Analysis of Hydrogen Vision Submissions

Contents

Summary

A total of 79 submissions from the public, industry, research institutions, local government agencies, and private sector organisations. 44 of the submissions were from organisations, the rest were from individuals.

In general, the majority of submissions support the government's hydrogen vision (The Vision). As would be expected, there was strong support from parties already engaged, in one form or another, in the hydrogen industry.

A majority of submitters supported green hydrogen, particularly those who valued its potential for emissions reduction. However, a number of submitters argued strongly for fossil fuel based hydrogen as a transition fuel, especially if CCS is utilised. This view was balanced though by other submitters who argued that adoption of fossil fuel based hydrogen must be avoided as it will prolong emissions and support for the fossil fuel industry, which they believe should end. In addition, a

number of submitters rejected CCS as being unsafe and unproven while others asserted the opposite.

A number of submitters were supportive of hydrogen but only if the economic case is proven. This sentiment was expressed in the following from the Major Electricity Users Group (MEUG):

> *we do not assume that hydrogen is necessarily complementary with electricity unless it is demonstrated that it is an economically efficient alternative to other solutions and technologies that achieve the same broader public policy outcomes. E.g.* on *H2 competitiveness with increased electrification (e.g. EVs, electric process heat, residential/ commercial heat pumps)* (MEUG)

Some submitters argued strongly against the use of any form of hydrogen, as they claim its production is inefficient relative to the direct use of electricity. A number of submitters argued that emphasis and support for hydrogen should be shifted to other renewable options such as marine energy, bioenergy or compressed air.

Some common arguments against the hydrogen included:

a. other technologies should be pursued instead e.g. bio-fuels, tidal, compressed air
b. hydrogen is uneconomic, energy inefficient and a waste of energy
c. the technology is immature and we should not commit to it
d. hydrogen is a serious safety public risk, the safety aspects cannot be mitigated and the public will never accept it
e. New Zealand should concentrate on electrification and cannot afford a new or parallel refuelling infrastructure, and
f. The vison contained a low level of detail compared to the Australian roadmap and did not provide a clear path and direction forward.

Some submitters claimed hydrogen is a scam because of recent advertisements that fish can swim in Fuel Cell Vehicle (FCV) exhaust, while others argued it is a scam promoted by the fossil fuel industry to prolong the use of coal using Carbon Capture and Storage (CCS) and gas for steam methane reforming of hydrogen.

> *CCS doesn't work. Any claims that it is 'almost ready' ought to be ignored since such claims are common among techs that are so tantalising. They've been saying the same about fusion for decades. (Kieran Martin)*

Some submitters were opposed to the need for a Vision:

> *why is the government asking the general public these things? Is it a test to see if the vision document caused a vision in the general reader? (Susan Krumdieck)*

A common theme among those working already in the hydrogen area was that government financial support is required to advance investment and achieve economies of scale. The contrary argument from those who supported hydrogen, but not government investment is that the role of government should be limited to removing regulatory barriers and that the market should decide on technologies viability.

Several submitters acknowledged the energy loss in hydrogen production but argued that despite this disadvantage hydrogen has certain attractions in niche areas:

- as a long distance and 24/7 transport fuel, and

- as a local store to compliment renewable electricity.

A number of submitters commented on the potential for distributed and longer-term hydrogen storage to improve resilience, and with scale reduce fossil fuel imports. Some argued there is a national defence or resilience aspect such that in the event of a break down in international trade, or competition for resources, New Zealand would not be wholly reliant on Lithium and other components of Battery Electric vehicles if we have access to hydrogen. The argument presented here was that we can produce hydrogen as a transport fuel from local resources improving our reliance.

Some recognised the potential for hydrogen to assist in process heat, but there was a strong argument from many submitters that the direct use of electricity would be more efficient.

Safety was a concern of many submitters. A common observation was the need to ensure standards and regulatory control of hydrogen production, storage and transport are sufficient and to ensure public safety. Some submitters however claimed that hydrogen is in their view so dangerous that it should never be deployed in New Zealand. Other submitters noted that many fossil fuels have similar safety issues and concerns, and several submitters observed that fuels such as LPG, petrol and diesel, if introduced today, would face significant safety acceptance issues. Several submitters identified the need for public education over hydrogen's role and safety.

The role for hydrogen export from New Zealand received mixed support. Some submitters argued that exports would improve the economy of scale for hydrogen development in New Zealand by providing access to technology that may otherwise prove more difficult or costly to obtain. A lesser number identified that helping other countries reduce emissions will have a net overall benefit for New Zealand by helping reduce global emissions. A few submitters argued against hydrogen export either because; they believe it would take valuable water from New Zealand and/or it would have a detrimental effect on future electricity prices in New Zealand.

A number of submitters raised the issue of water use in hydrogen production, its environmental effects, and any potential interaction with Maori/Iwi rights and values as a concern. Several stressed the paramount importance of meaningful engagement with Maori/Iwi on this issue going forward.

The role of submissions

The main purpose of the submissions is to provide additional information and knowledge for the policy development process; either by supporting or reinforcing ideas expressed in the Vision document, or by exposing issues that have been neglected, overlooked, under-analysed or expressed wrongly or poorly.

The next stage of the hydrogen strategy is the development of a roadmap or strategy. The key findings and observations from the submissions to the Vision will be used in shaping the work that the roadmap will undertake.

Approach to submissions analysis and expert status

As the summary indicates, in analysing the submissions on the hydrogen vision, it became apparent that some submitters hold strong views either for, or against, the development of hydrogen in the New Zealand economy. Some arguments raised in support or against hydrogen were countered by opposite arguments from other submitters. In addition, some submitters claimed 'expert' status in all or part of their submissions, while with others an 'expert' status could be inferred on the basis of their current position and experience. No attempt in this analysis has been made to categorise

submissions as having a greater lesser value depending on their claimed or inferred expert status or otherwise.

