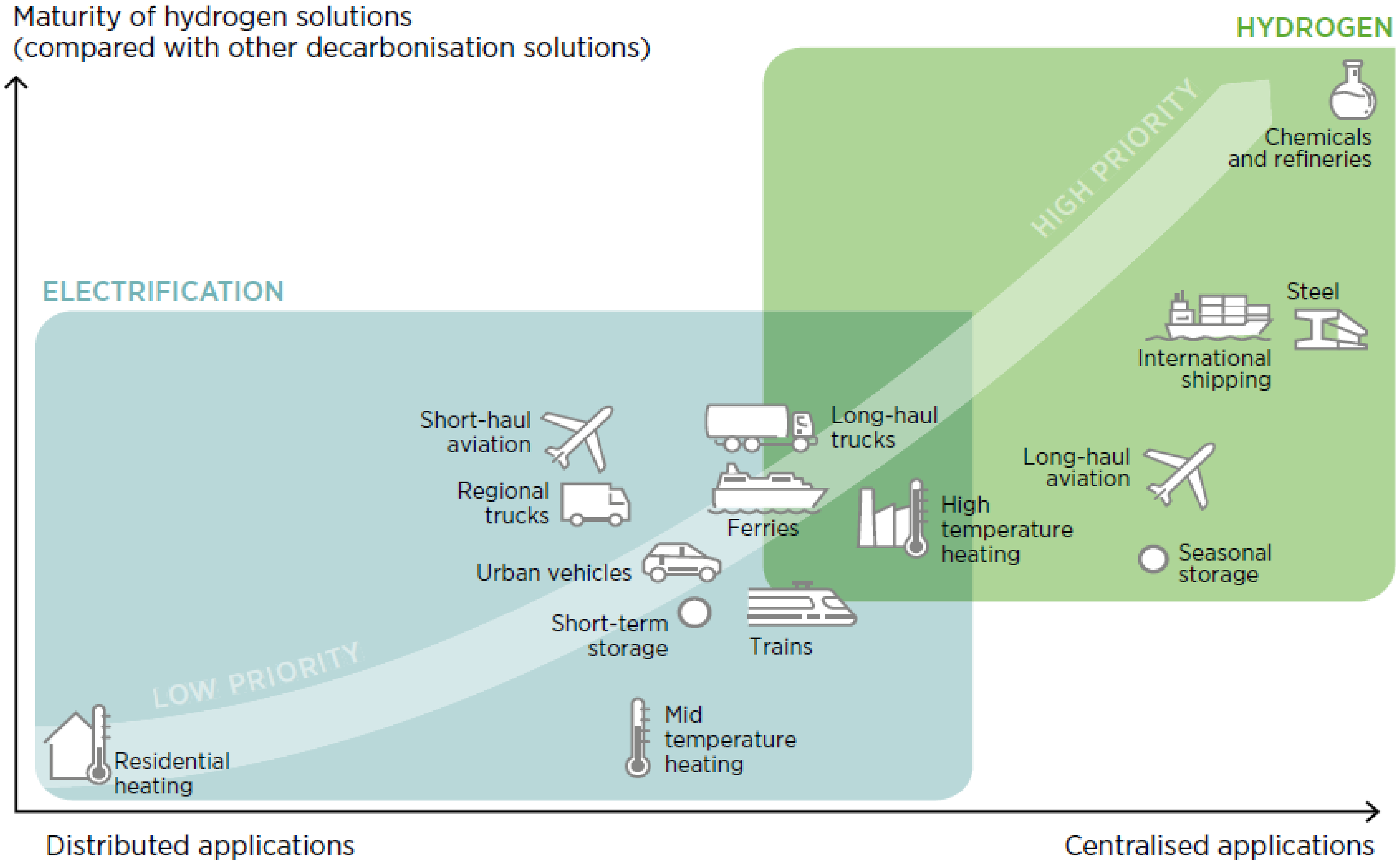
Hydrogen production and implementation



(DiChristopher, 2021)

- 95% of production uses steam methane reformation (SMR), 4% by electrolysis
  - H_2 from SMR cannot be directly used in fuel cells
  - SMR will continue to be the main source, but in the medium-term wind-powered electrolysis will be prominent
- P2G (Power-to-Gas) vs P2P (Power-to-power)
  - P2G regarded as a mature technology
  - P2G is limited to end-user products
  - P2P – Fuel cells are not that efficient
- Hydrogen's Chicken and Egg Problem (Sperling, 1988)

