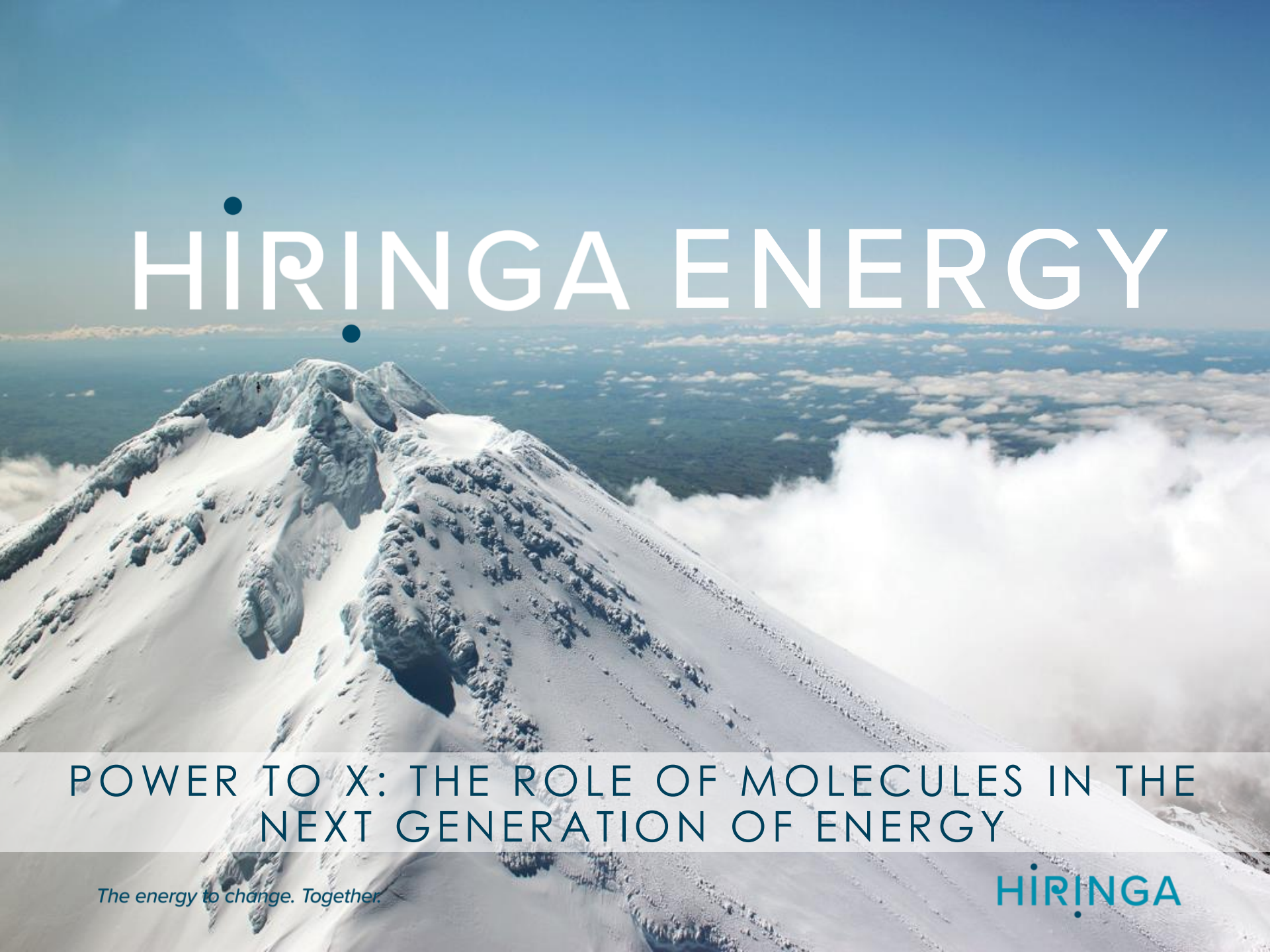


POWER TO X: THE ROLE OF MOLECULES IN THE NEXT GENERATION OF ENERGY

The energy to change. Together.

HIRINGA

A new kind of energy company.

Hiringa

(noun) perseverance, energy, determination, inspiration, vitality.

Our Vision:

To create a zero emission energy future for New Zealand.

How will we do this?

Together with partners, we are developing a network of hydrogen generation, distribution and refuelling infrastructure to supply this clean and sustainable fuel to commercial, industrial, public sector and retail customers in New Zealand.

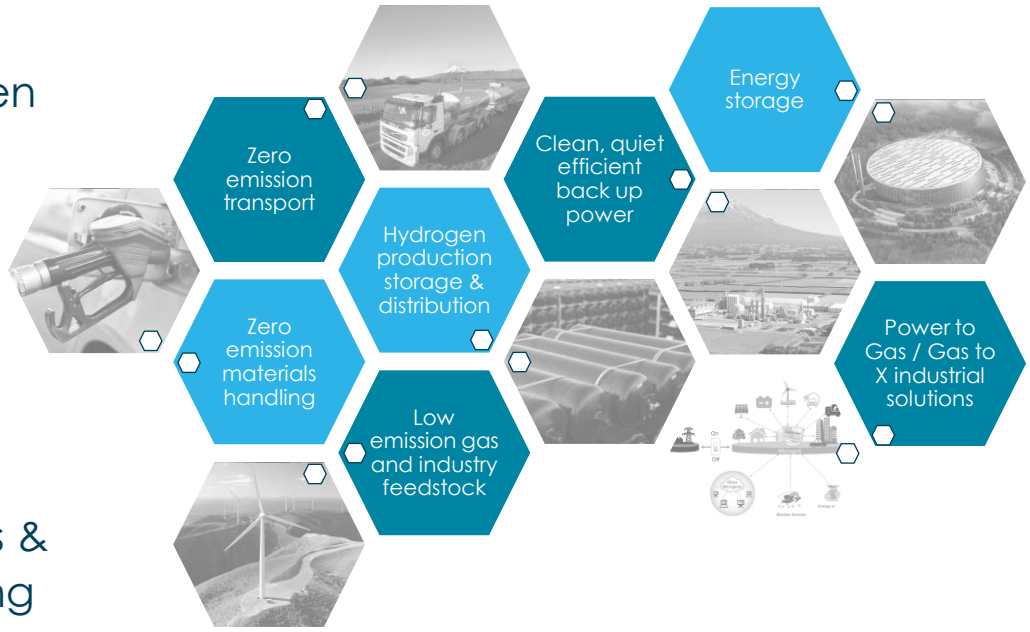
Hiringa Energy

We are a New Zealand company formed by a group of energy industry professionals. We are developing:

