THE Helen Clark FOUNDATION

The Role of Innovation in Getting to Carbon Zero

What place is there for next generation energy such as ‘green hydrogen’?

DISCUSSION PAPER

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CONTENT

ABOUT THE HELEN CLARK FOUNDATION

The Helen Clark Foundation is an independent public policy think tank based in Auckland, at the Auckland University of Technology. It is funded by members and donations. We advocate for ideas and encourage debate, we do not campaign for political parties or candidates. Launched in March 2019, the foundation will issue research and discussion papers on a broad range of economic, social and environmental issues. This is our first discussion paper.

OUR PHILOSOPHY

New problems confront our society and our environment, both in New Zealand and internationally. Unacceptable levels of inequality persist. Women's interests remain underrepresented. Through new technology we are more connected than ever, yet loneliness is increasing, and civic engagement is declining. Environmental neglect continues despite greater awareness. We aim to address these issues in a manner consistent with the values of former New Zealand Prime Minister Helen Clark, who serves as our patron.

OUR PURPOSE

The Foundation publishes research that aims to contribute to a more just, sustainable and peaceful society. Our goal is to gather, interpret and communicate evidence in order to both diagnose the problems we face and propose new solutions to tackle them. We welcome your support, please contact director@helenclark.foundation for more information about getting involved.

EXECUTIVE SUMMARY

- New Zealand needs to look at innovative ways to decrease carbon emissions. This includes increasing our renewable electricity supply, as demand for electricity will increase with the growth of electric vehicles and as we stop bringing new sources of fossil fuel online.
- 'Green hydrogen' is hydrogen which is generated from renewable electricity by electrolysis. 'Brown hydrogen' is that which is generated from fossil fuel.
- Green hydrogen can contribute to decarbonisation, especially for heavy vehicles (including trains), 24/7 warehouse operations such as forklifts and other 'return to base' style transport. It can also be a way to manage intermittent renewables, allowing New Zealand to phase out coal and gas generation.
- Any domestic industry needs scale and will depend to some extent on an export industry.
- Japan has significant potential as an export market. The recent investment to build a pilot green hydrogen plant in the central North Island by Obayashi Corporation in partnership with Tuaropaki trust is indicative of serious investor interest.

RECOMMENDATIONS

Based on our analysis, we propose the following recommendations for policy makers to consider.

1. New Zealand should explore a green hydrogen export industry.

2. New Zealand should explore the potential for hydrogen to decarbonise rail networks.

3. 'Green hydrogen' is defined by its seed fuel. Only hydrogen generated from renewable electricity should be classified as green hydrogen. New uses for gas are not a useful direction for climate conscious policy, and in practice '100% carbon capture' promises on new projects frequently do not deliver.

4. Green hydrogen should be analysed separately and more aggressively supported by government than hydrogen generated from fossil fuel.

5. New Zealand should work with other countries internationally who share interests in developing green hydrogen. This includes Japan, Norway, the Netherlands, the European Union, and possibly Australia (though we should resist all efforts to categorise brown coal hydrogen generation as green. Existing projects lack Carbon Capture and Storage (CCS) and prospects for implementing it are uncertain. Solar may be an area where Australia can move into green hydrogen in future).

6. Through these alliances, New Zealand can push for international carbon transparency standards for hydrogen globally. As well as being based on environmental principles, this can also serve New Zealand's economic interests by creating a global market for clean hydrogen, which we are in a uniquely strong position to manufacture.

INTRODUCTION

In 2018 the New Zealand government took a bold stance in legislating to stop new gas and oil exploration, and now faces a significant and ongoing backlash.

One strain of backlash argument essentially involves saying that if we continue to operate as *we do now*, the impacts of the ban will be counterproductive.[1] New Zealand will import more fossil fuel from dirtier sources. Supporters of the ban argue that this point ignores a rapidly changing international context, and presents insufficient urgency towards the imperative to stop burning fossil fuels to prevent climate change.

The campaign to overturn the ban usually analyses New Zealand in isolation - we are very small, and hence irrelevant to the fundamental direction of international institutions in this frame - and has low confidence in the role of international cooperation as a remedy.

A point of unexpected common ground can be seen in both sides' recognition of the magnitude of the change required, although they disagree on how possible, and even desirable, that change will be. In order to achieve the 2050 goal to be determined by the proposed Zero Carbon Bill, New Zealand will need to change its economy in profound ways. Policy work on this is ongoing, and major areas of focus are batteries, forestry, increased renewable generation (especially wind) and the most difficult area for New Zealand, agriculture.