Clean hydrogen policy priorities



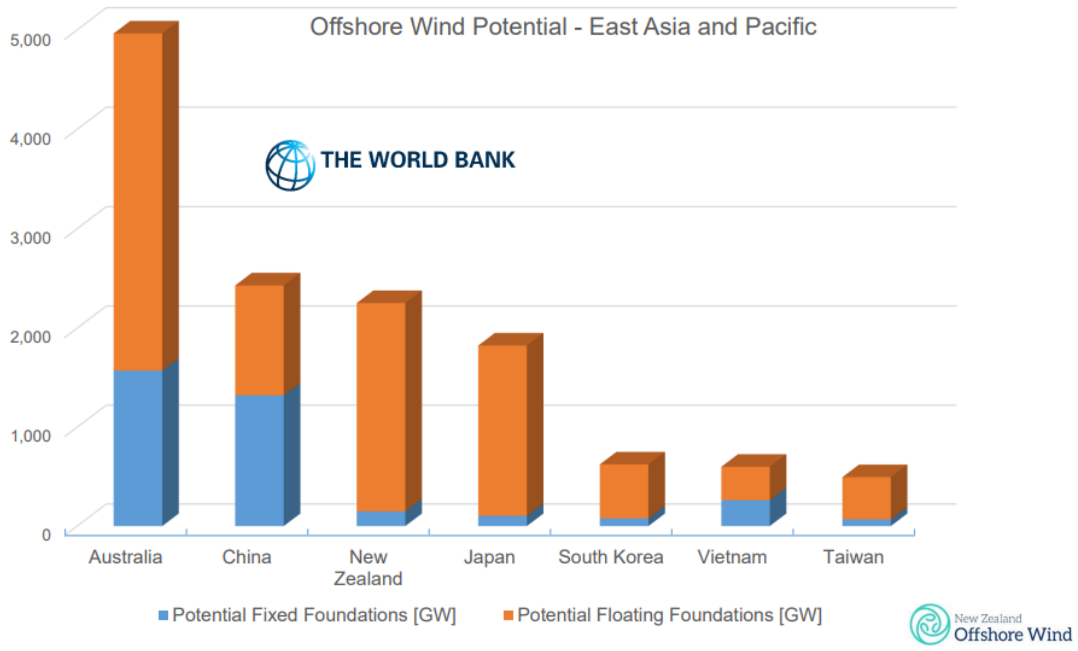
Source: IRENA (2022), The Geopolitics of the Energy Transformation: The Hydrogen Factor, slide 7.

Economics of Hydrogen

- For the widespread implementation of hydrogen, costs need to be on par with existing fuel sources.
- Fuel cells for heat and power in residential/commercial buildings: viable in 2030 with hydrogen costs of US$1.9/kg (Patel, 2020). (Optimistic)
- Large-scale power grid generation: If imported costs of US$3/kg hydrogen, power produced would cost US$140/MWh vs US$44-74/MWh from the combustion of unsubsidized natural gas (Patel, 2020).
- For transportation: costs of US$4.25-5.00/kg is needed to compete with internal combustion engines (Li and Taghizadeh-Hesary, 2020). (per km costs of FCEV are double that of ICEV)
- To compete with coal, hydrogen should be as cheap as US$0.53-0.85/kg, and US$1.29-1.41/kg to compete with natural gas (Li and Taghizadeh-Hesary, 2020).