- Integrated hydrogen supply chain and network of hydrogen refueling stations
- End markets for hydrogen

Key skills:

- Engineering & Project Management
- Hydrogen production, systems & refueling design, commissioning and operation
- Health and safety, and facilities operation management



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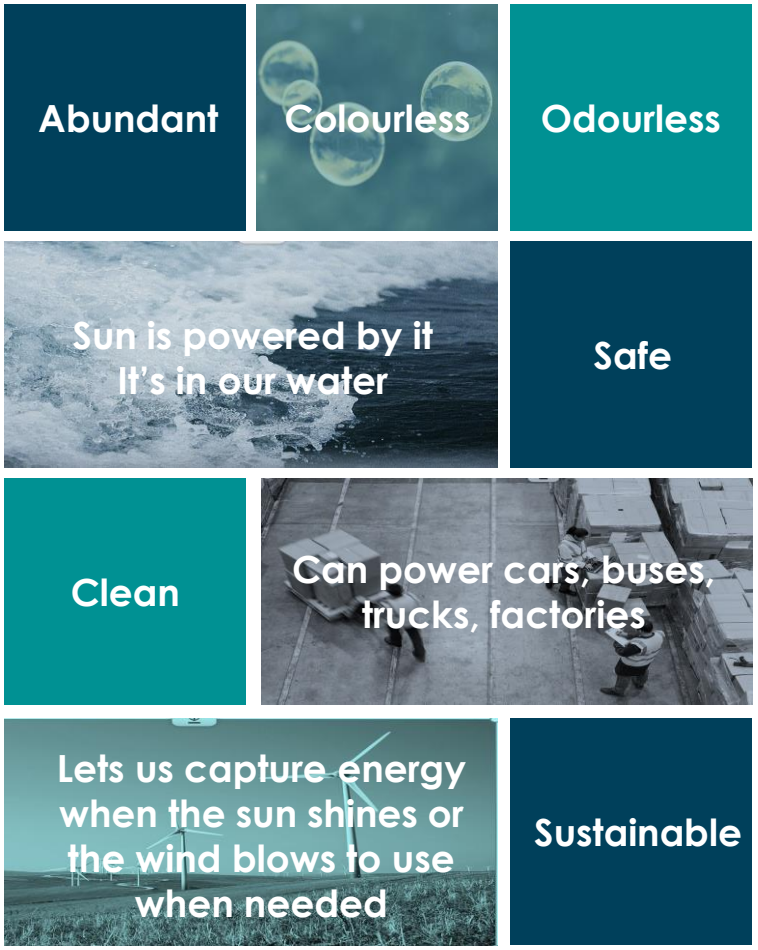
Why hydrogen?

- The world needs low-emission energy solutions to:
  - reduce pollution,
  - address global warming,
  - support a growing population,
  - reduce energy poverty.
- The production, transport and use of renewable energy at scale is required.
- We need mass-market, clean energy solutions for transport, industrial feedstock, energy storage, heat and power.
- Today energy supply is expected to be renewable, affordable and reliable.



Hydrogen in a global context

- Regions and corporations around the world are already using hydrogen.
- Governments are investing $850m p/a in hydrogen programs and moving from R&D to deployment:
  - Japan moving to a "Hydrogen Society"
  - China have shifted their focus from BEV to FCEV subsidies
  - Germany rolling out fueling stations, industrial and storage trials (already committing EUR 3.4 billion)
  - South Korea is converting its 26,000 bus fleet from CNG to hydrogen
  - Leeds City Gate planned to be a pilot hydrogen gas network conversion in UK
- Hydrogen Council formed with 25 major corporations from various industry and energy sectors planning to spend EUR 1.9 billion per year over next 5 years.

Why New Zealand?

New Zealand is in a unique position to lead the transition:

- Large potential energy resources
- Highly integrated energy, industry, transport, agricultural and urban ecosystems
- A culture of innovation