The role of new technology in climate change advocacy is an ambivalent one, for those who emphasise the urgency to reduce emissions. In an interview with Amanda Larsson from Greenpeace New Zealand she referred to the concept of 'technology fixes'. "Technology fixes are easy to get excited about and attract disproportionate investment compared to less exciting policies that act to reduce demand. One example is increased insulation for housing. This reduces energy demand but governments seem less excited about it than hydrogen."[2] Greenpeace is acutely aware that technology can be used as a red herring to defend further new generation from fossil fuel, and they do not consider carbon capture and storage (CCS) to be a "viable technology". Larsson gave as an example the risk that seismic activity in New Zealand could damage the supply of carbon stored underground.

On a practical level relating to CCS projects as they exist now, promises frequently do not eventuate. For example the pilot Loy Yang Australian brown coal hydrogen plant in Victoria marketed itself as using 100% CCS during the establishment phase, but none was ultimately used due to being uneconomic.[3] Current estimates do not show CCS being used for this project until 2030, and even then the efficacy will depend on available storage. The omens for genuine 100% CCS are concerning - similar energy projects in the same region paused CCS when storage issues arose.[4] Without reliable CCS the hydrogen generated from brown coal is one of the dirtiest fuels in existence.

1 For example, https://thespinoff.co.nz/politics/29-10-2018/if-the-oil-and-gas-ban-is-really-a-good-idea-why-are-they-rushing-it-through/

2 From interview on 21 February 2019

3 Concept Consulting 2019, Hydrogen in New Zealand, Report 3, Research, page 45

4 https://www.smh.com.au/business/the-economy/reality-check-on-a-half-billion-dollar-brown-coal-hydrogen-project-20180412-p4z98n.html

CCS as it currently exists presents an expensive opportunity to manage emissions, but not to reduce them.

Hydrogen can be clean energy or not, depending on the seed fuel. This report focuses on hydrogen as a case study of how new technologies can play a positive role towards lowering climate emissions so long as they are sufficiently understood, and presented in the appropriate context. It analyses at a high level the viability of a green hydrogen export industry in New Zealand, and argues that green hydrogen must be carved out conceptually from hydrogen generated from gas (which to date has dominated as a hydrogen seed fuel).

Carbon transparency surrounding hydrogen generation is the key recommendation, and this report advocates for NZ to set clear guidelines for this both domestically and internationally. We also recommend that New Zealand set an aggressive international strategy to define green hydrogen and to build alliances committed to transparency. These are both key steps to ensure that hydrogen as a next generation energy is a next generation clean energy.

HYDROGEN – THE NEW ZEALAND CONTEXT

Hydrogen is a next generation energy technology, with the potential to replace fossil fuels on both economic and environmental grounds.

Existing hydrogen generation in New Zealand is small scale, and overwhelmingly (95%) from natural gas. Many technologies related to generating hydrogen from water (via electrolysis, as opposed to steam reforming natural gas) are currently in the early stages of commercialisation, so are not yet cost competitive, but major investments from both government and industry mean that these costs are expected to reduce, and indeed are already doing so.

For New Zealand future expansion in this area could rest to an extent on the development of hydrogen as an export industry to Japan, which will create a significant domestic supply, raising the economic viability of other hydrogen infrastructure. As the hydrogen market globally expands, possible opportunities may arise elsewhere, such as South Korea and Europe.

In the medium term, hydrogen could substitute for coal and gas to deal with intermittent renewables. Hydrogen can be stored as liquid and production at hydrogen plants quickly scaled up for example during a year that New Zealand's hydro lakes are low. Hydrogen could be made at times when the fluctuating wholesale electricity market price is very low. Prices can be close to zero during periods of very low demand. This flexible hydrogen production could allow for the last piece of fossil fuel generation to be pushed off the grid. If successful, this technology could risk major gas investments made now becoming stranded assets.

In the short term, New Zealand has potential to become a competitive supplier of renewable hydrogen from our largely renewable electricity generation base, and significant quantity of developable renewable resource.