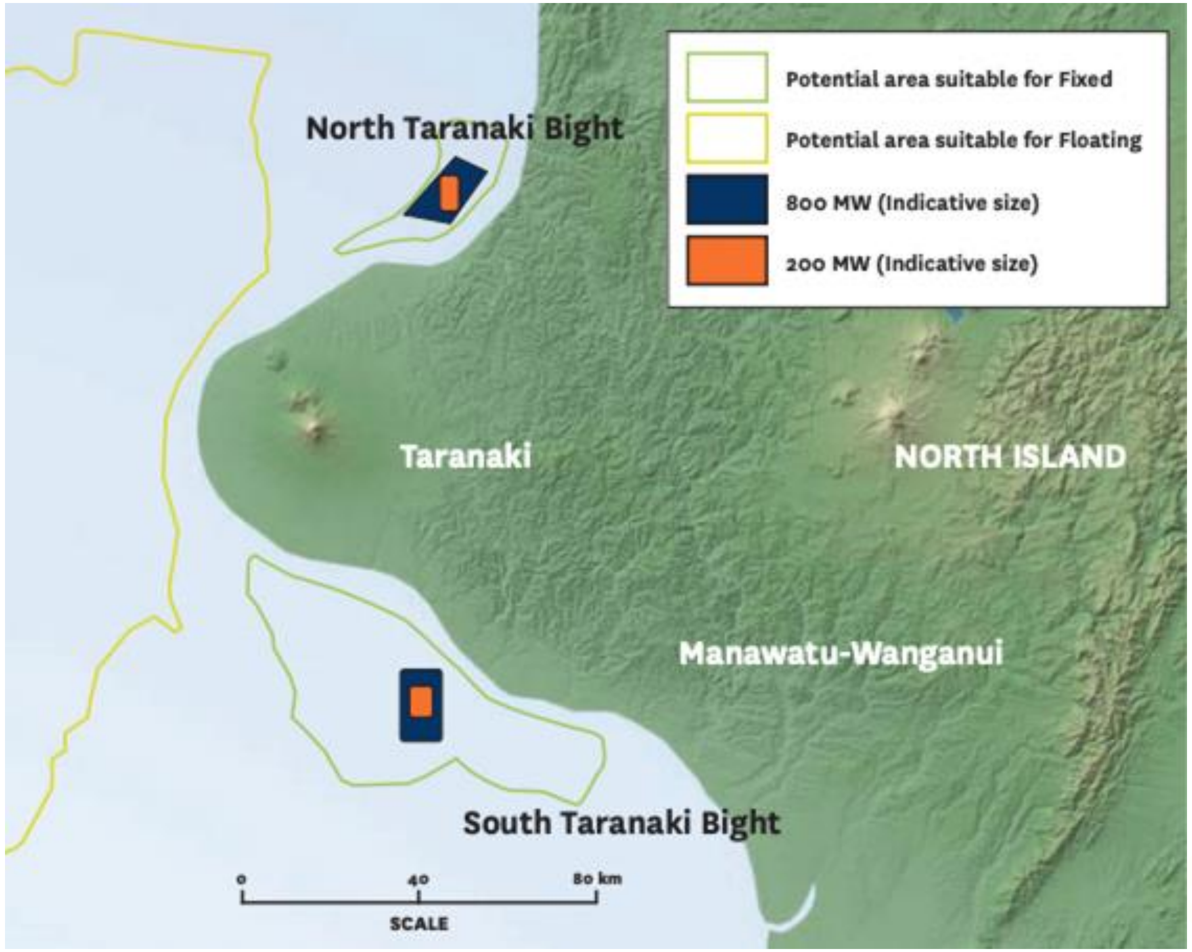
NZ Context

- Renewable potential
  - One of the best wind resources in the world
  - MBIE identified 8GW of offshore wind capacity in NZ, but development is unlikely before 2050
  - Potential large scale hydrogen production in Taranaki, storage in Ahuroa Gas Field



Offshore wind potential in Taranaki (Venture Taranaki)

- Consistent and high wind speeds
- Flat seabed allows for fixed turbines (<50m):
  - South:1800km² (12GW)
  - North:370km² (2.4GW)
- Potential for further expansion for floating turbines (100-150m):
  - 14000km² (90GW)
- A largely self-sufficient local offshore wind industry
- Large-scale offshore wind deployment could create an opportunity for energy exports in the form of green hydrogen.