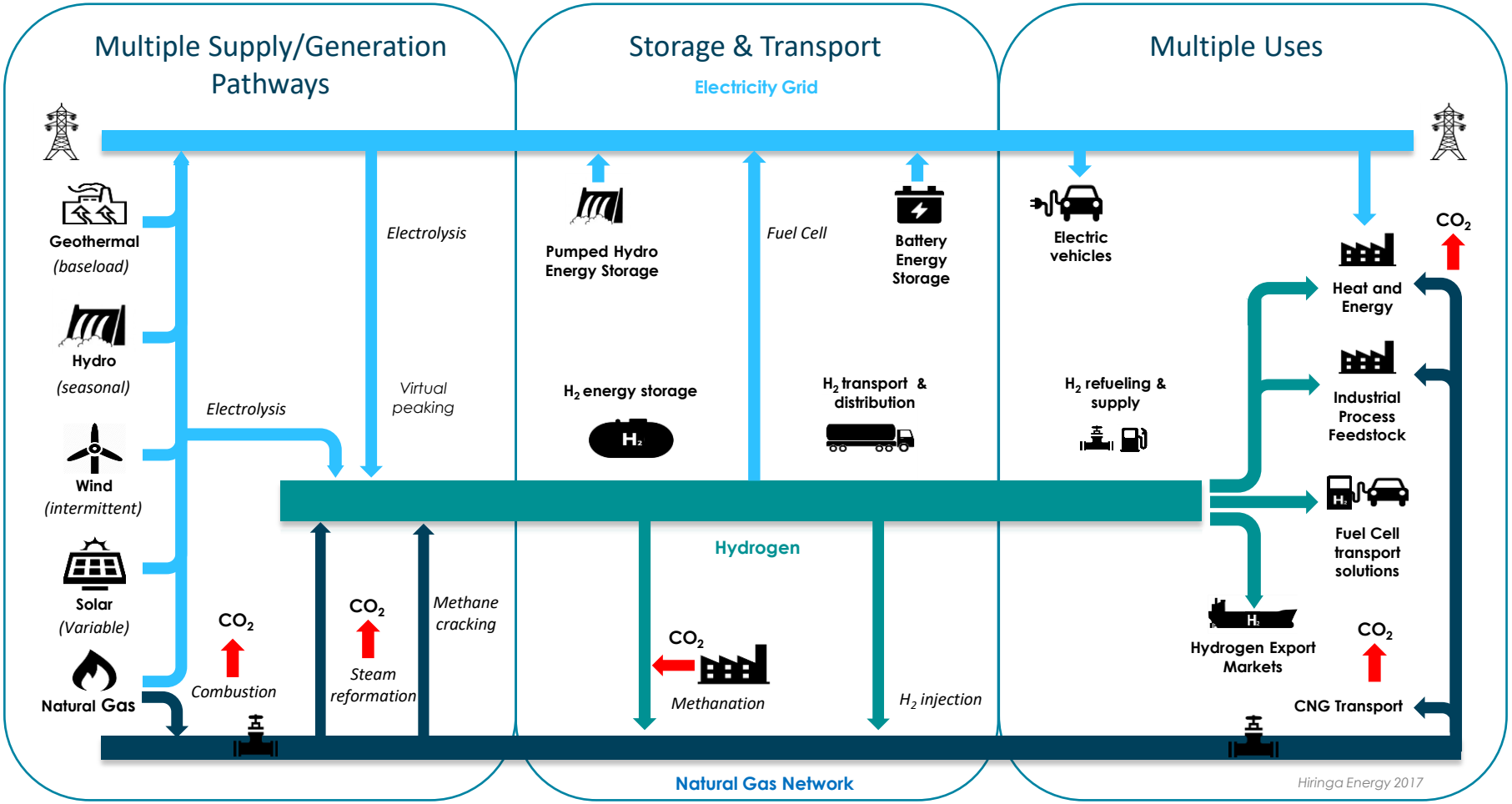
We can learn from others and accelerate a hydrogen solution.

Focus the first projects on:

- The most robust commercial models
- Areas where emissions reduction is otherwise challenging

Use these projects as a beach head to grow capability, new industry and jobs.

Hydrogen as an "Energy Vector"



Multiple supply = increased resilience, can change over time

Multiple uses = greater impact on greenhouse gas emissions

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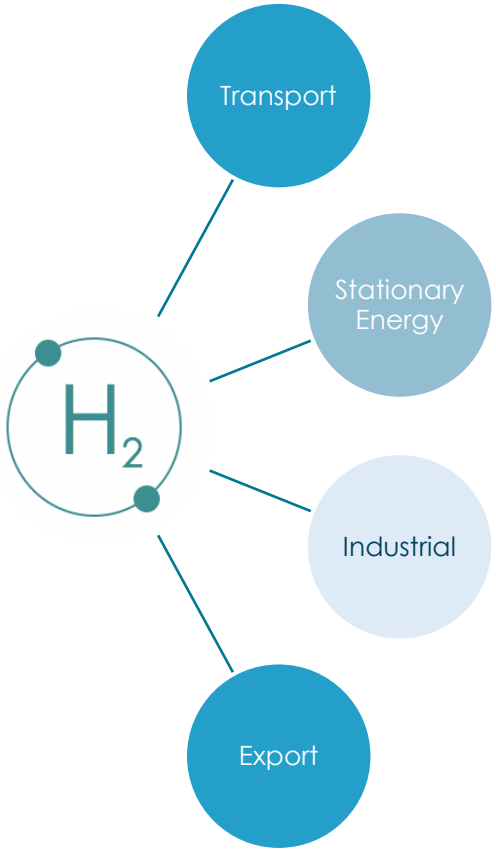
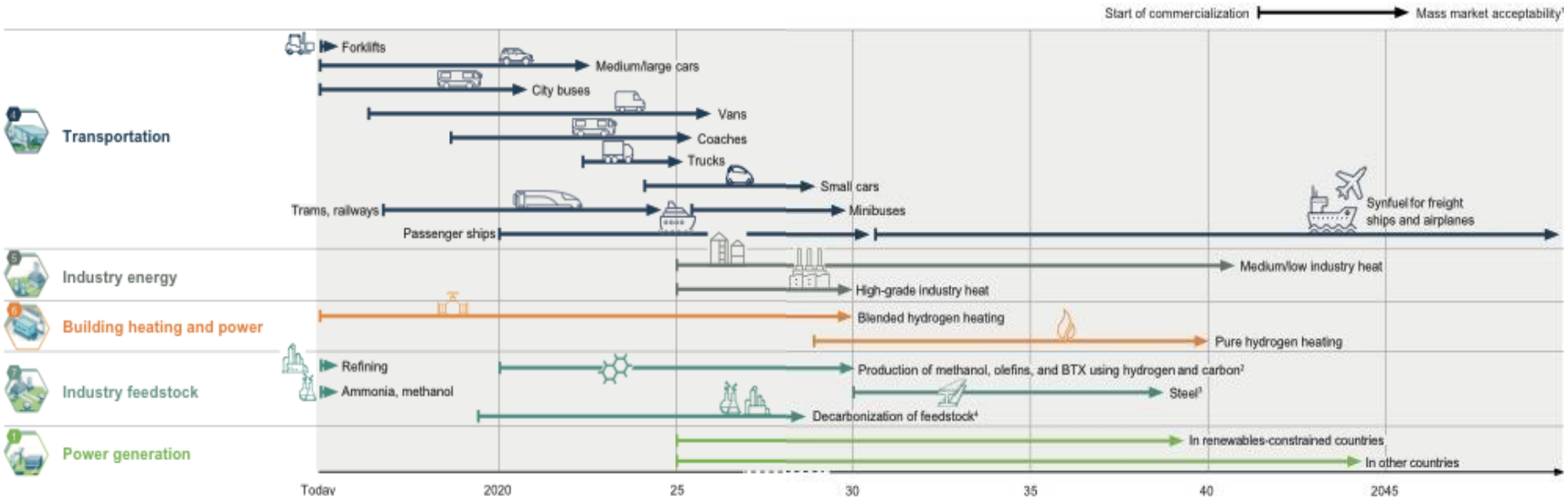
H_2 applications