A pilot plant to generate hydrogen from geothermal electricity built by Obayashi Corporation, in partnership with Tuaropaki Trust (the first privately owned electricity generator in New Zealand which opened the Mokai power station, near Taupō, in 2000) began construction in January 2019.[5] This pilot aims to trial generation of renewably produced hydrogen for export to Japan, and if successful will scale up to commercial operation.[6]

New Zealand's geothermal and wind resources give us a unique ability to upscale renewable generation of electricity, and to export it, given that New Zealand's levels of renewable generation resources significantly exceed existing capacity.[7]

Projected demand growth in New Zealand is a contested area – current growth rates are only

5 https://www.obayashi.co.jp/en/news/detail/news20190121_en_1.html

6 As above

7 Geothermal involves very few carbon emissions, though some small amounts of carbon dioxide are released. The small quantities of gases emitted from geothermal power plants are not created during power production because there's no combustion. These gases are natural, minor constituents of all geothermal reservoirs. They eventually would vent to the atmosphere without geothermal power development, although at much slower rates. Geothermal is considered by Greenpeace as a clean energy source. Total reinjection of separated water and condensate reduces emissions even further, and is standard in modern New Zealand plants according to the NZ geothermal association.

300-600 GWh per year, at this rate we would use less than half our renewable resources over the next 50 years.[8] Yet as transport electrifies, demand will increase unpredictably, depending on the speed of uptake. This is one of many uncertainties that policy makers grapple with.

Potential Uses of Hydrogen in New Zealand

If a supply of renewable hydrogen came online in New Zealand, how might we use it? The below list is not exhaustive, but gives a sense of what will be possible.

Heavy Vehicles, Forklifts and other Transport Uses

Like batteries, hydrogen fuel cells provide high-efficiency electrochemical conversion of energy. Being combustion-free, this process produces zero direct emissions. But, unlike batteries, hydrogen is stored in rapidly refillable on board tanks, similar to the process for conventional diesel trucks. The net result is the same zero-emission performance as a battery-electric truck, while also providing range and refuelling time roughly on par with a conventional diesel truck. While heavy electric vehicles exist, recharging the batteries takes considerable time during which the vehicle is out of service. This presents challenges to businesses wanting to upgrade to CO2 free fleets.[9]

A major entry barrier is installing hydrogen refuelling infrastructure. (Price and sourcing vehicles are also challenging for now given the early stage of commercialisation. There is for example an 18 month wait to source a hydrogen bus, according to Arup consultancy.) For this reason in small vehicles electrification will probably dominate, because there will be relatively few places to refill hydrogen vehicles. But even with very few stations, some uses are feasible.

For example:

- Heavy vehicles moving containers or goods around from port to distribution hubs.
- Return to base transport, such as tourist buses.
- Light commercial vehicles, like couriers.
- Hydrogen forklifts in warehouses (these can already be seen in Japan), and straddle carriers and similar heavy equipment at ports. Both are often 24/7 operations which benefit from longer hydrogen operations between refuelling.

In short it is likely that hydrogen 'hubs' will arise in connection to the nascent export industry. Ports are a likely point at which hydrogen vehicles could be refuelled, and trial projects are already underway in Auckland.[10]

8 'Supply and demand for renewable hydrogen in New Zealand' by Concept Consulting 2017, pg 3

9 Interview with Liz Halsted of Arup consultancy, 25 February 2019

10 http://www.poal.co.nz/media/ports-of-auckland-to-build-auckland%E2%80%99s-first-hydrogen-production-and-refuelling-facility

Hydrogen also has significant potential as a zero carbon fuel for rail operation. Germany is currently trialling a small number of hydrogen passenger trains as an alternative to traditional diesel or electric trains. The motivation for these trials is not only the desire to reduce diesel emissions, but also avoidance of the significant cost required to expand existing overhead electric networks; currently estimated to cost around 1.5 million EUR/km in Germany.[11] For New Zealand costs are likely to similar, if not higher, making hydrogen a potential serious alternative to fully electrifying the main trunk rail line, and for creating a carbon free passenger service for the Palmerston North and Wairarapa services to Wellington, and potentially for a future Auckland to Hamilton passenger service.