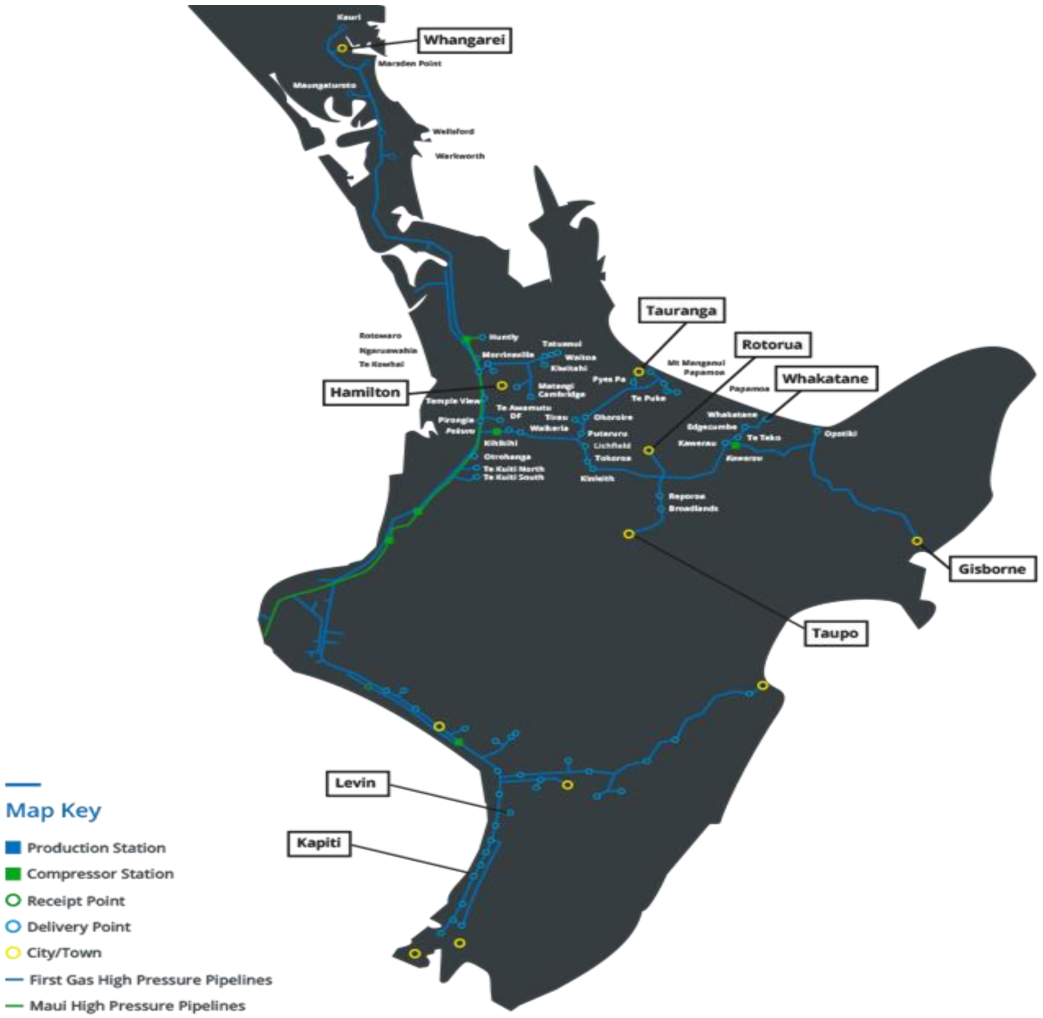


Market Distribution

- Selection of the Taranaki site, falls in line with the existing gas pipelines supplied by FirstGas.

- Within close proximity of the major ports of Auckland, Wellington and Tauranga.

