Hydrogen-fuelled vehicles

NZASE news article

To meet the issues of climate change we need to find alternative vehicle fuels that emit less carbon. Hydrogen-fuelled transport is gaining momentum in Aotearoa New Zealand (ANZ). In collaboration with iwi, we are making green hydrogen, trialling its use in heavy vehicles and researching aspects of a hydrogen-fuelled future. Mike Stone investigates.

Why hydrogen?

While electric batteries are providing a good alternative for the around-town family car, they are less viable for heavy vehicles, primarily due to their limited range and power and long charging times. Batteries must also be much bigger.

Hydrogen can be burnt as a fuel – mixed with air and ignited, just like petrol or diesel – only emitting water. This combustion rotates the crankshaft to move the car. While this produces no CO_2 due to the high temperature of combustion, it does produce nitrous oxides which contribute to air pollution.

However, when it is instead used in fuel cells, the hydrogen combines with oxygen to produce electricity which drives an electric motor to move the vehicle. Due to the modest operation temperature, only water is emitted.

Making hydrogen

Hydrogen gas is colourless, but it is classified by colour according to how the electricity for this process is made. Brown hydrogen is made from coal and grey hydrogen from natural gas; both processes emit carbon.

While blue hydrogen is made from natural gas, the carbon is captured and stored. Green hydrogen is the most environmentally friendly, as it is made by electrolysis using renewable electricity to split water into hydrogen and oxygen gases with no carbon emissions.

Hyundai's XCIENT hydrogen fuel cell truck. Photo: Hyundai.

The hydrogen is then stored in a tank. Being the lightest element, hydrogen is tricky to store. As 1kg of hydrogen takes up the volume of a small bathroom, it is usually compressed (at 700 bar pressure) or liquefied (at –252 °C). Both of these are energy consuming, and neither are ideal for long-term storage.

Green hydrogen in Aotearoa/NZ is currently made in two places: the BOC company in Glenbrook, south of Auckland; and Halcyon Power and iwi, using geothermal power at Mōkai near Taupō.

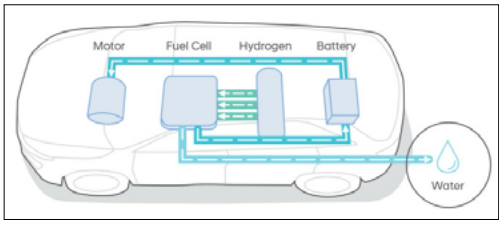
There is a temporary hydrogen refuelling station at the Ports of Auckland, with plans for a full plant to be developed. HW Richardson is also building a hydrogen refuelling station in Gore, while Hiringa Energy is building hydrogen refuelling stations at key points on the North Island's main highways.

Hydrogen fuel cells

When used in a fuel cell, hydrogen is a powerful and flexible clean energy source – emitting only electricity, water and some heat.

In the fuel cell, hydrogen at the anode is split into protons and electrons, with the protons travelling through the electrolyte to the cathode, while the electrons travel in a circuit powering the car's motor along the way.

At the cathode, oxygen combines with the hydrogen electrons and protons to make water.



How hydrogen makes electricity. By Hyundai.

A hydrogen-fuelled bus built by Global Bus Ventures for Auckland Transport. Photo: GBV.

Safety

Petrol is highly flammable, as both a liquid and a vapour. It can pose significant health and ecological threats when leaked, spilled, or burnt.

Hydrogen is also highly flammable, but it needs more oxygen than petrol does to ignite. Hydrogen can explode with 18-59% oxygen while for petrol it only takes 1-3%.

This means that petrol has a greater risk of explosion than hydrogen, especially at normal concentrations (20%). Conveniently, hydrogen is not toxic, and being lighter than air, if leaked it quickly rises and disperses into the atmosphere.

Local research

There are several ongoing research projects on green hydrogen in ANZ. One programme is part of the He Honoka Hauwai consortium, funded by the German and NZ governments, in collaboration with Ngāi Tahu.

Professor Sally Brooker, an inorganic chemist at the University of Otago, co-leads this research, which has several projects. Sally's team regularly visits schools to talk about the production and use of green hydrogen, and do hands-on science with students.

One research team is focussed on safe, compact hydrogen storage materials. A tank is first filled with a metal alloy powder before being filled with hydrogen. The hydrogen molecules interact with the surface of the powder, allowing them to pack in far more closely than they would otherwise. This allows very compact storage at close to room temperature and pressure.

The NZ-wide team works with its German partners to test whether or not New Zealand ilmenite can be used to generate these metal alloy materials cost effectively, sustainably and with the benefits retained in the region.

A consortium comprising Air New Zealand, Airbus, Christchurch Airport, Fabrum, Hiringa Energy and Fortescue Future Industries is also studying hydrogen aviation fuels.

Ngā Kupu

Āhuarangi hurihuri – Climate change
Hāora – Oxygen (O)
Haumura – Flammable gas
Hauwai – Hydrogen
Hauwai kākāriki – Green hydrogen
Hauwai rehu – Hydrogen gas (H_2)
Hiko – Electricity
Hinuheu – Diesel
Kora – Fuel
Muramura – Flammable
Rererangi – Aircraft, aviation
Taraka – Truck, lorry
Tukuwaro-iti – Low carbon emission.