The following sections outline the issues addressed by submitters in more detail. Where quotations have been used they are attributed to organisations where possible, rather than to individuals. Given the number of submissions, this document does not incorporate quotations from every submission, but does endeavour to capture the broad intent of all submissions.

Government Role

Of those who support the Vison a large number requested further government direction through a roadmap or strategy, involving advisory or expert groups as appropriate. Several submitters claimed that government's role was simply to ensure that there were no regulatory barriers and not to back any one technology. Submitters opposed to hydrogen development, supporters of alternative fuels and others argued that either no government support should be given for hydrogen development or that hydrogen development is a decision that should be left to the private sector; the government should not pick winners.

> *The role of government should be to remove barriers to the uptake of hydrogen to make the energy sector "hydrogen ready" (MEUG)*

Some submitters called for active government support in order to overcome scale economy issues and to enable the development and deployment of a new technology to enable a sustainable hydrogen economy to be achieved.

Some submitters argued the government should prioritise funding and regulatory support for demonstration projects, noting that the Provincial Growth Fund (PGF) does not fund activities in main centres which is where the best scale for initial hydrogen development may be found (in particular Auckland as a major freight and transport economy).

> *New applications for hydrogen stand at the riskiest point of the deployment curve and require significant investment. Investment risk mitigation should be a priority consideration for the Government. The most effective investment risk mitigation to deliver the hydrogen vision is the provision of Government incentives and grants. This will ensure that this important technology is deployed and that New Zealand is able to be regionally competitive in the development of the hydrogen industry. It might also include other financial tools such as loans and risk guarantee. (Ports of Auckland).*

Support for active government intervention was not confined to only supporters of green hydrogen,

> *Given the high cost of hydrogen production acting as a barrier to development and usage, BP believes the fastest way to drive production and uptake is for the government to create a pathway by supporting of all types of hydrogen production, i.e. brown, blue, grey and green. Once scale is achieved, subsequent transition to green hydrogen could be facilitated through policy development around carbon capture, use and storage (CCUS). (BP New Zealand)*

Some submitters made the point that climate mitigation strategies requires early investment and active government support for hydrogen, largely because the private sector may or will not act fast enough. That is, in their view the economic approach that created the problem will not necessarily provide the solution to transition the New Zealand economy away from fossil fuel dependence without some form of intervention.

> *… in terms of transitioning the New Zealand economy away from fossil fuel dependence in a timely fashion we cannot expect the same economic approach that has created the problems of deteriorating ecological sustainability to provide a solution. (If it did, it would have already occurred). The current liberalised economic framework is the barrier to rational and timely action being taken.*
>
> *The role of the State is to ensure that public welfare is maximised over the long term. If private sector investment is avoided because public benefits (or costs) are not accounted for in the investment accounting, then public welfare is likely to sub-optimal.* (Arete Consulting Ltd).

Some submitters claimed the vision lacked a clear desired direction or roadmap for hydrogen's development in New Zealand. We note, the vison was intended as an education document for stakeholders and the public to set out the opportunities, and challenges, for hydrogen in the New Zealand economy. Although the Vision does endorse green hydrogen from renewable energy as the preferred approach, a work programme that will develop a roadmap or pathway for hydrogens development in New Zealand will follow the vision.

> *the Government needs to commission a national roadmap for the country-wide implementation of hydrogen infrastructure and technologies - with the same level of detail as the Australian National Hydrogen Roadmap (Levi Farnum)*

Some argued that greater cross reference and coordination should have been undertaken with the Australian 2018 hydrogen roadmap, claiming that suppliers will take an Oceania view, therefore in these submitters view New Zealand needs to closely follow what Australia does, as it is the larger market.

One submitter called for a restructuring of government departments to ensure better clarity around hydrogen's development. This submission argued that the existing separately governed electricity and fossil fuel infrastructures are likely a substantial barrier to the development of a complementary role for hydrogen; calling for the for consideration to be given to combining the energy jurisdictions of the various government agencies (e.g. MBIE, EA, NZTA) into one entity, i.e. a Ministry of Energy.

Safety

Many submitters commented on the importance of addressing hydrogen safety and risk.

> *Safety concerns must be the first priority (Carbon Neutral New Zealand Trust)*

While only a few made reference to the Hindenburg airship disaster of the late 1930's, several raised the recent accident in a Norwegian hydrogen refuelling station, with some citing this as a reason not to proceed with hydrogen.

> *.. in June 2019 a car Hydrogen refuelling station exploded in Sandvika, Norway which prompted Toyota and Hyundai to freeze sales of its hydrogen fuel cell vehicles (WSP)*

One submitter claimed the high pressure of FCEV tanks posed an unacceptable public safety risk.

A number of submitters acknowledged hydrogen safety issues but then observed that other liquid and gaseous fuels also have associated safety risks, which are accepted and managed. Several submitters noted that if fuels such as LPG, petrol or diesel were to be introduced today, their explosive and flammability concerns would raise a similar or greater public concerns as hydrogen

may do. This observation was not to diminish genuine concerns about hydrogens safety, only to note that all fuels, even batteries, can be dangerous if misused.

The general theme of submissions on safety was that hydrogen safety issues exist but can be managed, and that public education and understanding is important.

> *In order for hydrogen to gain widespread use as a transport fuel, the public must have confidence in its safety. Consumers must be comfortable travelling in a vehicle carrying a compressed hydrogen tank. A widespread educational effort and a robust safety regime will play a crucial part. (GNS Science)*

> *Based on the experience of other countries, once hydrogen is being used safely in a public manner e.g. public buses with "hydrogen powered" on the side of them (as in Aberdeen and other cities), then hydrogen becomes quickly accepted. (Venture Taranaki)*

Although as one submitter noted, there are some problems that may be difficult to resolve:

> *Hydrogen vehicles in tunnels is a thorny issue, discussed at length at the recent International Conference for Hydrogen Safety. Capture of escaped hydrogen within a tunnel is a problem to be avoided (Gallagher Fuel Systems Limited)*

Regulation and Standards

Several supporters of hydrogen noted the lack of a clear regulatory framework for hydrogen; raising issues about uncertainty with regulatory coverage, regulatory boundaries, consenting under the RMA and what standards are relevant. A National Environment Standard (NES) to cover hydrogen was recommended by some submitters that would facilitate consistent rules and guidelines for hydrogen use across different territorial authorities.