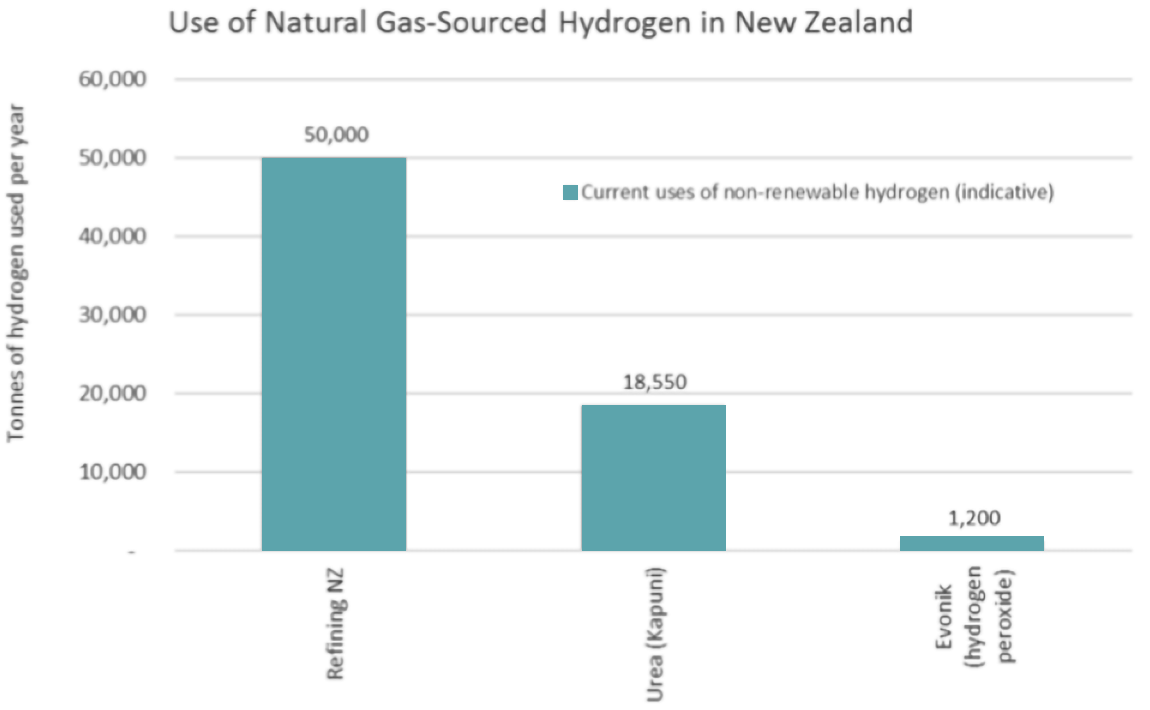
11 Figure provided by Alstom to MBIE, February 2019.

Table 1

Indicative additional renewable generation potential

Generation type	Existing capacity (MW)[12]	Potential capacity (MW)
Wind	700	10000[13]
Geothermal	1000	1200[14]
Hydro	5500	1000[15]
Solar	50	2500[16]

Figure 1



Source: Transitioning to Hydrogen Economy', CRL report number CRL07/11009, May 2007

12 The table and figure are reproduced from the originals in 'Supply and demand for renewable hydrogen in New Zealand' by Concept Consulting 2017.

13 Inferred from various data sources by Concept Consulting, including "Economic wind resource study" by Connell Wagner in 2007 that identified over 6,000MW of good wind sites ($80-$100/MWh, 2007) in the North Island alone. This report is silent on South Island sites, and slightly less viable sites above about $100/MWh (2007).

14 Drawn by Concept Consulting from the Geothermal Association of New Zealand.

15 Transmission to Enable Renewables Potential NZ Hydro Schemes, PB Associates, 2007

16 According to Concept Consulting, this is equivalent to half the houses in NZ having a 3 kW PV system. To integrate this level of PV into the power system would likely require significant system storage (e.g. batteries) or load flexibility (e.g. H2 plant).

ENERGY POLICY IN JAPAN, AND THE ROLE OF HYDROGEN

Japanese policy settings are of particular import to New Zealand in regards to hydrogen. This is because relative to most, if not all countries, Japan needs to import renewable energy. And New Zealand, relative to most if not all countries, is very well placed to export it.

Japanese energy policy faced a crisis in 2011 after the disaster at the Fukushima Daiichi Nuclear Power Plant.

The Japanese government immediately took all nuclear plants offline for safety testing, resulting in nearly 30% of generation being lost essentially overnight.