Applications	Advantages	Enablers
• Materials handling • Light vehicles • Buses, trams & trains • Medium & heavy vehicles • Marine	• Range • Weight • Quick refuel • Energy security	• Hub fleets • Demand aggregation • Availability of H2
• Large scale storage • Back-up energy • Remote energy supply • Grid stabilisation • Power to gas	• Low emissions • Reliable • Low maintenance • Efficient storage and use	• Dry season storage • Reducing cost of renewables • Legislation • New custom solutions
• Petro-chemicals • Agri-nutrients • Refining & smelting • Heating	• Feedstock for low emission chemicals	• Premium for green products • Cheap power • Scale
• LHG / LOHC • Ammonia	• Renewable energy carrier	• Capability demonstrated • Domestic market offtake

Hydrogen tech is ready to be deployed

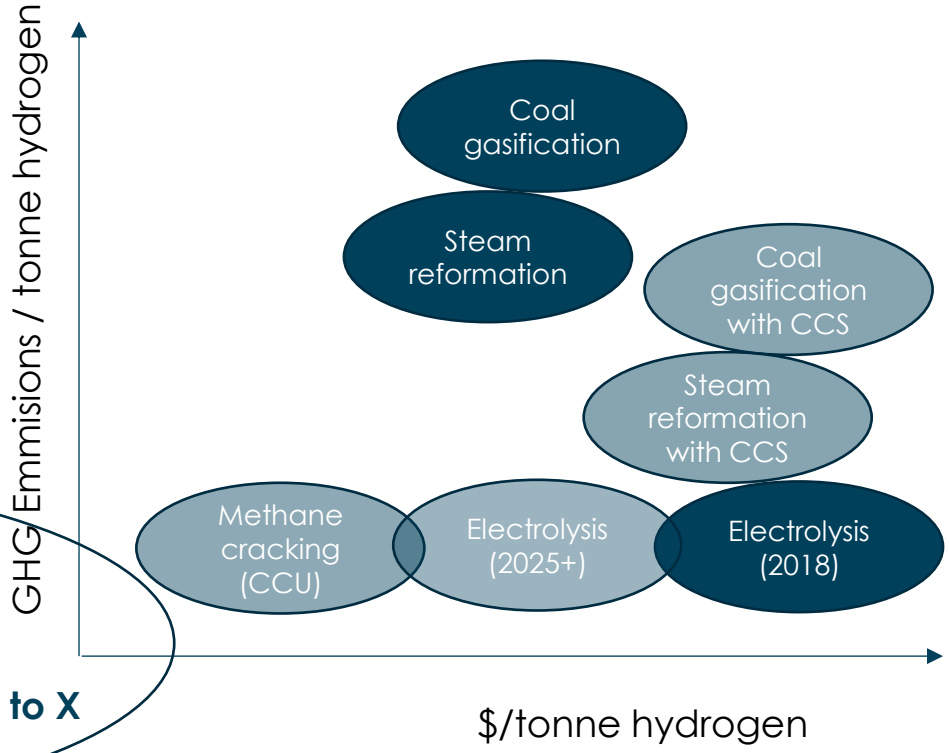


*Hydrogen Council, 2017

Hydrogen production

- Majority of production from coal gasification or natural gas steam reformation:
  - Produces CO2
  - Requires coupling with Carbon Capture Storage (CCS) to manage emissions
- Hiringa is developing options for low emission hydrogen supply:
  - Electrolysis from renewable energy via grid
  - Large scale electrolysis direct coupled to renewable developments
  - Active R&D program for Carbon Capture & Use (CCU) technology

Power to X



Hydrogen fuel cell vehicles (FCEVs)

- FCEVs are electric vehicles that use compressed hydrogen gas to power the electric motor. Hydrogen gas and oxygen from the air combine in a fuel cell to produce electricity.
- There is no combustion and the only emission is water vapour.
- Fuel cells are up to 95% recyclable

A FCEV car can travel up to 130km on 1kg of hydrogen and a bus 100km on 8kg

FCEVs can travel up to 800km and take 3-5minutes to refuel


Zero tailpipe emissions


Lower running costs


Quick refuelling


Instant torque


Less maintenance and longer vehicle life

High vehicle availability


Use renewable energy


Quiet


Efficient

H2 enables zero emission heavy transport

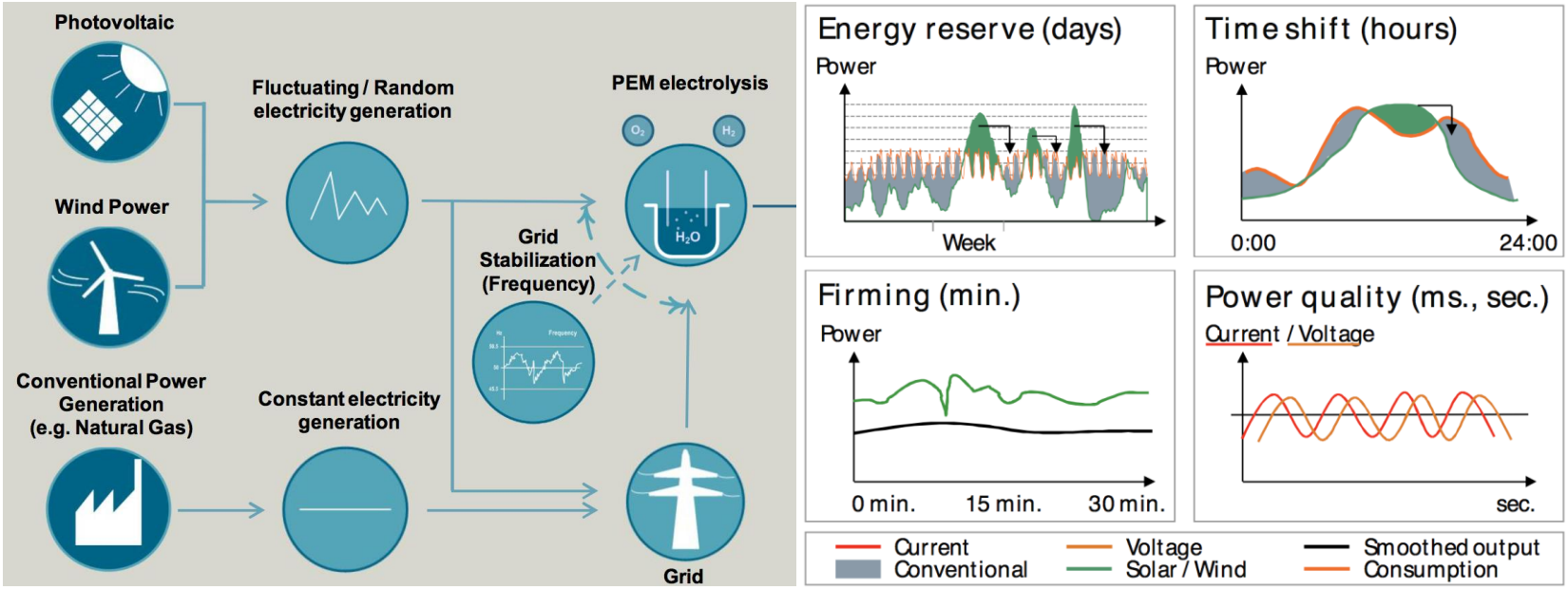
All the benefits of an electric drive train:

- High torque and acceleration
- Low noise
- Zero emission – no NOX
- Low maintenance cost

But solves key barriers associated with electrifying heavy transport:

- Quick refueling with full capacity
- Material payload advantage over battery
- Scalable infrastructure – ~40 times throughput compared with 400V DC fast chargers
- Avoid peak electricity costs/loads
- Avoid costs of conventional rail electrification

Hydrogen can assist grid stability

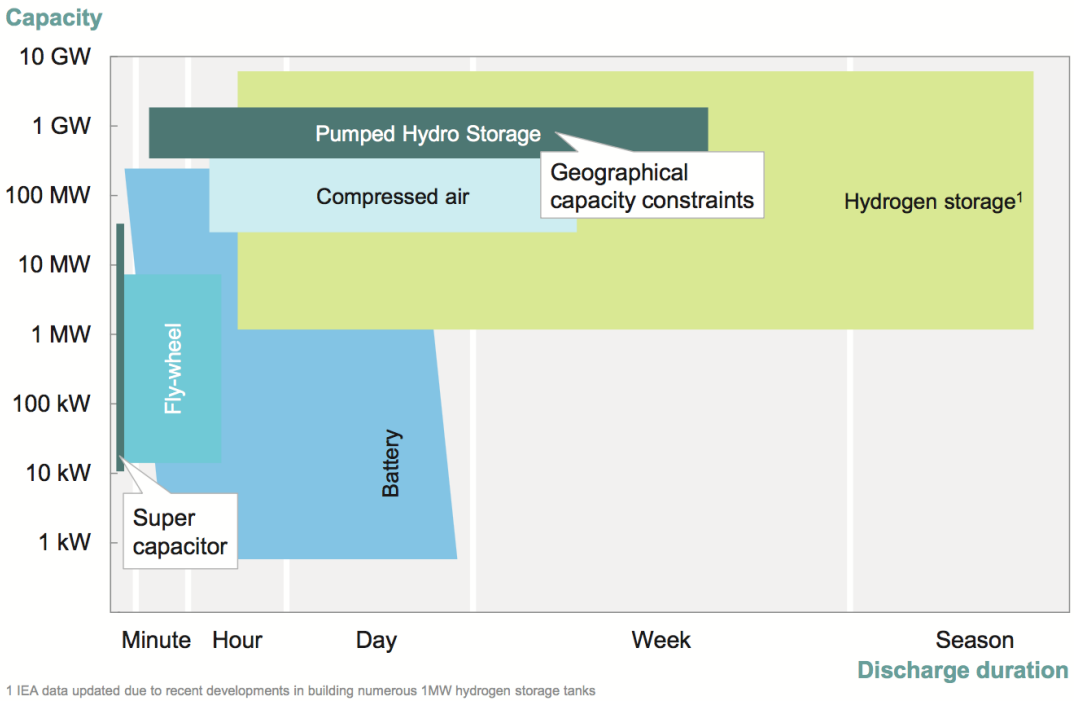


Source: Hydrogen and Beyond, Siemens 2017

Combining electrolysis with renewable generation can provide grid stabilisation benefits