> *Auckland Council's recommendation, from our experience of processing a resource consent for a hydrogen plant, is for the Government to develop a National Environment Standard (refer to paragraph 28 in the attached submission) which outlines specific standards, rules and consenting triggers. Currently, it is difficult to understand how a hydrogen facility fits within the policies and definitions of the Auckland Unitary Plan, or how it might be managed as a potential hazard under the Resource Management Act. (Auckland Council, Auckland Transport and Watercare)*

Other submitters highlighted other regulatory changes needed:

> *The development a hydrogen economy needs a regulatory framework that is specific to hydrogen. The Resource Management Act would require changes to allow hydrogen storage facilities to be developed; …. Electricity regulations and the Gas Act would need amending to support the complementarity of electricity and hydrogen – e.g. electricity regulations are largely centred on large rotating machines not solar farms, batteries or hydrogen fuel cells. (Refining NZ)*

There was strong support, especially with submitters currently involved in fossil fuel industries, for government endorsement and a regulatory environment for blue or grey hydrogen and CCS or CCUIS. These submitters argued CCS is a mature and economic technology with many working examples and should be endorsed and supported by government as it will be difficult, if not impossible under existing law.

CCS is, contrary to the apparent view in the Green Paper, already technically and financially viable. Large scale CCS is a reality today, with at least 18 large scale CCS facilities operating with five under construction and 20 in various stages of development. This includes the major CCS project at the Gorgon natural gas field in Western Australia.

We recommend that, to promote a level playing field, the Green Paper notes the regulatory barriers to CCS and recommends these be remedied. (PEPANZ)

Other submitters took a contrary view arguing that CCS is unproven and only green hydrogen should be supported, with some claiming that fossil fuel based hydrogen essentially prolongs the life of an industry they believe should close.

In relation to carbon capture, use and storage (CCUS) on which blue hydrogen relies for its justification, evidence overseas shows that it fails to effectively remove GHG and is largely a dissembling tactic used by fossil fuel companies to prolong their operations.

Research overseas and within our GNS indicates that CCUS is a risky, immature and as yet unreliable technology (Climate Justice Taranaki Inc.).

Many submitters stressed the importance of alignment with international hydrogen standards.

Alignment to international standards is crucial. Allied to that qualified inspectors and regulatory management. (*Gallagher Fuel Systems Limited)*

From supporters of green hydrogen there was strong support for certification internationally for a green hydrogen standard, to ensure hydrogen promotes a legitimate carbon reduction.

Lastly, Utilities Disputes commented that when hydrogen becomes a widespread consumer commodity it will be important that Utilities Disputes has jurisdiction.

Transport

Transport was one area where many submitters saw and supported the potential of hydrogen, noting in particular the emissions reduction that hydrogen may provide:

There is real potential for green hydrogen to make a significant contribution to reducing CO2 emissions from transport, and from industrial processes in energy intensive industries including refining (Refining NZ)

It is well acknowledged that hydrogen and HFC technology will be more suited to the heavy transport sector (John Hill)

Hydrogen has a high energy density and therefore is best suited to long-range, high payload and/or utilization applications like commercial logistics, heavy freight, buses, and material handling equipment (Hiringa Energy Ltd)

opportunity to convert New Zealand's heavy transport fleet to a hybrid model that uses both diesel and green hydrogen. This hybrid technology is being developed in the U.S. and elsewhere (e.g. Ulemco in the UK), and would prove a viable transition for heavy duty truck operators as it would require less capital than a full hydrogen model and provide additional range with a reduction in emissions (Refining NZ)

The BEC TIMES-NZ energy scenarios did not see hydrogen as an economic option for transport or industrial heat applications. However, we know from sensitivity analysis that the

assumed purchase cost of hydrogen fuel-cell trucks only needs to drop by less than 5% for them to be preferable to electric trucks, (BECC)

However, several submitters noted the advantages and established position of EVs in the market over hydrogen vehicles:

There is already a battery electric technology solution developed and growing in this light passenger transport segment which challenges the feasibility of having hydrogen powered light passenger vehicles. This also relates to light commercial vehicles, for example delivery vans, where there is increased availability of fit for purpose battery electric vans. Hydrogen powered light passenger vehicles will potentially find it hard to compete in this vehicle market segment. (Ellen Cavanagh)

There is no rational argument for the promotion of hydrogen fuel cell light vehicles over light battery electric vehicles (BEV). (- Climate Justice Taranaki Inc.)

There may be a role for hydrogen fuel cell for heavy, long-haul freight, maritime transport or port and warehousing facilities. (Climate Justice Taranaki Inc.)

Several submitters stressed that the higher energy efficiency of electric vehicles argued against hydrogen vehicles now and in the future.

