Hiringa is developing a hydrogen supply chain to support broad decarbonisation

We are a New Zealand company with key capabilities:

- Hydrogen production, refueling design, commissioning and operation
- Whole of hydrogen supply chain solutions
- Knowledge of vehicle and fuel cell technology
- Engineering and project management
- Health and safety management, gas facilities operation and maintenance

We are building a network of projects that are commercially viable and provide the backbone for nationwide supply & refuelling infrastructure.
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/Generation Pathways

- Geothermal (baseload)
- Hydro (seasonal)
- Wind (intermittent)
- Solar (Variable)
- Natural Gas

Storage & Transport

Electricity Grid

- Electrolysis
- Virtual peaking
- Pumped Hydro Energy Storage
- Fuel Cell
- Battery Energy Storage
- H₂ transport & distribution
- H₂ refueling & supply
- Electric vehicles
- Heat and Energy
- Industrial Process Feedstock
- Fuel Cell transport solutions
- CNG Transport

Multiple Uses

- Hydrogen Export Markets
- Methane cracking
- Methanation
- H₂ injection
- CNG Transport
- CO₂

Multiple supply = increased resilience, can change over time

Multiple uses = greater impact on greenhouse gas emissions

The energy to change. Together.
Hydrogen fuel cell vehicles (FCEVs)
Membrane

Anode (+)

Cathode (-)

Hydrogen → Hydrogen

Oxygen → Oxygen

Gas diffusion layer

Gas diffusion layer

e⁻

O

O

H

H

H

H

e⁻

O

O

H

H

H

H

Water

Electricity Output

The energy to change. Together.
Hydrogen offers the no-compromise option

<table>
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<tr>
<th>Diesel &amp; LNG</th>
<th>Battery EVs</th>
<th>Fuel Cell EVs</th>
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<td>Flexible Fleets</td>
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WHAT ABOUT COSTS?
The cost of establishment

- 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
- ETS alone isn’t sufficient incentive for investment

Cost

New generation & infrastructure technology costs
New vehicle technology costs
Incumbent vehicle, energy and infrastructure costs
Base vehicle costs
Base energy & infrastructure costs

This is the shared prize

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The ultimate “Catch 22”
Hydrogen is about Total Cost of Ownership (TCO)

- Fast refueling times: High vehicle utilisation, More loads/day, Reduced OPEX
- Increased range: Route flexibility, Less vehicles required, Reduced CAPEX and OPEX
- High torque and acceleration: Increased average speeds, More loads/day, Increased revenues
- Reduced maintenance requirements: Reduced OPEX, Extended vehicle life, Reduced Vehicle CAPEX
- Weight advantage over BEV: ~3-8 tonnes/truck, Increased payloads, Increased revenues
- Renewable fuel supply: Energy security, Opportunity to invest in supply chain, Reduced OPEX
- True zero emission logistics: Sustainability benefits, Workforce & community benefits, Branding benefits

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Example - 20T delivery load on 800 km daily duty

Due to their reduced freight capacity, 2 battery powered trucks are required to haul the 20T delivery

The energy to change. Together.
Key metric: Cost per Tonne-km

Freight weight: Diesel & H₂ trucks: 20 T / EV trucks: 13 T
Kilometers a year: Diesel & H₂ trucks: 208 000km/ EV (50kW charger):120 000km/ EV (150kW charger): 203 000 km
The range is smaller for battery trucks due to charging time

The energy to change. Together.
WHAT IS THE STATUS OF FUEL CELL VEHICLES?
Materials handling business case is fully established

- >50,000 units in operation OEM models and conversations available

- **Performance** – can operate over an 8 hour shift at full speed, including -30°C cold stores, without performance degradation.

- **Increased uptime** – hydrogen fuel cells can be rapidly refueled in just 1-3 minutes – labour and equipment efficiencies

- **Reduced Maintenance** - constant voltage reducing wear. Fuel cells also have improved lifetime over batteries.

- **Increased space** - remove the need for battery rooms & logistics

*The energy to change. Together.*
Light & medium truck technology

High levels of activity in Asia:

- Large volumes of light duty trucks being produced in China
- Hyundai has announced a new medium sized truck will go into production this year with 1000 to be delivered to Switzerland
- Activity driving costs down

Specialist trucks developed in Europe

- Conversions being undertaken
- OEM’s such as Scania and DAF developing products

Business case for FCEVs driven by fleet utilisation, power demand, range and payload drivers.

Not all light/medium truck fleets will need FCEVs

*The energy to change. Together.*
Heavy truck FCEV developments

Significant increase in activity in US

• Toyota trialing 2nd generation Class 8 drayage tractor with 480 km range
• Kenworth truck also operational in Port of LA
• Nikola plans to commercialise multiple tractor unit designs starting 2021:
  • Nikola One – sleeper
  • Nikola Two – day cab (800 ordered by Anheuser Busch)
  • Nikola Tre – European style heavy tractor unit (2023)
  • Up to 1500km range, 15 minutes refuel

*The energy to change. Together.*
Fuel cells have significant applications in marine

- **Batteries**: Lower Power, Shorter Range
- **Fuel Cell**: Higher Power, Longer Range
- **Either**: Lower Power, Shorter Range
- **Fuel cell**: Higher Power, Longer Range
Hydrail opportunities

Significant development of hydrail opportunities in Germany, UK and Japan.