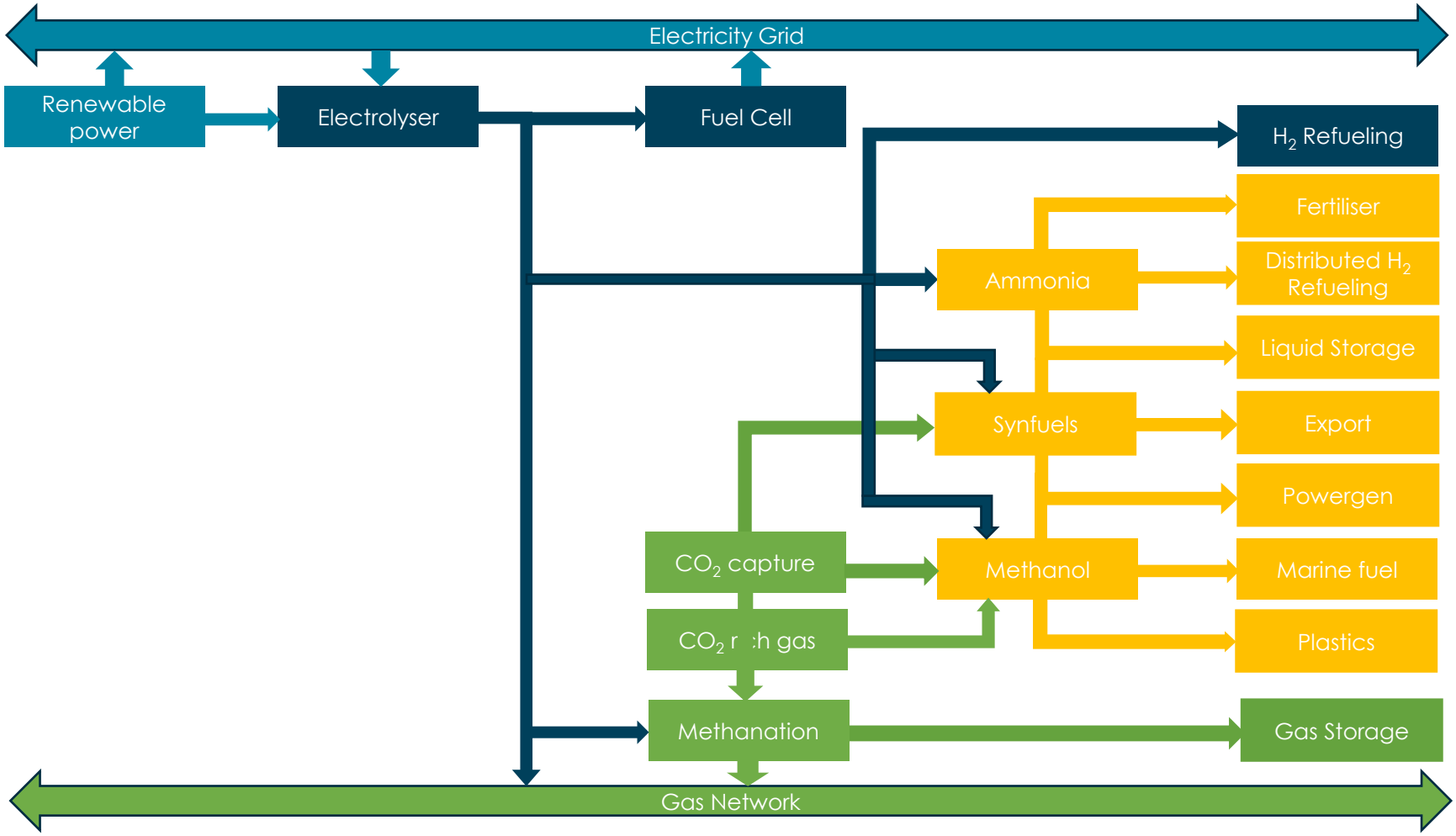
Power to X has a role to play in energy storage

- Hydrogen can provide a long term and large scale energy storage solution
- A hydrogen eco-system effectively acts as a large storage medium
- May be an option for addressing NZ seasonal hydrology challenges
  - Store as H2
  - Store as Ammonia
  - Store as Methanol
  - Store as Methane

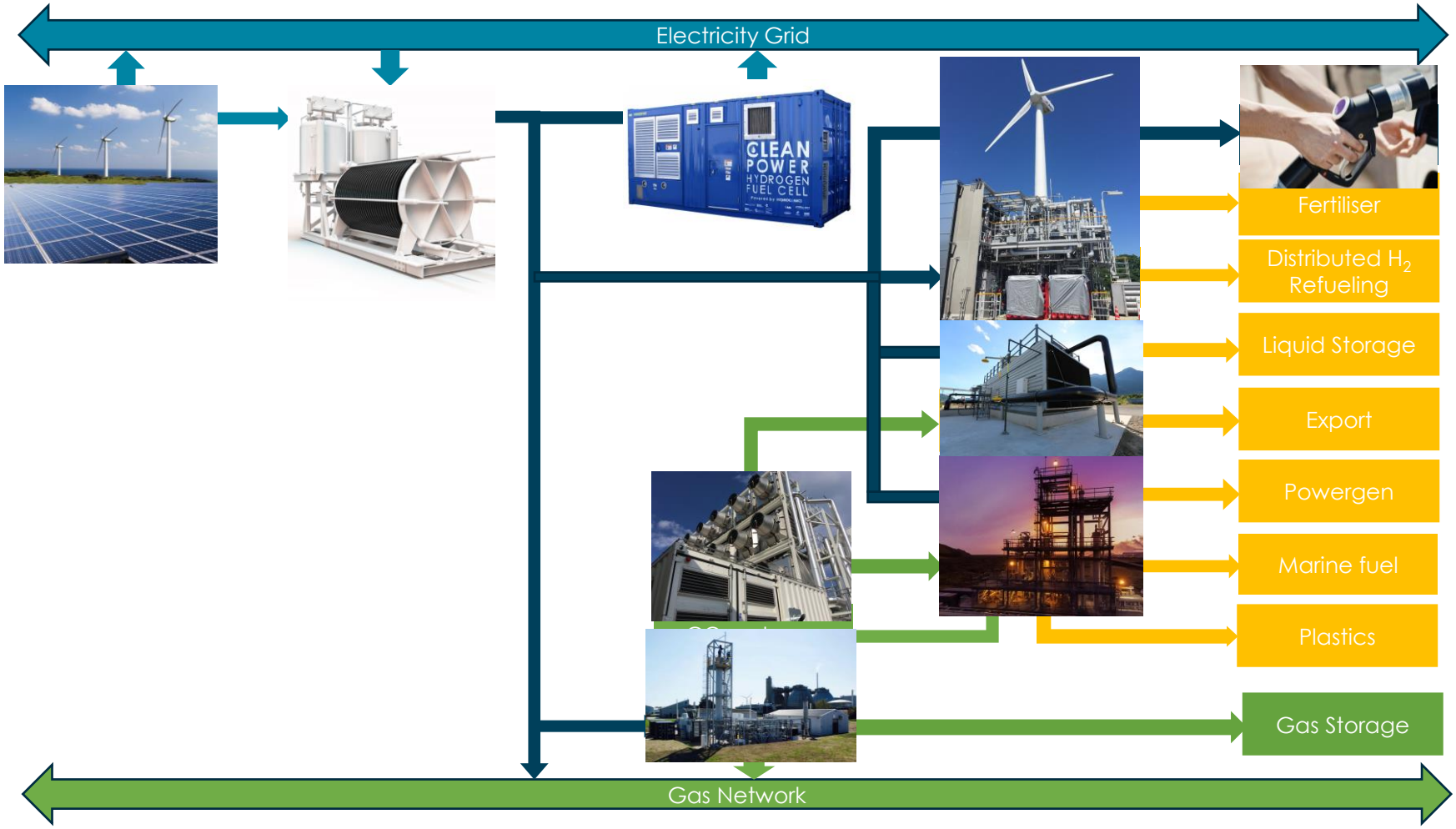


Source: Hydrogen Council Vision Document, 2017

Power to X - Industrial feedstock example



Power to X - Industrial feedstock example




HIRINGA ENERGY
THANK YOU
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Supporting Material