BEV solutions would not require same level of investment and are currently more energy and cost efficient, this may be competing technology (WSP)

Although others pointed out what they saw as some of the drawbacks of EVs relative to FEV:

Widespread deployment of FCEV's reduces New Zealand's reliance on importing and managing the disposal infrastructure, costs and obligations associated with hazardous end of life batteries (e.g. lithium ion) Current FCEV technology provides the equivalent range and convenience of diesel fuel for heavy vehicles and is therefore the logical zero emission replacement fuel if commercially viable.. (New Zealand Hydrogen Association)

The cost of the infrastructure required to enable fleet-wide implementation of fuel-cell vehicles is likely less than the cost of the infrastructure for fleet-wide implementation of battery-powered vehicles (Venture Taranaki Trust and New Plymouth District Council)

Some submitters argued that New Zealand cannot afford to adopt another transport fuel option

We already have a partly developed EV charging network so there is no point in having a hydrogen network that only delivers 30% of the electrical energy that you started with. I.e. just use the electricity directly …

… it would be ridiculously expensive to add a third vehicle refuelling system alongside petrol/diesel and EV chargers. (Scott Rabone)

Some submitters went further and opposed entirely the use of hydrogen for transport

The government should pass regulations against use of green hydrogen as a fuel for light vehicles. This is because it is wasteful of New Zealand renewable energy resources to have to have to support the inefficiencies of green hydrogen creation and conversion back to green electricity as created from fuel cells. Much less renewable generating capacity would need to

be constructed if the electricity is used directly to charge EV batteries. (Earl Bardsley, University of Waikato)

Other submitters argued the government should take a more neutral stance, for example:

The government should stay neutral on policies that drive the uptake towards decarbonizing the transport sector. The rationale for this is that it is impossible to predict what the winners of tomorrow's technologies will be given that I believe the technologies of tomorrow have not yet been identified. (Rob Kirkpatrick)

Or alternatively that it should provide more direction

currently no national strategy with regards to how hydrogen should be used to contribute to the reduction of emission across the transport sector. Real Journeys Ltd

One submitter argued that rather than supporting hydrogen, the government should be seizing the opportunity to decrease the role of private motor vehicles instead of just shifting from one fuel to another.

it is nonsensical for New Zealand to switch its light vehicle fleet from fossil fuel to green hydrogen. The time is now for redesigning our cities, transport modes, highway networks and fuel supplies to new configurations not just shifting from one fuel to another. (Carbon Neutral New Zealand Trust)

Balancing these negative views, many submitters supported the idea that hydrogen from renewable electricity may be most economical and effective way to electrify certain parts of the transport sector, such as commercial and heavy freight, buses and material handling equipment.

Hydrogen is a real option to meet the needs of transport operators for certain use-cases, but it will take some time for cost-effective hydrogen fuelled vehicles to grow to material volume. (Z Energy)

And National Energy Research Institute (NERI) noted

Green Hydrogen is virtually unique in its ability to service high duty cycle industrial vehicles where emissions are an issue. (NERI)

Hiringa Energy Ltd, who is currently engaged in the commercial development of hydrogen transport infrastructure for heavy vehicles noted:

Hydrogen from renewable electricity is the most economical and effective way to electrify certain parts of the transport sector, such as commercial and heavy freight, buses and material handling equipment. (Hiringa)

The New Zealand Hydrogen Association (the Association) identified that it will take 25 years to turnover our existing internal combustion engine car fleet at the current new vehicle entry rate. In the Association's (and others) view this indicates the need for a regulatory framework that supports and speeds up the transition to a zero emission vehicles; using fiscal incentives and mechanisms targeted at such as emission limit on vehicle sales), carbon tax and fuel excise relief for zero emission fuels to incentivise new vehicle uptake.

Z Energy recommended the consideration of the Californian Low Carbon Fuel Standard as a way to promote and incentivises low carbon energy in transport, where the lower the carbon intensity of the fuel or energy source, the higher the incentive.

In a similar vein, Hiringa for example noted the potential for disincentive regulation:

> *For example preventing use of fossil fuel buses in public transit by 2025 in Europe has created a large market for zero emission alternatives that is driving greater uptake of FCEV solution. A similar program sends strong signals to operators and technology vendors that NZ committed changing its fleet make up. (Hiringa)*

Such polices are not of course specific to the promotion of hydrogen and would equally benefit other low emissions technologies.

Lastly, several submitters noted that hydrogen low emissions vehicles do not enjoy the same incentives as battery electric vehicles in New Zealand, with some calling for this to change.

> *Hydrogen vehicles are not classified as EV's and as such, do not enjoy the same benefits designed to incentive use. (Refining NZ)*

Auckland Council noted that hydrogen and electric vehicles both use an electric motor to propel the vehicle and therefore should therefore both be exempt from Road User Charges (RUC). However, the

> *Energy Innovation (Electric Vehicles and Other Matters) Amendment Act 2017, which in section 21 (2, b) talks about the definition for an heavy EV as one that derives "…motive power wholly or partly from an external source of electricity." (Auckland International Airport Ltd.)*

In general those who argued for support for hydrogen vehicles argued for a change to RUC provisions to put hydrogen vehicles on the same footing as EVs.

Rail

Submitters were generally supportive of the potential for hydrogen in rail and marine systems.

> *the government owns Kiwi Rail and can certainly invest in hydrogen powered train engines and ferries (Pat Wall)*

Venture Taranaki noted potential interlinkages between these applications commenting that a relatively modest level of infrastructure at ports would have potential to support use by both the rail and trucking industries.

The Carbon Neutral New Zealand Trust stated it believed that green hydrogen has a role to play in the rail and marine transport sectors.

Several submitters supported the consideration of hydrogen by KiwiRail, though one noted:

> *We understand that KiwiRail presented solutions for improving services in the Golden Triangle, with no consideration for Fuel Cell locomotives at that time. Perhaps this needs revisiting. (Gallagher Fuel Systems Limited)*

KiwiRail commented it is committed to supporting New Zealand's goal of achieving a net carbon zero economy by 2050. KiwiRail however commented that in its view:

> *At present, the only viable zero-emissions technology for heavy freight rail is through electrification, which is worth considering on the heavily utilised routes of the North Island Main Trunk (NIMT) between Auckland and Wellington, and the East Coast Main Trunk (ECMT) between Auckland and Tauranga. The section of the NIMT between Hamilton and Palmerston North is already electrified. (KiwiRail)*