This was replaced almost entirely by LNG, coal and oil imports. The share of fossil fuel in the energy mix rose to 95% in 2013. This had major impacts on Japanese energy self-sufficiency which fell from 20% before the disaster to the low single digits and as of 2017 was only back to just below 8%.[17] The shipping routes for imported oil can be dangerous, for example 60% of Japan's oil must pass through the Strait of Malacca.

To try and improve this dismal outlook, the Japanese government has set the goal of 20-22% of generation coming from nuclear by 2030.[18]

Yet many local commentators are sceptical about whether this is politically feasible, given the widely and strongly held opposition to nuclear generation by the public.

Restarting the plants has been slow and difficult – local communities typically file a series of lawsuits, some of which succeed. In one case in Kansai a restarted plant had to again be suspended after a judge ruled in favour of the local community – an extremely expensive outcome.[19]

So the Japanese government is looking at a mix of nuclear, next generation energy, imported LNG, coal and gas, as well as expanding renewables to try and address the crisis they find themselves in. Hydrogen has emerged as a priority focus.

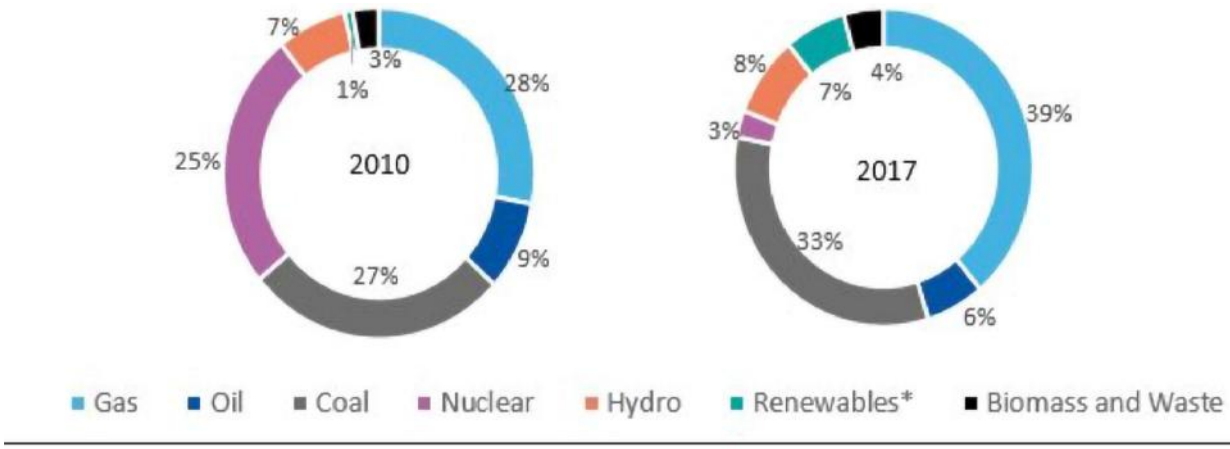
17 Strategic Energy Plan 2018, Ministry of Trade, Economy and Industry, Page 6. http://www.meti.go.jp/english/press/2018/pdf/0703_002c.pdf

18 Goals drawn from the Japanese government updated basic energy policy 2018, for English reporting see: https://www.reuters.com/article/japan-energy/japan-backs-role-of-nuclear-power-in-2030-energy-plan-idUSL3N1SN0TE

19 For more see https://www.reuters.com/article/us-japan-nuclear-courts-idUSKCN0WB0QH?feedType=RSS&feedName=environmentNews

Figure 2

Pre - and post - Fukushina power generation mix (%)



Note: Renewable energies include geothermal, wind, and solar
Source: GECF Secretariat based on data from the GECF GGM

The Japanese government has also set an ambitious target for greenhouse gas reductions – 80% by 2050 under the Paris accord. In light of this, the drivers are clear on economic, security and environmental grounds to pursue a source of renewable hydrogen for import purposes.