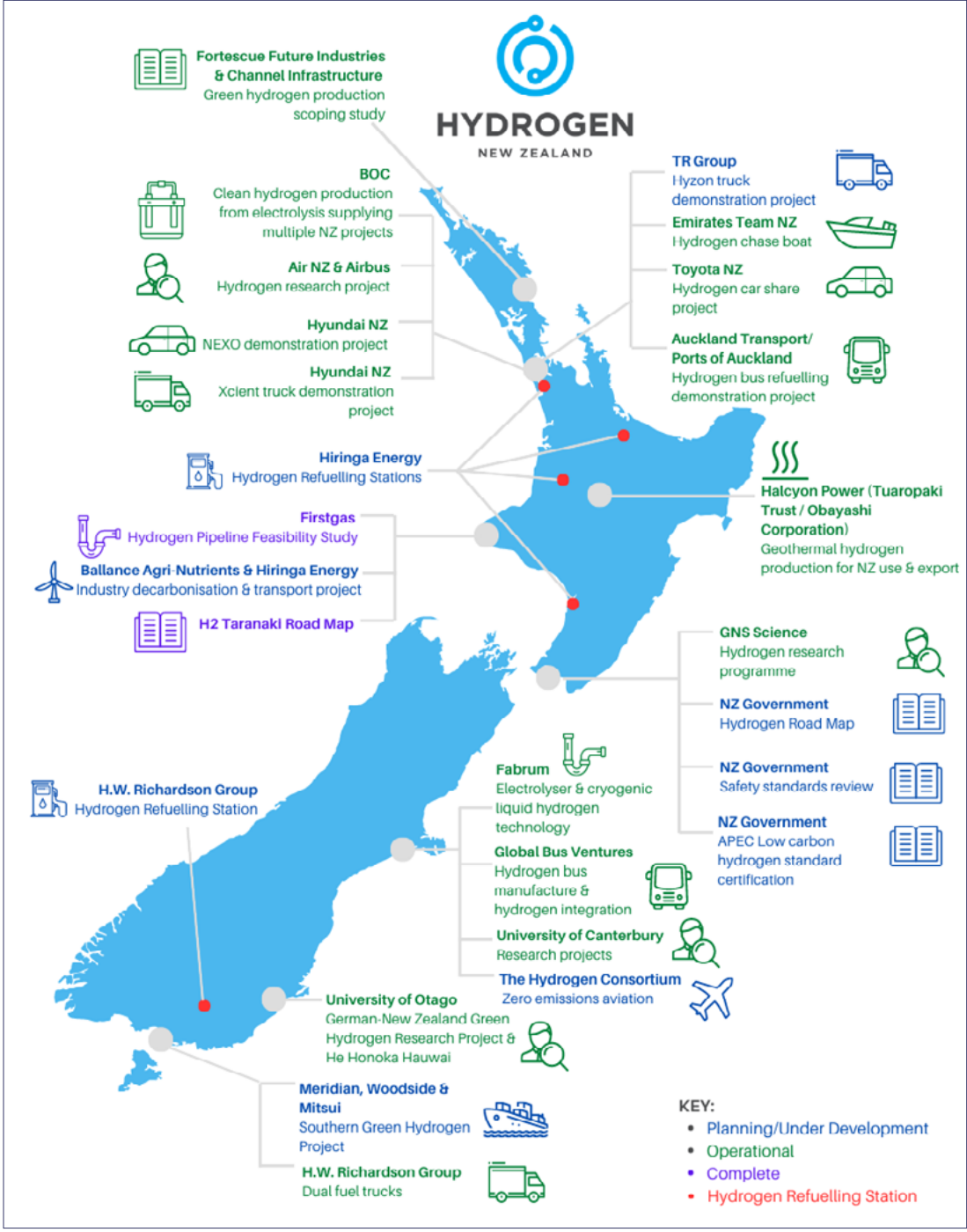
From Te Aka Māori Dictionary and Paekupu

Vehicles

Several hydrogen vehicles are being trialled here:

- Auckland Transport is testing a hydrogen fuel cell bus.
- NZ Post is testing two Hyundai Xcient hydrogen fuel cell trucks.
- HW Richardson (HWR) transport is using a dual fuel truck that burns both hydrogen and diesel, with carbon emissions reduced by about 40%. These are retrofits of diesel trucks that can use the fossil fuel if there is no hydrogen fuel station nearby.
- Emirates Team New Zealand has a hydrogen fuel cell chase boat, Chase Zero.

While these hydrogen-fuelled vehicles are



Current hydrogen projects in NZ, NZ Hydrogen Council.

being trialled, hydrogen stations for refuelling are still being built, with the first due to be finished soon.

The future

We are one of the few countries with a high proportion of its power already generated from renewable sources, and the potential to triple existing wind and solar generation.

As such, ANZ is well placed to make and use green hydrogen. We can look forward realistically to a low-emission transport future, with both electric cars and hydrogen-fuelled heavy vehicles.

References

GNS Science/Te Pū Ao, 2022, Green hydrogen's international status and GNS H2 strategy.

Hydrogen NZ, May 2023, Current hydrogen projects in New Zealand (above).

Reactions, 2022, How do hydrogen fuel cells work? 8m video.

Garrick Thorn, 2022, Introducing Te Waipounamu scientists researching hydrogen, 7m video.

Links

Professor Sally Brooker, November 2021, NZ in the box seat on hydrogen, *Newsroom*.

Professor Sally Brooker, December 2021, An urgent step change from fossil to future fuels, *Newsroom*.

Questions

1. **A**. Grey and blue hydrogen use the same source. What is the difference between them?

B. Why might the fossil fuel industry be promoting blue hydrogen?

2. Draw a labelled diagram for the fuel cell showing how it works.

3. Give an equation for making hydrogen from water. Research the other reactants needed, then give equations for making hydrogen from coal and natural gas.

4. Analyse the pros and cons.

A. What is the evidence in the article that hydrogen is a good focus for future energy?

B. What is the evidence in the article that hydrogen isn't always perfectly green?

5. Apart from a vehicle fuel, research other uses for green hydrogen.

This article was improved by critique from Ian McHale.