 Longer term opportunity to replace diesel, while still avoiding cost of catenary electrification:

• Develop freight & passenger solutions
  • Convert diesel electric locomotives
  • Regional passenger rail
  • Install refueling infrastructure at rail hubs
• Transport hydrogen on rail
• Possibly commission hydrogen hybrid for Interislander

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BUT WHAT ABOUT THE INFRASTRUCTURE?
Commercial scale infrastructure is key

- Investment in demonstration scale infrastructure is pointless
- Government assistance will be required to overcome market growth uncertainty
Hiringa Energy awarded government grant to develop first pilot infrastructure project in New Zealand.

Scope:

- **Supply/Generation** - 1-2 hydrogen generation facilities (including central and distributed options)
- **Storage/Distribution** - Mobile compressed tube trailers
- **Refuelling** - 3 hydrogen refuelling stations

Project will provide excellent test bed for rolling out infrastructure across NZ.
Hydrogen production integration with renewables

Hydrogen lends itself to hybrid coupling with renewable generation:

- Industrial parks provide high density hub
- Un-utilised roof space provides potential cost effective solar power generation
- Some locations identified have wind power potential
- Power utilised to generate hydrogen off peak and reduce power costs during peak periods

Hiringa Energy’s integrated renewable / hydrogen production site selection tool
Modular refueling stations

Proven technology exists and is in operation in several countries.

Hiringa’s solution is leveraging existing technology but ensuring fit for purpose for New Zealand:

• Flexible & expandable modular platform
• Integrates with on-site production or delivered hydrogen
• Multiple refueling options/combinations for materials handling, light vehicles and heavy vehicles
• Equipment designed to ISO and SAE Standards
• Integrated network will provide economy of scale, enhanced reliability and provide platform for broader uptake

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Multi-warehouse hub example

- Possible future Solar generation ~2.2MW capacity
- Station Module & public H2 refuelling
- Low pressure interconnect
- Station modules
- H2 Generation Electrolysis
- Materials handling & medium/heavy hub distribution trucking
Infrastructure roll-out

- **Targeting** applications that play to hydrogen’s strengths:
  - High availability, range, payload
- **Aggregating** demand to build scale:
  - Light, medium and heavy vehicles, rail, materials handling and industrial offtake from same production
- **Creating** hubs at:
  - Industrial parks, bus & rail terminals, ports, airports, fleet hubs, transport corridors
- **Leveraging** hubs to provide transport corridors and industrial supply.

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H2 Taranaki initiative

Aims:
- Drive public/private investment in deploying hydrogen infrastructure
- Accelerate local demand for hydrogen
- Position Taranaki businesses to participate in a growing international industry.
- Nurture and enable the development of a major new energy export opportunity.

Roadmap development:
- Led by Venture Taranaki, co-sponsored by NPDC and Hiringa Energy
- Identify opportunities and develop business cases for initial projects
- Official launch March 2019
Creation of zero emission industrial hubs

- Hydrogen (H₂) produced from electrolysis replaces fossil fuel feedstock
- Tech exists – scale up required
- Integration and market development required

NZ has natural advantages for the production of green hydrogen due to our renewable energy potential

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Case example of a hydrogen system

Ammonia Plant

Grid connect

Peak power

4 New Wind Turbines

Excess power

4.3 Mw Plant power

Electrolysis

H₂ for green ammonia/urea

7000t Green Urea / annum

H₂ for zero emission transport market

Transport Market

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Thank you.
Activities & resources

Key milestones & activities:

• **March 2019**: Launch of H2 Taranaki – outlining the role of Taranaki in establishing the hydrogen sector in New Zealand
• **Mid 2019**: Launch of the New Zealand hydrogen strategy
• **2020 Tokyo Olympics**: demonstration of the hydrogen society by Japan
• **2020**: start up of hydrogen refuelling stations in New Zealand

Web resources

• Hiringa Energy: [www.hiringa.co.nz](http://www.hiringa.co.nz)
• Hydrogen Council: [www.hydrogencouncil.com](http://www.hydrogencouncil.com)
Supporting Material
Hydrogen Safety

There are hundreds of hydrogen refuelling stations now in operation.

Hydrogen can be stored and handled safely:

- It is odourless, colourless and non-toxic
- Hydrogen is flammable but diffuses rapidly
- Hydrogen has low emissivity (doesn’t radiate heat)

Hydrogen refuelling stations:

- are designed to international standards
- follow best practice safety in design principles

*The energy to change. Together.*
The suite of solutions for low emission transport

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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 energy to change. Together.*
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

A car can drive over 100km on 1kg hydrogen

FCEVs can travel 600km+ and take 3 mins to refuel

Refuelling is safe and over 100 stations are in operation

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