Kiwirail stated that outside of these areas, it will move towards alternative zero-emissions propulsion systems as the technology and necessary infrastructure develops, where the final solutions are likely to be a mix of battery and hydrogen fuel-cell technology. However, KiwiRail also noted that in its view hydrogen freight locomotives are a long while off as

> *While the technology required to operate a freight locomotive is all theoretically in place and available, no-one has yet synthesised this into a viable product. Until this happens, it is difficult to forecast a timeframe for adoption of this technology in New Zealand. At present KiwiRail believes it likely to be beyond 2040 before we see a commercially available product that is relevant to our operating environment. (KiwiRail)*

Marine

Hydrogen use in marine settings has a large potential for emissions reduction; both for ships at sea and for power supply when ships are stationary in port. NERI commented on this potential:

> *Emissions from New Zealand bunkered marine fuels come from international shipping (2/3rds), with coastal freight, the fishing fleet, and Cook Strait most of the remainder. Cruise liners/ferries where emissions and noise are an issue could eventually move to all-electric systems using FCs with hydrogen carriers, and in the interim adopt lower emission auxiliary power. However, for most applications it is likely that alternative renewables e.g. drop-in bio-marine fuel oils will be cheaper. (NERI)*

One of the likely early uses of hydrogen in New Zealand is in continuous or 24/7 transport applications such as container cranes and forklifts. The Ports of Auckland project is an active example of this sort of development to deploy hydrogen technologies in port facilities.

Aviation

Some submitters noted the potential for hydrogen application at airports in similar manner as at ports in providing energy for airport transport operations that have similar continuous or 24/7 requirements. Other submitters noted that the application of hydrogen technologies within aircraft whether as motive power, or as fuel cell batteries is likely to be a long way off.

Refuelling infrastructure

Many submitters who commented on hydrogens potential, or otherwise, in transportation discussed the issues and concerns around refuelling infrastructure. These submitters recognised that lack of a refuelling infrastructure is a significant barrier to the deployment of FCEVs.

However, submitters response to this problem varied. Many opposed to hydrogen cited this lack and the advantage of EV's being able to be charged "anywhere" e.g. at home as reasons why hydrogen should not be supported. Others, argued the similarity between hydrogen and traditional petroleum refuelling meant that less infrastructure was needed to a hydrogen fleet, citing this as an advantage.

> *Refuelling stations to support the uptake of heavy transport switching to hydrogen present less of a problem compared to recharging infrastructure required to stimulate the mass uptake of EVs in the light vehicle fleet. The existing network of truck stops for traditional hydrocarbon refuelling could be extended to provide hydrogen refuelling at locations to*

support the use of hydrogen fuelled heavy transport. What will be needed for any investment to be made in the building of hydrogen refuelling stations is a strong signal from Government that the use of hydrogen within the road transport sector is not a short-lived policy that saw CNG come and go within a relatively short period of time. (Stephanie Gregor)

As noted above, heavy vehicle transport is one niche where hydrogen may be adopted earlier in New Zealand, and is the focus of many of the currently active hydrogen projects such as Hiringa. Some submitters noted that this focus on the commercial heavy vehicle market, rather than the general public and light vehicles, will at least initially, reduce the size of the infrastructure problem:

Refuelling networks and supporting infrastructure must be designed around the needs of the target end users. In BP's case, and in the establishment of the supply chain, we believe that hydrogen infrastructure is at first best targeted to commercial ecosystems for heavy transport, in both off road (marine and rail) and on road (long haul trucks, bus fleets) uses. (BP New Zealand)

A large network of refilling stations will not be required to start with, but a commercial model will take time to develop due to small scale operations to start the transition. On that basis, it may be beneficial to look at incentives and support to create a basic network of refuelling stations to get to some sort of scale. (BP New Zealand)

Given this initial concentration on commercial vehicles, there is unlikely to be the same imperative to create a nationwide and dense hydrogen refuelling network. This would by itself act to constrain the extent to which such vehicles may become attractive as light passenger vehicles, if they ever do. As Todd Corporation noted:

Given New Zealand's geography and population density, Todd does not consider it economic to invest in development of a sufficiently dense national re-fuelling network that would be required for hydrogen-fuelled light vehicles. (Todd Corporation)

Submitters also recognised the implications of hydrogen for training:

The service sector for hydrogen vehicles needs to also be considered, particularly around training and safety regulations. For example, training and apprenticeship programme, retrofitting or developing specialist hydrogen workshops, on-site fuelling procedures and HSNO regulations. (Z Energy)

Availability of suitable hydrogen vehicles

Several submitters noted access to suitable FCEVs was a limiting factor as well:

Another barrier for the roll-out of hydrogen is the availability of technology and infrastructure. For example, transport, where New Zealand's market size might limit access to heavy trucks (left-hand-drive). (BEC)

There is limited availability of buses and heavy-duty vehicles, with long lead times (one year to 18 months) for delivery to smaller and more distant markets such as New Zealand as larger orders may be prioritised over smaller orders. (BEC)

Auckland Transport's procurement of a hydrogen bus for its trial highlighted some of the challenges of procuring hydrogen vehicles. In particular it noted that:

Hydrogen buses currently available internationally are not built to suitable standards and set up for an Auckland context. They are designed for a UK context. (Auckland Council, Auckland Transport and Watercare)

Industrial use of hydrogen

Submitters were generally supportive of government developing hydrogens potential for industry,

Govt needs to lead production of a road map for industrial process uptake of green hydrogen (Alister Gardiner)

The role of Government in encouraging the use of hydrogen for industrial processes, including process heat supply (New Zealand Hydrogen Association)

Government support will be required for early projects that substitute existing fossil fuel feedstocks for industry, (Hiringa Energy Ltd)

predominantly green transport system will be an asset for tourism. Further, active promotion of the use of green hydrogen for rental vehicles and rental motor homes, widens this to the NZ tourist base. (Arnim Littek)

Some submitters in particular noted its ability to reduce the carbon footprint of some industrial processes:

green hydrogen is also a key ingredient for authentic biofuels (Refining NZ)

There is real potential for green hydrogen to make a significant contribution to reducing CO2 emissions from transport, and from industrial processes in energy intensive industries including refining (Refining NZ)

green hydrogen to offset ammonia imports and NG usage in fertiliser production. (Alister Gardiner)

(Swedish example:) Steel production with hydrogen instead of coal. The project is called Hydrogen Breakthrough Ironmaking Technology or "HYBRIT (Les Pepper)

biorefining appears likely to be a significant area of growth in New Zealand with implications for Green Hydrogen production (and other biofuels), and its use as a reducing agent.