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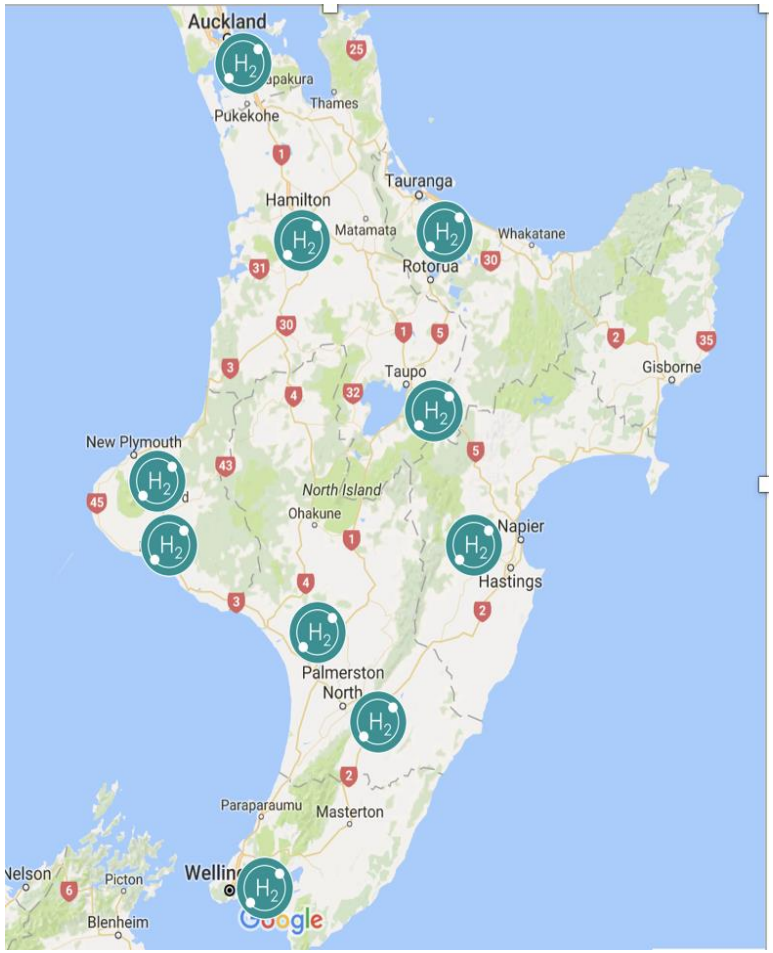
The Gartner Hype Cycle…

Our strategy to establish infrastructure

- **Targeting** applications that play to hydrogen's strengths:
  - High availability
  - Range
  - Weight
- **Aggregating** demand to build scale:
  - Light, medium and heavy vehicles, rail, materials handling and industrial offtake from same production
- **Creating** hubs at:
  - bus & rail terminals, coastal & inland ports, airports, industrial parks, dairy factories.
- **Leveraging** hubs to provide transport corridors and industrial supply.



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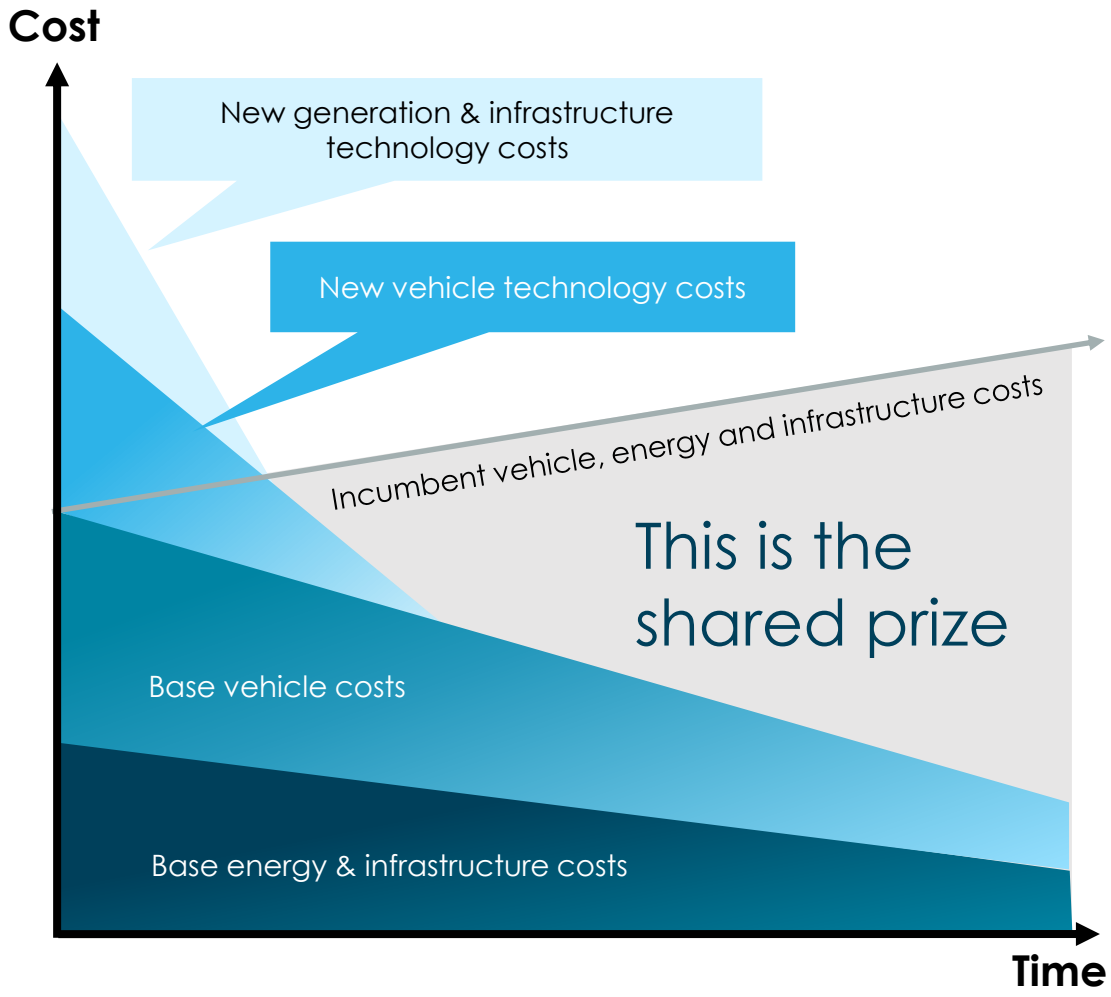
Early Government support and private sector investment is key

