[redacted]

From: no-reply@mbie.govt.nz
Sent: Friday, 25 October 2019 3:30 p.m.
To: [redacted]; Hydrogen
Subject: Hydrogen green paper - submission
Attachments: [redacted]

Submission on Hydrogen green paper recevied:

Introduction
Name

Richard Coxon

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Business name or organisation (if applicable):

Gallagher Fuel Systems Limited

Position title (if applicable):

Managing Director

Is this an individual submission or on behalf of a group or organisation?

Behalf of group or organisation

Please give the name of the group or organisation this submission is on behalf of.

Gallagher Fuel Systems Limited

What is the role of Government in developing hydrogen for storage and distribution?
What are the challenges for using hydrogen for storage and distribution?
What are the opportunities for using hydrogen for storage and distribution?
What is the role of Government in developing the complementary role of electricity and hydrogen?
What are the challenges for achieving this complementary role of electricity and hydrogen?
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What is the role of Government in supporting hydrogen use for the transport sector?
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In addition, we welcome your feedback about the opportunities of hydrogen to Māori and how this will support their aspirations for social and economic development.
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If you wish to, you can attach a document to this submission.

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Yes

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If there is information in your submission that you wish to remain confidential, please note them below:

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To help us analyse of your feedback, we would appreciate clear written submissions that indicate the number and question being addressed.

1a **What is the role of Government in developing hydrogen for storage and distribution?**

The Government is committed to decarbonization of the nation over the next thirty years, there is global recognition that hydrogen appears to be the primary energy vector enabling the planet's decarbonization process.

- This is categorically not a chicken-or-egg-first process. Infrastructure must come first. Planning to optimize that infrastructure is wise.
- Green hydrogen generation via wind and solar power will generally not advantageously be done at or near major urban centres. Distribution in time and place of >100% renewable electrical power supply must be done to balance grid loading, and to enable hydrogen export to finance the rollout of hydrogen infrastructure.
- Coherent planning with national scope is required to optimize resource usage. From a government perspective, this ensures that the benefits of infrastructure and capital injection to New Zealand is done with government goals clearly in mind, not least active encouragement of projects outside of major centres.
- Creating the storage and distribution infrastructure for hydrogen which underpins the decarbonization programme will require a consistent hand. Mixed messages to the (required) global investment community are counterproductive.

1b **What are the challenges for using hydrogen for storage and distribution?**

- Very immediately, standards and equipment certification. Alignment to international standards is crucial. Allied to that qualified inspectors and regulatory management.
- A weak point is hydrogen's low density, in compressed gas or liquid form, necessitating large and expensive infrastructure. Global advances in this space are either converstion to/from denser molecules rich in hydrogen (NH_3/CH_4/higher order hydrocarbons), which may be considered from a governmental perspective as tradeoffs of density/handling improvement vs. environmental risk. CRIs may be productively invoked to examine equally promising gains in the domain of metal hydride matrix solutions, which need to be demonstrated to be scalable, eventually in a national context. This has relevance to Gallagher Fuel Systems, my immediate focus.
- Large scale storage in an earthquake prone nation is a challenge, all the more so for the fact that hydrogen is the smallest atom, ie. more challenging in preventing leakage. Converting to/from larger hydrogen-dense molecules such as ammonia or methane invokes an energy conversion penalty, but in some cases, eg. large

scale export, this may be desirable for density improvement. The Japanese and Californian experience suggest earthquakes are already taken into consideration internationally.

- Long haul trucking is an economic sweet spot for hydrogen transport, as well as a critical element of the decarbonization agenda. Servicing a fast-growing FCEV long haul truck market will require more hydrogen than can be realistically be supplied by tube trailers. Optimal distribution may require more pipeline builds. KiwiRail can foreseeably step up to fill an intermediate role between trucking and pipelines, by establishing major hydrogen storage depots at (all?) railheads around the country. This can solve significant problems, not least of which is an expansion of hydrogen dispensing facilities beyond KiwiRail's own needs to pull those trains. Meshing the active government support for KiwiRail with the decarbonization agenda seems a logical extension of the Government's KiwiRail improvement agenda.
- Pipeline builds will encounter NIMBY backlash, as will the renewable energy generation infrastructure to enable green hydrogen generation.
- The social acceptability of hydrogen is one small step, even if the spectre of the Hindenburg has mostly disappeared from the public conscience. It is no small factor that hydrogen has been used safely at industrial scale for over a century. Transferrance of this to publicly accessible facilities is the key. The reality is that if petrol and other hydrocarbon fuels were introduced today as new, they would face similar difficulties due to their flammability and toxicity.
- The larger step might be the extreme pressures required to achieve economically practical energy densities, even if for the most part 70MPa means nothing in real terms to the average citizen.