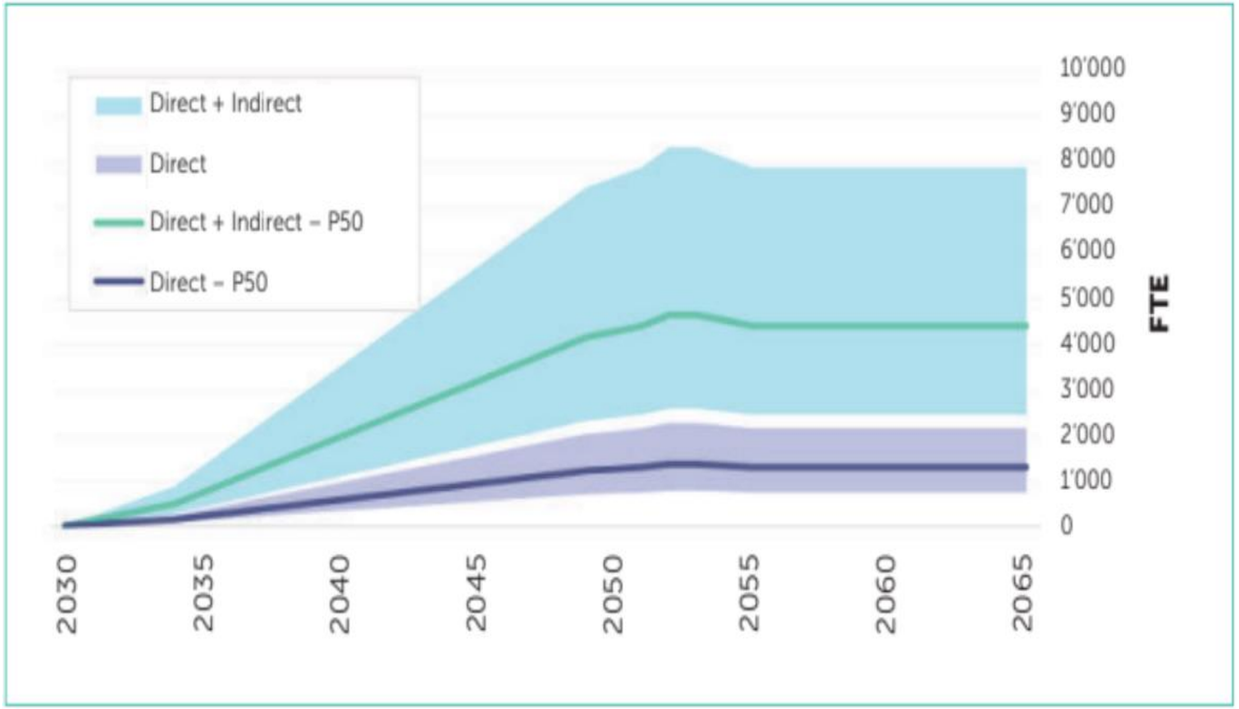
- Export opportunities
  - Exports to Asian countries due to a favorable geographical location and negatively correlated
  - Exporting green hydrogen to Japan as ammonia or liquid hydrogen
  - NZ could achieve landed costs of green hydrogen at US$4.3-5.6/kg in 2025 and US$3-4/kg in 2030



NZ Context

- Storage opportunities
  - Existing gas infrastructure installed is beneficial for the transition to hydrogen
  - Ahuroa Gas facility is a location for large storage but needs upgrades to be feasible.
  - Types of storage methods: Ammonia, Compressed Hydrogen, Liquid Hydrogen

- Employment
  - Assuming 9.9GW of offshore wind is realized in the next 20 years, the industry is likely to scale up rapidly
  - 1000 direct jobs and 4000 direct + indirect jobs are expected to be seen by 2040
  - In 2050, when all offshore farms are operational, operation and maintenance employees can reach up to 8,300.



(Briggs et al., 2021)

Cost Estimates

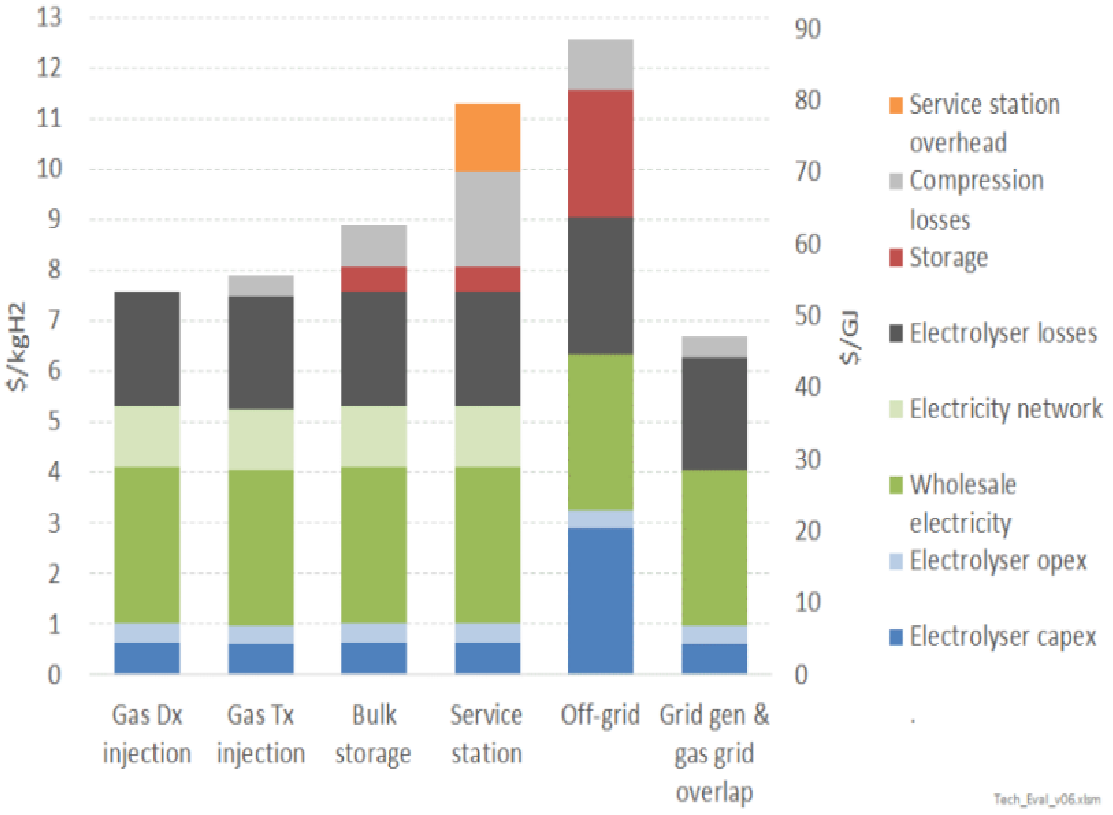
- Ideal Scenario for Green Hydrogen
  - Connection of electrolyzers to the distribution grid for peak utilization
  - Assumption: electricity being used is supplied by renewable sources
  - Main Aim: Produce hydrogen in times of low demand to take advantage of surplus in electricity.
  - Renewable electricity generated is not going to waste, but instead building up the 'battery' for future demand.
- Sources of Cost Estimates
  - Concept Consulting
  - Non-NZ specific literature
  - MBIE and Castalia modelling for future hydrogen supply and demand