- High upfront capital due to early stage technologies
- Clear role for public sector intervention to bridge early cost gap
- Investment requires market and regulatory certainty
- Business models then need to demonstrate sustainability



Hydrogen safety

Hydrogen is safely managed in many NZ industries and public refuelling stations internationally an a daily basis.

Fuelling stations designed to SAE and ISO standards

Key characteristics of hydrogen:

- Lighter than air and diffuses rapidly.
  - Hard to contain to create a combustible or asphyxiation situation
- Odorless, colorless and tasteless
  - Leaks harder to detect – sensors are utilised
- Flames have low radiant heat.
  - Reduces the risk of fires spreading
- Non-toxic and non-poisonous
- Explosive in range18.3- 59% concentration
  - Less chance of an explosion than petrol or LPG

Reference: https://www.arhab.org/static/h2_safety_fsheet.pdf

Photo 1 - Time: 0 min, 0 sec - Hydrogen powered vehicle on the left. Gasoline powered vehicle on the right.

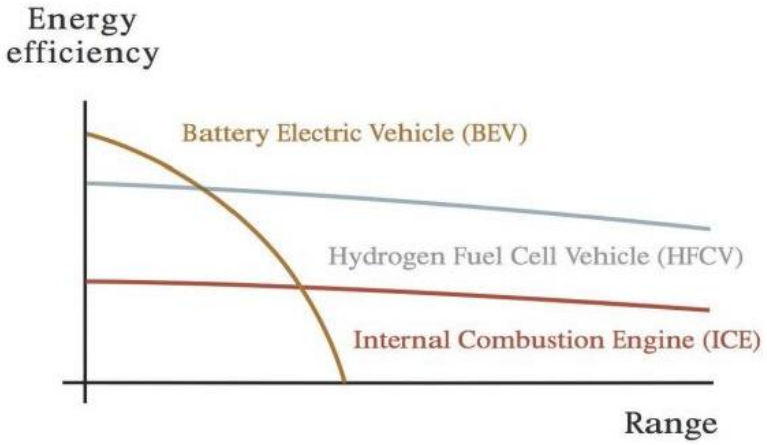
Photo 2 - Time 0 min, 3 seconds - Ignition of both fuels occur. Hydrogen flow rate 2100 SCFM. Gasoline flow rate 680 cc/min.

Photo 3 - Time: 1 min, 0 sec - Hydrogen flow is subsiding, view of gasoline vehicle begins to enlarge

The efficiency question…the vehicle

Our primary concerns are:

- GHG emissions
- Total energy consumption
- Total system cost



Key observations on the drivers of vehicle efficiency

- Vehicle efficiency is highly dependent on weight
- Powertrain efficiency is not dependent on weight – therefore not well correlated to vehicle efficiency
- Weight is highly dependent on a) the choice of powertrain and b) designed vehicle range

Hence the choice of powertrain should be different for different applications.

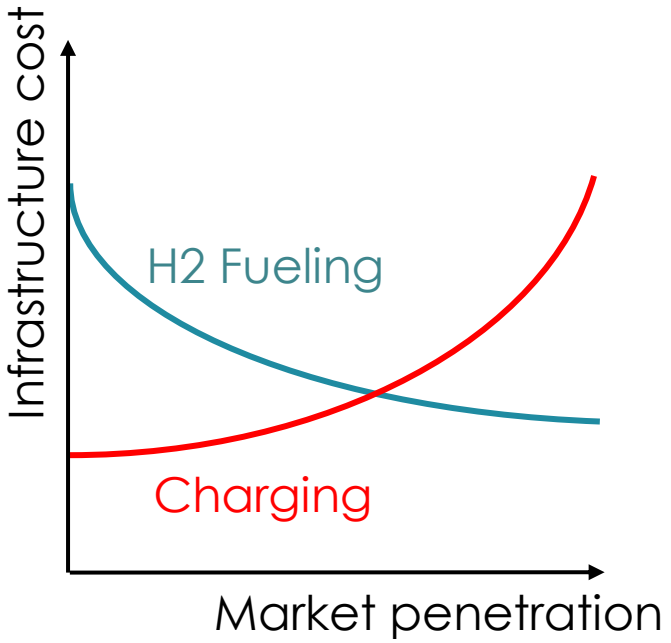
The efficiency question…the system

Incremental peak load on the grid in NZ requires thermal peaker plants, thus increasing GHGs:

- This is manageable with short range BEV applications by charging off-peak at night
  - However long range applications require charging stations in full use during peak demand

System efficiency impacted by optimum use of assets:

  - Charging stations and grid need to be built for the increased peak load >> average daily load
  - Reducing recharging time will exacerbate the demand on the grid
- This can be avoided by decoupling when the energy is drawn from the grid and when the energy is required by the consumer.



FCEV infrastructure is scalable

Flexibility on when and where hydrogen is produced

- Capacity can be increased by adding storage tanks
- High throughput – one station can provide ~40 times the throughput of a DC fast charger
- Production can be stopped during peak times avoiding peak electricity charges
- Quick refueling reduces the number of stations required
- Range means fewer stations required to service key corridors