1c **What are the opportunities for using hydrogen for storage and distribution?**

As well outlined in a cogent op-ed piece in August by Z Energy[1], electrification is the dominant theme of the global decarbonization agenda.

- Hydrogen as a form of stored energy, distributed around the nation is a strategic resource. In addition to the decarbonization of transport and industry, a commitment to distributed large scale stores of hydrogen will improve national resilience, in terms of the nation's energy security, of Civil Defence, of National Defence, and if done appropriately can reduce the load on the nation's highways.
- Storage is the key to optimising renewables generation efficiency and electrolyzer utilization.
- Storage/distribution is the fabric that
    - enables NZ to pass through the threshold of 100% renewable electricity, to facilitate export of green hydrogen.
    - underpins the improvement in national energy security through large scale distributed energy stores around the country
    - enables electrical network robustness against local systems failures.

- Distribution is the key to optimizing the national storage resource, and hence national energy security. Whether KiwiRail plays that role, or coastal shipping, large scale distribution requires facilities beyond the roading system.
- New jobs, lots of them, across many industries, and across the country, including in the regions. This provides an opportunity for many New Zealanders to upskill themselves, with active roles in the national decarbonization process, and eliminating the national debt. The upskilling programme required can in part be addressed by Defence employees, once the Ministry of Defence recognizes the national need for energy security can be addressed through large scale hydrogen storage and distribution.

2a **What is the role of Government in developing the complementary role of electricity and hydrogen?**

Government proactivity is laudable and essential to the decarbonization agenda. Success of the energy transformation process will be driven by clear, long term Government commitment. The Government role can include:

- Active deprecation/disincentivization of non-renewable electricity generation. Drive the nation toward 300% renewable electricity capacity as a long term target. For instance, the Z Energy piece[1] advocates improving the affordability of hydrogen against fossil fuels.
- The ultimate authority for planning/managing hydrogen's role in load balancing with increased electrification in the decarbonization programme, and accommodating large scale hydrogen export potential.
- Fair, equitable, environmentally and socially appropriate handling of the removal of large quantities of water for this role. The opportunities will be larger once seawater is proven as a viable source (ref. hydrogen export feedback).

2b **What are the challenges for achieving this complementary role of electricity and hydrogen?**

- Coherent large scale commitment to achieve cost efficiencies to make the hydrogen transformation economically tractable
- Unification of purpose. Renewable energy providers, storage system providers, hydrogen distribution infrastructure builders and large scale users must work together to drive the business case, in an encouraging business environment. For counter-examples, witness the historical LNG example in Australia, ref. [2]. More immediately, witness the discord in Australia currently by pro-renewables governments in South Australia, Western Australia, the Chief Scientist etc. when the Energy Minister in Canberra sings a completely different tune[3].

2c **What are the opportunities for this complementary role of electricity and hydrogen?**

- Grid load balancing is the obvious opportunity, via time/place shifting of hydrogen for electricity generation on demand. The long life of hydrogen storage enables seasonal or longer time shifts, if needed.
- A stable, robust distributed national grid, capable of absorbing local failures with no cascade effects. In the event of a coronal mass ejection[4] taking down the national grid, distributed hydrogen storage would be key to early restoration of services. Appropriate storage of hydrogen will be immune to even massive solar EMP, or even man-made nuclear EMP. This should be a pillar of the national Defence strategy, serving a second purpose of relieving the Defence's dependence on oil imports.
- Actively taking control of New Zealand's energy security provides a programme to protect the economy against international disruptions – political, economic and otherwise, as an economic stabilizer.
- Environmentally clean fallback power for emergency vehicles/hospitals in the event of earthquakes/tsunami etc. Clean water production from stationary fuel cells is realistic.