Concept vs Castalia Model

- Concept:
  - Assumes green hydrogen through grid electricity distribution using electrolyzers, compressed and stored in bulk. Model looks at all inclusive costs.
  - Variables include wholesale electricity, network costs, efficiency losses, CAPEX, storage, OPEX.
  - Electrolyzer utilization factor is estimated to be 85% (relatively high)
  - Electricity costs now and in the future are estimated to be NZ$75/MWh
- Castalia:
  - Model accounts for electricity costs, utilization factors in NZ and internationally, natural gas and diesel price changes, percentage that hydrogen can be blended into the gas network.
  - Utilization factor base case of 41.5%
  - Base case of NZ$61/MWh electricity cost for 2020 with a 0.25% expected annual decrease in prices both in NZ and internationally

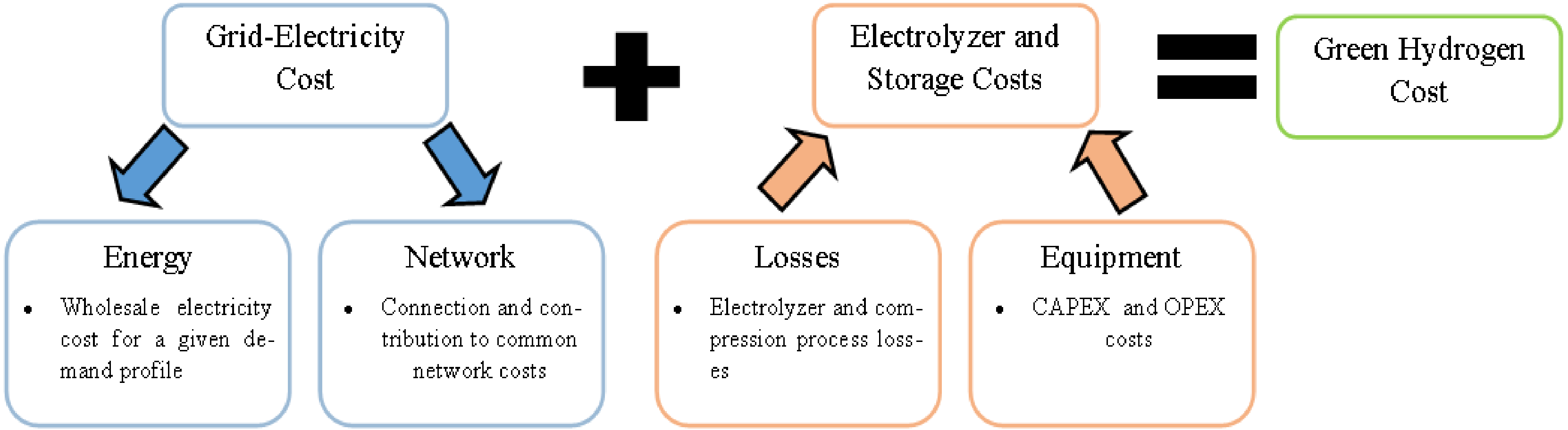
Different Scenarios

- Modelling also included alternative uses of hydrogen – looking to alleviate some of the higher costs from hydrogen storage
- Method which avoids storage costs is P2G:
  - Gas Dx and Gas Tx injection
  - Compared to the bulk storage scenario, there are lower compression losses, electricity network costs, electricity distribution losses and electrolyzer costs