Another area of potential growth for Green Hydrogen could be in synthetic fuels. (National Energy Research Institute)

Tiwai Point and Glenbrook, generate CO2 by using carbon to reduce their feedstocks. In the latter case hydrogen is being explored to replace the carbon as the reducing agent (National Energy Research Institute)

there may be opportunities for hydrogen production to decarbonise emissions-intensive processes, such as for ammonia/urea and steel production The key opportunity in New Zealand appears to be using green hydrogen as an industrial feedstock to replace hydrogen currently produced from natural gas. (Todd Corporation)

Some submitters recognised that hydrogen could create resource issues as well as benefits:

A potential challenge for industrial scale hydrogen is that electricity and water are required – both of which are key process inputs for Fonterra's operations. Depending on the location of

hydrogen processing plants, this could create resource competition for Fonterra, particularly in water constrained regions. (Fonterra Co-operative Group Limited)

However, some submitters noted, other technologies may provide a more versatile and efficient path than the use of hydrogen in some industrial processes:

the suggestion of expanding our renewable energy capacity to produce green hydrogen for 'low-carbon oil refining' or drying milk (without coal) for export borders on the farcical. On the latter, burning waste wood or producing biogas from farm wastes for heating and electricity are proven and much more economical than hydrogen. (BP New Zealand)

no point in using hydrogen for industrial processes in place of using electricity (Scott Rabone)

Hydrogen is unlikely to be economic for low temperature process heat (<100 ^{o}C) applications due to round trip energy efficiency economics compared to electricity alternatives (Transpower)

The increasingly popular electric heat pumps and induction cook-tops are energy efficient and climate friendly when the electricity is generated from renewable sources. Hence, there is no reason or advantage to switch domestic heating or cooking from electric to hydrogen (20% concentration) supplied through existing gas network. (Climate Justice Taranaki Inc.)

Fonterra noted that while hydrogen may be interesting at this stage, technical limitations make it difficult to fit with their current business operations:

there are currently no technically feasible options for hydrogen tankers that would suit New Zealand conditions. (Fonterra Co-operative Group Limited)

compared to other low emission options. This makes it difficult to provide a useful assessment of the potential of hydrogen as a fuel for our tanker fleet. (Fonterra Co-operative Group Limited)

Additionally, our manufacturing sites are largely based in rural locations, so building and maintaining infrastructure for hydrogen re-fuelling could be costly. These factors will influence the technical feasibility and economics of hydrogen (Additionally, our manufacturing sites are largely based in rural locations, so building and maintaining infrastructure for hydrogen re-fuelling could be costly (Fonterra Co-operative Group Limited)

Several submitters supported the exploration of hydrogen in gas reticulation:

Using a blended reticulated gas network of 20 per cent hydrogen would be a way to reduce natural gas use while investing into research and development to identify viable, long-term solutions that are 100 per cent renewable. (Auckland Council, Auckland Transport and Watercare)

There are many new local polymer pipe based low pressure LPG distribution networks in the South Island and elsewhere which might be more amenable to hydrogen injection. It may be worthwhile undertaking a study and if feasible support pilot trials on LPG distribution networks in association with suitable green hydrogen production projects. (Alister Gardiner)

Acknowledging though limitations such as:

> *a need to replace our gas transmission network if the hydrogen concentration is to be above 20% (Bryan Leyland)*
>
> *due to different burner properties and characteristics of the gases, only a modest level of enrichment may be practical without upgrading equipment and pipelines. (Gary Wilson)*
>
> *Industries wanting to use green hydrogen for process heat would need confidence that their supply is reliable (Gary Wilson)*

Hydrogen Export

Submitters recognised the future potential of an international hydrogen market:

> *By 2030, potential demand for imported hydrogen in the big Asian economies such as Japan, China and South Korea is expected to total nearly 4m tonnes (Gary Wilson)*
>
> *Germany would have a strong interest in importing green hydrogen from New Zealand, showing a willingness to pay the additional cost of producing green, instead of brown or grey, hydrogen (Tina Schirr)*

But the possibility of hydrogen export from New Zealand was another issue that divided submitters.

Some submitters argued against hydrogen exports because they believe it would be detrimental to New Zealand's interests; either by consuming excessive levels of renewable electricity, raising electricity prices (because the price being paid to all generation needed to meet demand for hydrogen production will drive up the price for consumers) or potentially strain fresh water resources.

Some submitters were strongly opposed to hydrogen exports, for example

> *Producing hydrogen for export makes absolutely no sense environmentally or economically when there are existing storage technologies that are cheap, proven and environmentally friendly. (Dr Stuart Jeanne Bramhall)*
>
> *It is ludicrous to think that we can or should develop a hydrogen export commodity market with Japan or anywhere else. It makes no energy or economic sense, when we realise that we must ensure our own energy, water and food security, reduce our emissions to zero, stop overshooting the known planetary boundaries and have capacity to sustain not only our own populations but climate refugees (Climate Justice Taranaki Inc.)*
>
> *Export cannot be even considered at this stage. You do have to learn to walk before you run. The technology is not available, the electricity is not available and hydrogen tankers do not exist. (Bryan Leyland)*
>
> *The government should firstly look to New Zealand's requirements for transportation and industrial requirements before participating in international trading. (*Evonik Peroxide Limited*)*
>
> *This is totally ridiculous. We don't have any surplus renewable electricity in the first place and exporting requires port facilities and ships with massive cryogenic vessels to handle liquid hydrogen. Think massive cost for no gain. (Scott Rabone)*