3a **What is the role of Government in supporting hydrogen use for the transport sector?**

- The Ministry for the Environment clearly indicates the trend of increasing contribution to greenhouse gas emissions from transport, notably faster than the growth via the other large sector, agriculture. It is technologically possible to all-but-eliminate the contributions from transport, over time.
- GHG emissions aside, eliminating vehicle emissions have other health benefits, especially in urban areas. Whether this later reflects clearly in Ministry of Health statistics, or ACC statistics, remains to be seen, but the costs to Government are there.
- Active participation in the national infrastructure rollout planning, including addressing regional needs as well as major centers to adopt fuel cell-based transport. High usage applications must pay for infrastructure for the foreseeable future. Active incentivization of the conversion heavy duty truck market not only has GHG impacts, but aids the drive to profitability of the hydrogen infrastructure. If done aggressively, this may have global impact. Such a programme will succeed economically earlier than incentives for light duty vehicles.
- Drive coherent planning and provide incentives for regional bus lines to enable large scale purchase of fuel cell-driven transport, which in turn can create nodes of hydrogen dispensing for commercial and private vehicles. The Californian

subsidy programme for bus transit includes a small subsidy for blue hydrogen and significantly larger subsidy for green hydrogen. A detailed review of incentive programmes in other nations with thrusts toward hydrogen as key to the decarbonization agenda – the UK, Germany, Japan, Korea and China, will provide ideas for accelerating uptake of zero emissions transport options.

- Active encouragement of hydrogen infrastructure via the rail network – as a user, a national distribution system, nation-wide hydrogen storage facilities, with attached hydrogen dispensing for private vehicles and trucking.
- Coastal shipping and ferries are legitimate targets for decarbonization. Some of these directly fall under the aegis of KiwiRail where Government support for a hydrogen transformation can have national impact in multiple dimensions.

3b **What are the challenges when using hydrogen for mobility and transport?**

- The coherence of the above plan on a nationwide basis will be key to making the hydrogen transition economically viable, leveraging economies of scale.
- The economics, particularly for private operators, will be challenging in the near future. Whether the Government can imitate Chinese, Korean, British and other incentive schemes to encourage the decarbonization of transport, is a question of the urgency behind the decarbonization agenda.
- Although heavy vehicles/high usage vehicles are an economic sweet spot, their availability in the next 5 to 10 years in New Zealand may be problematic. How does one incentivize local organizations to retrofit existing heavy vehicles, based on support from established suppliers of fuel cell vehicle technology, who are heavily promoting assistance to spread the technology? Two standout examples of this are Toyota and Hyundai.
- 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.
- Finding and training staff will initially be an issue. Ministry of Defence adoption of hydrogen as a core energy security mechanism can build the national resource in skilled staff.

3c **What are the opportunities for using hydrogen for mobility and transport?**

- Transport is one of the more technically and economically manageable ways to impact on the carbon footprint of the country.
- The Z Energy piece [1] quotes that heavy trucks present 7% of the total vehicle km travelled, but 25% of emissions (presumably vehicle emissions).
- Fonterra operates a large fleet of heavy vehicles. Reducing Fonterra's CO_2 emissions this way will be more easily realized than similar reductions achievable for CH_4 emissions in their vast dairy farm network. Can the Government encourage Fonterra's decarbonization programme? Given the

foreseeable shortage of new Fuel Cell trucks in coming years[1] an active programme of retrofitting may be realistic at that scale.

- Transport has the advantage of being the most visible decarbonization process, ie. it can impact many residents on a personal level. Halting the acceleration, indeed reversing the trend of GHG emissions in the transport sector is an opportunity in itself to introduce hydrogen to the general public in a non-threatening way – urban buses and trains for instance.
- Bus opportunities extend beyond long distance buses. The worst emissions, and the worst efficiencies in bus operation are in the stop-and-go of city traffic. The key is the combination of high usage and rapid refueling, with zero emissions.
- 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.
- 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. If transported hydrogen is available to supplement these, longer term emergency services are also possible from the same equipment.
- A 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.

4a **What is the role of Government in encouraging the use of hydrogen for industrial processes including process heat supply?**

- Drive NZ Steel to reduce emissions [7]. Potential avenues for steel, cement and plastic production are highlighted in [8].
- When the electrical grid achieves >100% renewable capacity, then the focus becomes reduction of fossil fuel 'exhaust' from chemical and industrial processes. There will be room for disincentives for hydrocarbon emissions, and incentives to transform.
- Active encouragement of transition of high heat processes to utilizing hydrogen can become a government programme, eg. MBIE incentives.

4b **What are the challenges for using hydrogen in industrial processes?**

4c **What are the opportunities for the use of hydrogen in industrial processes?**

- The demonstrated capability to provide >100% renewable energy can be marketed internationally to attract energy-intensive industry, where it makes economic and environmental sense for a facility to be based in New Zealand. If provision of green hydrogen as industrial feedstock is an additional incentive, so much the better.