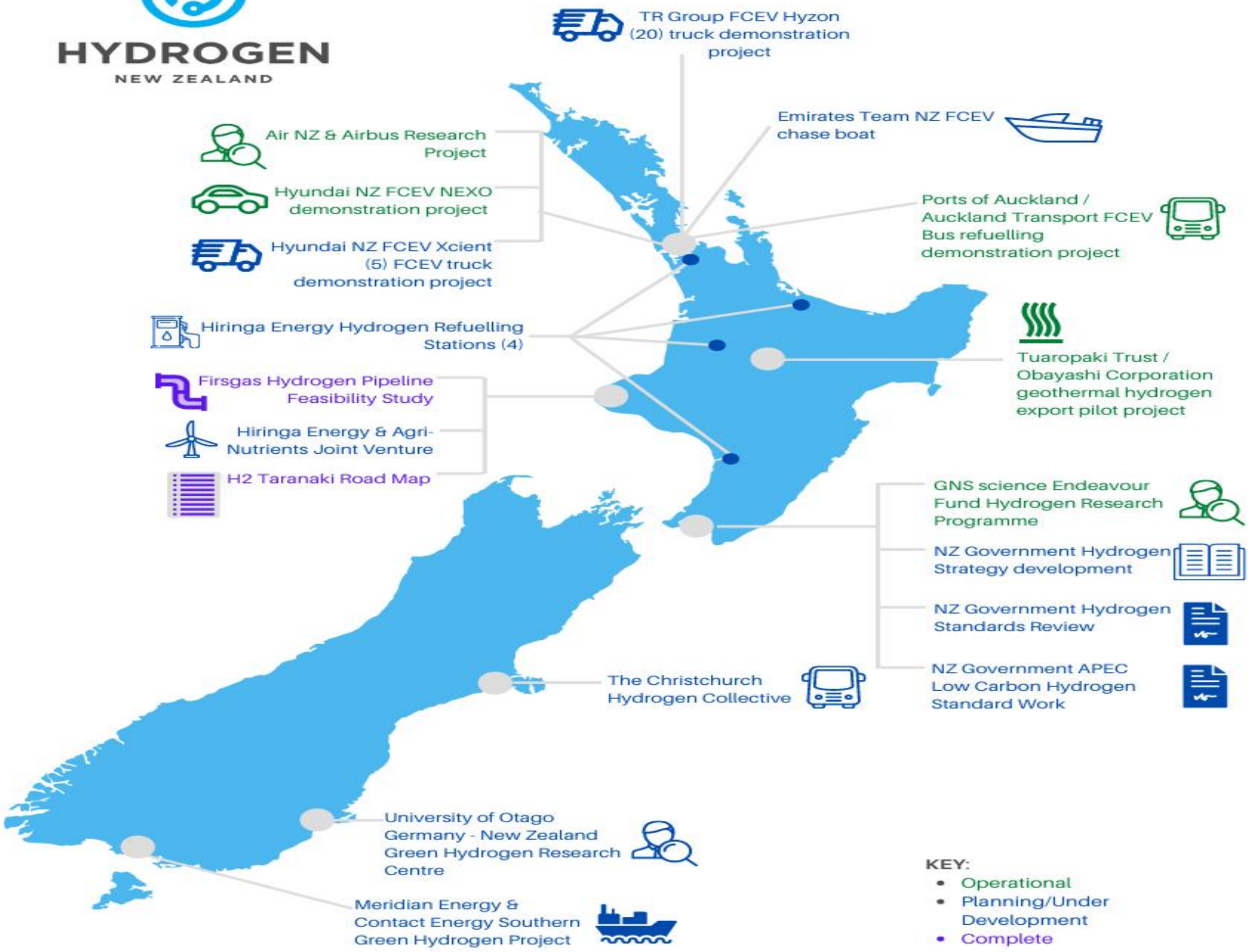


(Concept Consulting,2019)

Findings



- Concept Consulting (2019):
  - Estimated current production cost is US$5.95/kg H2 (NZ$8.91) and US$4.64/kg H2 (NZ$6.94) in 2039, which is relatively high
- Castalia:
  - Castalia's base case estimates the LCOE currently is US$3.83/kg H2 (NZ$5.72), and around US$2.68/kg H2 (NZ$4) in 2039.