The Japanese government has already approved a hydrogen strategy at cabinet level. Key points are that:

- The Japanese government is investing with the explicit goal to make hydrogen competitive on a *cost basis alone* with LNG.
- They have a firm price goal: 17 yen/kWh by around 2030.
- They see a role for hydrogen as a way to deal with intermittent renewables.
- They have detailed ambitious numeric goals to increase hydrogen infrastructure and uptake in the transport sector. For example, they aim to have 800,000 Fuel Cell Vehicles (FCVs) on the road by 2030.[20]

20 See full strategy here: http://www.meti.go.jp/english/press/2017/pdf/1226_003a.pdf

NEW ZEALAND POTENTIAL AS AN EXPORTER OF RENEWABLE ENERGY

Investor interest is already apparent. Japan's Obayashi Corporation and Tuaropaki Trust in Taupō are working together to construct a pilot plant to generate hydrogen from geothermal electricity. Construction began in January 2019.[21]

If the pilot is successful, and is hypothetically scaled up to commercial scale for export purposes, this would create a large supply of green hydrogen in New Zealand in the near future. New Zealand has obvious strengths, namely:

- A relatively fast shipping route to Japan, about 20 days.
- A competitive energy market.
- Stable political environment.

While the decisions from now on will rest with the commercial interests involved, New Zealand policy makers are already preparing for the arrival of hydrogen energy. The most significant development to date has been the Hydrogen Memorandum of Cooperation (MoC) signed in Tokyo by Minister Megan Woods and Minister Hiroshige Seko in 2018. The MoC promises that both countries will work towards:

- Facilitation of human exchange amongst government officials, academic institutions and exchange of information on hydrogen policy in order to create a hydrogen industry.
- Cooperation on development of renewable energy based hydrogen production technology.
- Cooperation on creating a hydrogen strategic road map for New Zealand to develop and expand the demand of hydrogen in New Zealand.
- Cooperation toward creation of an international supply chain of hydrogen.
- Cooperation to reduce hydrogen supply chain cost(s) to make hydrogen compete with other energy resources.
- Cooperation toward initiatives to disseminate hydrogen technology utilization policies throughout the world.
- Cooperation on exchanging information to coordinate regulations, codes and standards for expanding hydrogen demand and supply.
- Consideration of other possible initiatives to promote the research, development and use of hydrogen bilaterally, regionally and internationally.
- Sharing information on hydrogen safety to enable safe and sustainable production, delivery, and storage and infrastructure operation.

The full text is available online on the Japanese Ministry of Economy, Trade and Industry website.[22]

21 https://www.obayashi.co.jp/en/news/detail/news20190121_en_1.html
22 http://www.meti.go.jp/english/press/2018/1023_006.html

CONCLUSION

New Zealand needs to move fast to set up the regulatory and policy framework around hydrogen. Achieving the first Memorandum of Cooperation (MoC) with Japan on this issue was significant, but it is too early to tell if it will be leveraged to our advantage over the next decade.

As can be seen from the MoC text – which explicitly commits New Zealand to work on a strategy or 'roadmap' to increase the uptake of hydrogen domestically - international partners expect a consistent government strategy as a foundation to any commercial activity. Perceived weak commitment from government would undermine private sector confidence in the various projects being considered across New Zealand.

This is the danger in the 'just leave it to business' approach domestically. The domestic context cannot be disconnected from the international. Next generation industries in their establishment phase need strategic investment from government. Or else they will not eventuate.

Many partners internationally do not recognise an absolute separation between government and business. Whether we like it or not, central government policy will have a major influence on whether international companies choose to invest. Current projections have the global hydrogen trade worth 215 billion USD by 2022.[23]