- Present R&D incentives are based on economic targets. Is there room to build in decarbonization incentives? Conversely, disincentives for not pursuing decarbonization actively?
- Water quality is a problem this country must address. For a hydrogen-driven approach, ref. [9]. In extreme cases, stationary power systems based on hydrogen can provide quantities of very clean water.
- At this point we are not aware of any investment being made into the fuel cell infrastructure required in New Zealand to convert stored hydrogen into energy for use during natural disaster or emergency use. Investment in this domain can fit the national agenda.

5a **What is the role of Government in encouraging hydrogen uptake for decarbonisation of our natural gas uses?**
5b **What are the challenges for hydrogen to decarbonise the applications using natural gas?**

- per 4b above.

5c **What are the opportunities for hydrogen to decarbonise our gas demand?**

- Where gas is used for backup power or remote power, hydrogen can fill the demand off-the shelf. Making this economically competitive may be incentivized.
- Where gas is used for home heating, achieving >100% renewables for electricity generation means electricity costs must be competitive with gas. Whether that means disincentives for gas usage, or incentives for conversion to electricity is open. Increasing taxation on all hydrocarbon consumption can discourage petrol/diesel/gas usage for combustion.

6a **What is the role of Government in producing hydrogen in sufficient volume for export?**

- Recognizing that export of hydrogen can pay for New Zealand's hydrogen infrastructure build must be a key starting point.
- Mid last century the German government correctly recognized that a people's car would be a key factor in reviving the war-torn economy. The fact that the German government still owns a large share of VW (despite Dieselgate) ensures that the company must be particularly attentive to social and environmental impact of its work. A segment of the NZ voting population would raise a hue and cry at Government ownership of hydrogen infrastructure, but if the Government is motivated to actively drive decarbonization, this may be the single best choice to invest large $$$ to achieve decarbonization in the target timelines, with a reasonable prospect of recovery of the investment, never mind the additional jobs and small-to-medium enterprises required to support it.

- Government ownership increases bankability of projects beyond the equity injected.
- Government involvement coordinating this stage will almost certainly be massively less expensive than cleaning up an uncoordinated commercial effort, or multinationals with no imperative for the national decarbonization agenda.
- An Australian government report highlights prospective hydrogen producing regions clearly targeting export[10]. The Government can take a proactive role in the marketability of green export hydrogen with New Zealand branding.
- Direct Government support for mitigating the regulatory, social and technical hurdles in transferring large quantities of hydrogen across borders enables the income potential. Hopefully the agreement signed early this year with the Japanese government underpins this role. To what extent does this agreement equate to [5]?

6b **What are the challenges for hydrogen if produced for export?**

- 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. This should also make an easier fit to the Iwi perspective. There are lab prototypes extant in research groups around the world. GNS is looking for meaningful ways to participate in the hydrogen transformation – they have research staff of the requisite capability.
- The Australian government has recently inked a deal with the Japanese government for safety standards shipping liquid hydrogen [5]. Government proactivity in this domain is also relelvant.
- The techological challenges will be manageable. The social/environmental challenges will be larger – maintaining the social and environmental equity at the same time. CSIRO has a paper addressing this from the AU perspective [6]. Auastralian academics have likewise engaged on this topic, again in evidence at the recent Hydrogen Safety conference.

6c **What are the opportunities for hydrogen if produced for export?**

- Hydrogen is the new Oil, dressed in green.
- The national debt was as of Dec. 2018 cited at $158B and growing. Oil imports for the year to Aug. 2019 are cited at 7.3B. For every dollar reducing the oil import total by replacing it with a dollar of hydrogen export, the balance of payments improves by two dollars. A net positive position is foreseeable in the timespan of the decarbonization programme. What does this mean to Treasury? What does this prospect do for justifying the national investment in hydrogen infrastructure?
- Treasury will also be interested in reducing or eliminating the “energy security insurance premiums” paid to oil companies annually in the form of subsidies,

once the national dependence on oil imports is being reduced. This change is likely to be popular with a large segment of the voting public.