Role of govt for export - None. If it was economical the private sector would do it. (Luke Schneider)

There is no certainty that we could produce green hydrogen at lower cost than competing brown hydrogen in a global hydrogen market, should such a market ever happen. If we wish to contribute toward global decarbonisation from our gas sales, it would be more logical to seek to discover and develop major offshore gas fields, selling the gas to China for power generation there in place of coal. (Earl Bardsley)

Some submitters claimed that New Zealand is unlikely to be cost competitive for hydrogen exports:

NZ does not offer a natural competitive advantage to produce renewable hydrogen. There are better wind (e.g. Chile) and solar (e.g. Australia) resources elsewhere (Rob Kirkpatrick)

New Zealand's Green Hydrogen exports won't compete in markets where the margin for Green Hydrogen (renewable) over Blue (low emissions) is small. (National Energy Research Institute)

New Zealand's green hydrogen will also have to compete with countries where green hydrogen might be produced more cheaply, such as Australia and those closer to market (BEC Tina Schirr)

New Zealand may struggle to compete globally for the cost-effective production of hydrogen. Australia, South American and Middle Eastern countries may be able to produce hydrogen at lower costs due to lower cost renewable energy potential. There are already projects in these regions where the delivered energy cost is being struck at NZD$25-45/MWh compared with costs of over $60/MWh in New Zealand. New Zealand may only have a niche position as an exporter and it may therefore be more cost effective to import hydrogen for domestic needs (Transpower)

main challenge is New Zealand's cost competitiveness with other countries with green hydrogen supply strategies. The utilisation of solar power is currently the cheapest way to produce green hydrogen, and countries like Australia, Chile and the UAE have a natural advantage which means NZ could struggle to compete on cost. (Sheena Thomas)

However, other submitters recognised that hydrogen exports may bring scale to the development of infrastructure which could bring local benefits:

Recognizing that export of hydrogen can pay for New Zealand's hydrogen infrastructure build must be a key starting point (Gallagher Fuel Systems Limited)
A side benefit is that production at export scale would drive investment in renewable generation, and reduce the overall cost of hydrogen production in New Zealand. (Alister Gardiner)

Revenue generated from exporting hydrogen made from excess renewable energy may support the business case for increased and faster build of renewable electricity capacity in New Zealand, as it would allow greater utilisation of capital. (Fonterra Co-operative Group Limited)

Presently, there are a number of countries evaluating the role of future hydrogen imports to supplement their own limited renewable energy resources. New Zealand is only one possible source, and as some submitters observed may not be as cost competitive as other potential locations. Submitters were concerned that any goal to export does not affect local supply, or should give priority to local supply.

> *The paper states that exporting hydrogen is an aspirational goal and is based on New Zealand's abundant renewable resources. We believe the government has a key role in ensuring that this aspiration is balanced with the demands of the domestic energy market. Policy and infrastructure must be developed to support the growth of this market without sacrificing domestic energy sovereignty, security or price. (Fonterra Co-operative Group Limited)*
>
> *There is no role for Government to ensure sufficient volume of hydrogen for export. The primary concern for Government is in ensuring domestic energy security consistent with also meeting international obligations to reduce net carbon emissions. (Major Gas Users Group)*

Some submitters were concerned that international hydrogen prices could feedback into domestic prices:

> *should we begin exporting hydrogen we could face international market prices for hydrogen, and potential price volatility. (Fonterra Co-operative Group Limited)*
>
> *Once green hydrogen is produced for export it becomes an international commodity. This will have flow-on effects on the local price of hydrogen. In turn this will impact on the potential local uses of hydrogen and on the local price of renewable electricity. (Venture Taranaki Trust and New Plymouth District Council)*
>
> *a major challenge and risk is to ensure both hydrogen and indirectly, renewable electricity, are not priced to an international market at the disadvantage of domestic consumers. We note this occurred on the east coast of Australia in 2016 when the LNG market was developed for export. (Fonterra Co-operative Group Limited)*

or that a balance is needed between local and international use

> *it is important that the Government regulates hydrogen stocks to ensure adequate capacity is maintained within New Zealand. (Auckland Council, Auckland Transport and Watercare)*
>
> *there needs to be a balance between the use of hydrogen in NZ so that only excess production volumes are exported (Stephanie Gregor)*
>
> *ensure New Zealand balances green hydrogen export opportunities alongside energy requirements for hydrogen use domestically (Rob Kirkpatrick)*
> *May be in the "greater good" not to export energy since energy is wasted used in transport and may be more viable assist and support nations to building their own capabilities. (Les Pepper)*

Should hydrogen exports develop, some submitters recognised the central role that government can play to help ensure its success:

> *Extend the 100% pure NZ brand to include Green NZ Hydrogen …. Help to develop a premium Green Hydrogen product to assist marketing this internationally (Les Pepper)*

Exporting hydrogen will require facilities for transport that are compatible with overseas countries. The government should take a lead in drawing up international agreements on infrastructure standards, as these will be important for a successful export sector. (Gary Wilson)

Support and facilitate government to government cooperation with potential hydrogen importing countries to advance hydrogen export opportunities and also with countries that are advancing hydrogen export technologies. (New Zealand Hydrogen Association)

Some submitters recognised that the value of hydrogen exports was also in global energy and emissions reduction, not just a local benefit:

The purpose of exporting green hydrogen, aside from the financial gains, is to address global greenhouse gas emissions. It is important to consider the entire lifecycle impacts of green hydrogen, (Auckland Council, Auckland Transport and Watercare)

New Zealand has the best wind resource in the world, but wind by nature is very unstable and difficult to store. If the energy can be harvested and converted to hydrogen products which can be shipped and exported to other countries such as pacific island countries, it will tighten the strength between the links to the people and culture and their economy growth. (Koru Consultants)

Overall, the general submitter view on exports is best summed up in the statement:

The role of Government is in being realistic about the benefits of exporting hydrogen. (Daniel Lister)

Security of Supply

Several submitters saw the value of hydrogen in improving our security of supply.