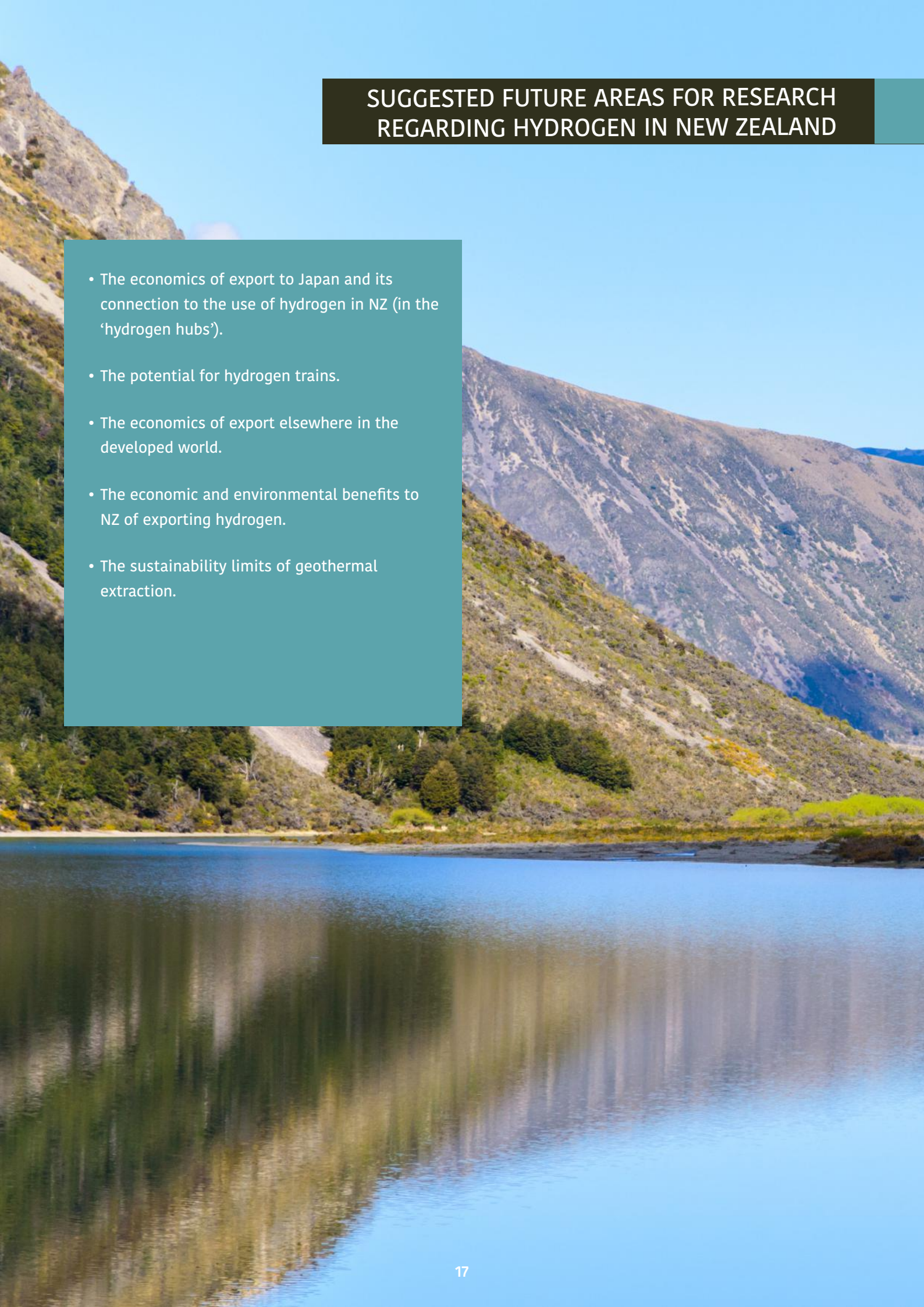
Other countries are catching up, with bigger budgets. The Australian Labor Party has committed to spend 1 billion dollars on renewable hydrogen if elected later this year. This funding includes 10 million AUD for hydrogen refuelling infrastructure domestically.[24]

If New Zealand sits on its hands we could lose a hard won advantage.

23 https://www.theguardian.com/australia-news/2019/jan/22/labor-promises-to-supercharge-hydrogen-industry-as-green-groups-say-no-role-for-coal

24 As above

SUGGESTED FUTURE AREAS FOR RESEARCH REGARDING HYDROGEN IN NEW ZEALAND



- The economics of export to Japan and its connection to the use of hydrogen in NZ (in the 'hydrogen hubs').
- The potential for hydrogen trains.
- The economics of export elsewhere in the developed world.
- The economic and environmental benefits to NZ of exporting hydrogen.
- The sustainability limits of geothermal extraction.

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Auckland University of Technology is partnering with The Helen Clark Foundation while the Foundation becomes established. This aligns with the University's commitment to research for the public good, and public communication of research. The University supports the Foundation's aim to fund and facilitate research on a range of topics; however its support is not an endorsement of any individual item of work, output or statement made by the Foundation's staff, directors or patron.


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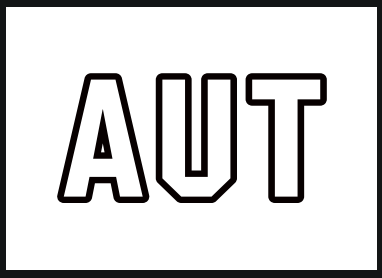
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