NZ Hydrogen Projects

- FirstGas Hydrogen Pipeline Feasibility Study (supported by government funding)
  - 2035, 20% H2 blending achieved
  - 2050, all networks converted to 100% H2.
- Hiringa Energy Hydrogen Refuelling Station
  - An initial 8 refuelling stations
  - Further 16 by 2025
  - Over 100 by 2030
- Hiringa Energy and Agri-Nutrients Joint Venture
  - 24MW onshore wind produces green hydrogen – 7,000 tonnes of urea per year.
- Southern Green Hydrogen Project
  - Meridian Energy and Contract Energy co-fund a $2 million feasibility study into large-scale green hydrogen production.

Emirates Team New Zealand’s hydrogen boat

Chase Zero was launched in Auckland on March 31

Largest green hydrogen projects, 2021

AU:

- 1.6bn in government funding
- 7 hubs
- The goal of the Australian Renewable Energy Agency <AU$2/kg

1. HyDeal Ambition (67GW) .... Western Europe
2. Unnamed (30GW) .... Kazakhstan
3. Western Green Energy Hub (28GW) ...... Australia
4. AMAN (16GW)[a] .... Mauritania
5. Asian Renewable Energy Hub (14GW) ... Australia
6. Oman Green Energy Hub (14GW)[a] .... Oman
7. AquaVentus (10GW) .... Germany
8. NorthH2 (10GW) .... Netherlands
9. H2 Magallanes (8GW) .... Chile
10. Beijing Jingneng (5GW) .... China
11. Project Nour (5GW)[a] .... Mauritania
12. HyEnergy Zero Carbon Hydrogen (4GW)[a]. Australia
13. Pacific solar Hydrogen (3.6GW) .... Australia
14. Green Marlin (3.2GW)...................... Ireland
15. H2-Hub Gladstone (3GW) .... Australia
16. Moolawatana Renewable Hydrogen Project (3GW)[a] – Australia
17. Murchison Renewable Hydrogen Project (3GW) – Australia
18. Unnamed (3GW)............................ Namibia
19. Base One (2GW)[a]............................ Brazil
20. Helios green Fuels Project (2GW) .... Saudi Arabia

Note: Size refers to electrolyser capacity. Information based on announced plans.
a. Estimated electrolyser capacity based on a comparison with similar-sized schemes.

Source: IRENA (2022), The Geopolitics of the Energy Transformation: The Hydrogen Factor, slide 26.

Summary of remaining parts of the study

- International Implementation of Offshore Wind and Hydrogen
  - Looked at countries in proximity, similar sizes and geography, and leaders in the offshore wind space
  - Countries included are Australia, Japan, UK, Vietnam, and Brazil
  - Section discussed their own implementations and timelines, and possible lessons learnt from their progress
- Regulatory Consideration for Renewables and Hydrogen
  - Discussed regulatory developments in these countries, how they differ from what NZ has legislated, and what NZ can learn from them.
  - Provided guidance on what "good" policies would look like to promote renewable energy generation
  - Overall message: Policy and regulatory interventions are very important in the hydrogen economy cycle

Conclusion

- Integration of offshore wind and green hydrogen can and will play an important role in the decarbonization of NZ's economy
- NZ can take more action to further develop both these industries to attain some of the opportunities
- Southland also has the potential for offshore wind, and as it is far from load centers in the North Island, hydrogen production could be an option.
- Current cost estimates for hydrogen in NZ are not cost-competitive with existing fossil fuels but may be in the future
- Grants, subsidies, regulatory incentives, and higher carbon prices are some actions the government can take to bring costs down and incentivize development further.
- A public-private partnership could accelerate wind-hydrogen technology, such as, co-investment by private sectors and governments could de-risk long-term market uncertainty.
- Lastly, more research is required for cost estimation for very NZ-specific scenarios to provide insight into which project will be more efficient or cost-effective. For example, co-design of offshore wind and green hydrogen could reduce the implementation cost.

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Thank you for your attention!

"We cannot direct the wind, but we can adjust the sails."

--Dolly Parton

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