Distributed storage of hydrogen (both stationary and on board) provides an inherent and enhanced disaster and crisis ride-through capability greater than that currently available through the fossil fuel infrastructures. (Alister Gardiner)

For civil defence emergencies, a fuel cell locomotive can provide power in the event of longer term loss of electrical connections to outlying communities. Fuel cell powered ships/ferries can provide emergency power to towns and even cities (Gallagher Fuel Systems Limited)

Also by facilitating more renewable electricity development:

Green Hydrogen will accelerate the deployment of renewable generation and increase security of supply, enabling New Zealand to meet its ambitious climate targets without compromising the energy system. (Hiringa)

By facilitating greater decentralisation of energy production:

De-centralised power generation would be the best way to build a resilient energy network, paying a fair price to citizen-generators will increase the energy available to hydrogen generators. Especially in locations where networks were not designed for a high load from a hydrogen plant, the network of citizen-generators would ease the load. (Daniel Lister)

Government may need to fund and incentivise regions to manufacture hydrogen from electricity (electrolysis), gas (SMR) and coal (gasification) to allow regional microgrids (John Hill)

Some submitters saw how this use of hydrogen could be particularly advantageous in supporting disadvantaged and remote regions

disadvantaged regions present an opportunity for pop up microgrids and hydrogen production and storage to provide process heating at competitive prices and support regional economic development. (Arnim Littek)

Hydrogen could open up many more opportunities for groups and communities, especially in more remote areas of NZ, as Green Hydrogen can be produced locally (using geothermal and wind generation) and then stored and/or used for process heat for applications like glasshouses, timber drying and food processing etc. (Les Pepper)

Social license and water use

Several submitters commented on the need for water as a resource to create hydrogen:

One of the key challenges for creating high volumes of hydrogen for export will be to create a viable, scalable, cost-efficient way to break down seawater instead of requiring the masses of high quality fresh water. (Gallagher Fuel Systems Limited)

And also how this use of resources may create social license or acceptability levels, particularly if it involves exports

Large scale onshore and potentially offshore wind development will require public acceptance which may be challenging, especially if these resources were developed only for energy export. (Z Energy)

There is also a social licence challenge. There is the opportunity for international demand to drive significant investment in renewable energy generation. There may be local concern about the impacts of some forms of renewable generation e.g. the landscape impacts of additional wind generation. These concerns may be heightened if the electricity produced is being used for producing green hydrogen for export rather than for local supply. (Venture Taranaki Trust and New Plymouth District Council)

We express concern regarding the impacts on water, its usage and allocation for the generation of hydrogen. The Māori World view and Treaty of Waitangi is incorporated within the vision paper, however requires further consideration, specifically regarding the use and allocation of water. (Auckland Council, Auckland Transport and Watercare)

Issues raised concerning Maori values and interests

The Vison attempted to outline how the renewable aspects of the use and concept of green hydrogen is broadly compatible with Maori values. Some submitters noted how hydrogens development may be of benefit to Maori.

Many Māori groups now have access to large capital funds which they could use to develop and partner with investors for Green Hydrogen production, storage and distribution network developments. (Les Pepper)

Development of hydrogen facilities on Iwi land using Iwi resources represents a real opportunity for young Māori to gain experience, education, and training in the technology and to directly participate in building NZ's energy future. (Les Pepper)

Hydrogen could open up many more opportunities for Māori groups and communities, especially in more remote areas of NZ. There are potential economic and social opportunities for Māori businesses and investments in hydrogen, if the concerns outlined above (and within the Safety & Resilience section below) are adequately resolved and align with the Māori World view. (Auckland Council, Auckland Transport and Watercare)

Māori land trusts are involved in many renewable energy projects, particularly in the central North Island. These projects could link with hydrogen production. (Gary Wilson)

The introduction of hydrogen into Maori's life through pipeline transportation can effectively solve the problem of energy supply and increase the local employment rate to a certain extent (Koru Consultants)

The development of green hydrogen production in New Zealand provides a range of opportunities which Māori may choose to take advantage of. (Venture Taranaki Trust and New Plymouth District Council)

Opportunities to utilise Māori geothermal resources to produce green hydrogen for use in Iwi owned business enterprises and for potential export. (New Zealand Hydrogen Association)

Submitters commented on the importance of involving Maori in the development of this policy

Maori are incredibly important stakeholders in this decision on energy policy, especially as renewable energy takes over - they will be and should be leading this effort (John Gorman)

Maori are incredibly important stakeholders in this decision on energy policy, especially as renewable energy takes over - they will be and should be leading this effort (John Gorman)

However, some submitters did not feel the Vision went far enough, or did not represent Maori interest correctly:

This document does not illustrate a true partnership between Crown & Māori. In the next round (and especially the Renewable Energy Strategy) I hope to see a marked improvement in building meaningful, sustainable relationships. (Kingi Gilbert)

Think of Māori organisations and communities as being co-authors of the paper. I'm afraid that while tokenistic engagement practices are adopted we will continue to see the widening gap instead of bridging a transition to a new NZ. (Kingi Gilbert)
In reality the Crown has never honoured Te Tiriti o Waitangi properly and Māori has not had the ability to outright refuse oil and gas well drilling on their whenua. We do not see how hydrogen development would be different. How would it "assist whānau, hapū and iwi to thrive" rather than negatively impact them, (Climate Justice Taranaki Inc.)

The infographics used are offensive as they try to incorporate capitalist ideas into our traditions and tikanga that do not sit within the exploitative ideology of capitalism (Climate Justice Taranaki Inc.)