- Maximizing New Zealand's head start on getting beyond 100% renewable electricity generation must be a marketing tactic of the highest order for smoothing the path to market. There can be no better way to assure the greenness of the source. Achieving this can translate into a long term advantage to make it more difficult for second-comers to break the NZ position.
- Long term reduction of petroleum imports can lead to using Marsden Point for cleaner synfuel generation from hydrogen (ie. absorbing CO_2 = carbon neutral) for the remaining requirements for hydrocarbon fuels. A desirable outcome is reduce the hold Big Oil has over the nation.
- Government involvement can optimize the likelihood that all New Zealanders benefit from the hydrogen transformation of the economy and environment.
- Production of liquid hydrogen optimizes density for shipping internationally. Large scale is required to justify this. The same large scale infrastructure used for export hydrogen can be used to make internal hydrogen transport and usage more economical and pragmatic.
- Tiwai is once again headline news. Repurposing Tiwai when the aluminum refinery is no longer economically viable, nicely fits the hydrogen export picture. A large scale hydrogen export facility at Bluff can replace the employment lost through Tiwai's repurposing, with potential to do more than Rio Tinto/Sumitomo ever did for the national balance of payments.
- Likewise, Westport must be a potential location for green hydrogen production for export, to replace industry that has since departed. Finding the right entrepreneur or corporate interest will be required. Reducing the West Coast dependence on income from exporting coal directly addresses Climate Change issues. With the large scale Chinese commitment to hydrogen, the markets for that coal will not improve. Leaving the coal in the ground is an optimal contribution to global decarbonization. CCS au naturel.
- It is the dependence on optimal locations for renewable energy which provides potential for economic development in the regions. Nothing drives this harder than high volume hydrogen production for export. Potential to leverage these regional locations for commercial/industrial diversification based on the availability of low cost renewable energy and hydrogen, needs further consideration.

In addition, we welcome your feedback about the opportunities of hydrogen to Māori and how this will support their aspirations for social and economic development.

- Beyond Tuaropaki Trust, there will be other sources of untapped renewable energy around New Zealand, under Iwi control. Leveraging the learning from Tuaropaki Trust may be an easy example to hold up. Bootstrapping others may also be an agenda item.

- Many of the processes involved in the hydrogen transformation/decarbonization of New Zealand will produce waste heat. This may have specific application to Maori concerns and ambitions. Similarly the output produced from fuel cells is pure H_2O at source.
- The earlier example citing Graforce [9] can be relevant to Maori *and* Pakeha in locations where water quality is particularly problematic. Lake Horowhenua is an egregious example, as the destination for 4 of the dirtiest flows in the country. Using the Graforce equipment to turn it into a source for biofuel may be a welcome opportunity for the Iwi in that location.

Richard Coxon, 25 October 2019
Managing Director, Gallagher Fuel Systems

References:

[1] Z Energy: http://nzx-prod-s7fsd7f98s.s3-website-ap-southeast-2.amazonaws.com/attachments/ZEL/338430/304472.pdf

[2] p6 of "Attracting hydrogen investment". National Hydrogen Strategy, COAG Energy Council, Australian Government. Further lessons from this example are cited on p10.

[3] https://reneweconomy.com.au/is-angus-taylor-on-a-one-man-mission-to-stop-wind-and-solar-30126/

[4] https://www.nationalgeographic.com/news/2011/3/110302-solar-flares-sun-storms-earth-danger-carrington-event-science/

https://www.wired.com/2012/02/massive-solar-flare/

and many more.

[5] https://www.amsa.gov.au/news-community/news-and-media-releases/australia-and-japan-develop-safety-standards-shipping-liquid

[6] https://www.en-former.com/en/hydrogen-revolution-steel-production/

[7] https://research.csiro.au/hydrogenfsp/social-science-for-a-hydrogen-energy-future/ This can be improved upon, not least in the NZ context.

[8] http://www.energy-transitions.org/mission-possible

[9] https://graforce.de/en/applications/automotive-and-transport-industries

[10] https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/130930

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- Active participation in the national infrastructure rollout planning, including addressing regional needs as well as major centers to adopt fuel cell-based transport. High usage applications must pay for infrastructure for the foreseeable future. Active incentivization of the conversion heavy duty truck market not only has GHG impacts, but aids the drive to profitability of the hydrogen infrastructure. If done aggressively, this may have global impact. Such a programme will succeed economically earlier than incentives for light duty vehicles.
- Drive coherent planning and provide incentives for regional bus lines to enable large scale purchase of fuel cell-driven transport, which in turn can create nodes of hydrogen dispensing for commercial and private vehicles. The Californian

subsidy programme for bus transit includes a small subsidy for blue hydrogen and significantly larger subsidy for green hydrogen. A detailed review of incentive programmes in other nations with thrusts toward hydrogen as key to the decarbonization agenda – the UK, Germany, Japan, Korea and China, will provide ideas for accelerating uptake of zero emissions transport options.

- Active encouragement of hydrogen infrastructure via the rail network – as a user, a national distribution system, nation-wide hydrogen storage facilities, with attached hydrogen dispensing for private vehicles and trucking.
- Coastal shipping and ferries are legitimate targets for decarbonization. Some of these directly fall under the aegis of KiwiRail where Government support for a hydrogen transformation can have national impact in multiple dimensions.

3b **What are the challenges when using hydrogen for mobility and transport?**

- The coherence of the above plan on a nationwide basis will be key to making the hydrogen transition economically viable, leveraging economies of scale.
- The economics, particularly for private operators, will be challenging in the near future. Whether the Government can imitate Chinese, Korean, British and other incentive schemes to encourage the decarbonization of transport, is a question of the urgency behind the decarbonization agenda.
- Although heavy vehicles/high usage vehicles are an economic sweet spot, their availability in the next 5 to 10 years in New Zealand may be problematic. How does one incentivize local organizations to retrofit existing heavy vehicles, based on support from established suppliers of fuel cell vehicle technology, who are heavily promoting assistance to spread the technology? Two standout examples of this are Toyota and Hyundai.
- 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.
- Finding and training staff will initially be an issue. Ministry of Defence adoption of hydrogen as a core energy security mechanism can build the national resource in skilled staff.

3c **What are the opportunities for using hydrogen for mobility and transport?**

- Transport is one of the more technically and economically manageable ways to impact on the carbon footprint of the country.
- The Z Energy piece [1] quotes that heavy trucks present 7% of the total vehicle km travelled, but 25% of emissions (presumably vehicle emissions).
- Fonterra operates a large fleet of heavy vehicles. Reducing Fonterra's CO_2 emissions this way will be more easily realized than similar reductions achievable for CH_4 emissions in their vast dairy farm network. Can the Government encourage Fonterra's decarbonization programme? Given the

foreseeable shortage of new Fuel Cell trucks in coming years[1] an active programme of retrofitting may be realistic at that scale.

- Transport has the advantage of being the most visible decarbonization process, ie. it can impact many residents on a personal level. Halting the acceleration, indeed reversing the trend of GHG emissions in the transport sector is an opportunity in itself to introduce hydrogen to the general public in a non-threatening way – urban buses and trains for instance.
- Bus opportunities extend beyond long distance buses. The worst emissions, and the worst efficiencies in bus operation are in the stop-and-go of city traffic. The key is the combination of high usage and rapid refueling, with zero emissions.
- 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.
- 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. If transported hydrogen is available to supplement these, longer term emergency services are also possible from the same equipment.
- A 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.

4a **What is the role of Government in encouraging the use of hydrogen for industrial processes including process heat supply?**

- Drive NZ Steel to reduce emissions [7]. Potential avenues for steel, cement and plastic production are highlighted in [8].
- When the electrical grid achieves >100% renewable capacity, then the focus becomes reduction of fossil fuel 'exhaust' from chemical and industrial processes. There will be room for disincentives for hydrocarbon emissions, and incentives to transform.
- Active encouragement of transition of high heat processes to utilizing hydrogen can become a government programme, eg. MBIE incentives.

4b **What are the challenges for using hydrogen in industrial processes?**

4c **What are the opportunities for the use of hydrogen in industrial processes?**

- The demonstrated capability to provide >100% renewable energy can be marketed internationally to attract energy-intensive industry, where it makes economic and environmental sense for a facility to be based in New Zealand. If provision of green hydrogen as industrial feedstock is an additional incentive, so much the better.

- Present R&D incentives are based on economic targets. Is there room to build in decarbonization incentives? Conversely, disincentives for not pursuing decarbonization actively?
- Water quality is a problem this country must address. For a hydrogen-driven approach, ref. [9]. In extreme cases, stationary power systems based on hydrogen can provide quantities of very clean water.
- At this point we are not aware of any investment being made into the fuel cell infrastructure required in New Zealand to convert stored hydrogen into energy for use during natural disaster or emergency use. Investment in this domain can fit the national agenda.

5a **What is the role of Government in encouraging hydrogen uptake for decarbonisation of our natural gas uses?**
5b **What are the challenges for hydrogen to decarbonise the applications using natural gas?**

- per 4b above.

5c **What are the opportunities for hydrogen to decarbonise our gas demand?**

- Where gas is used for backup power or remote power, hydrogen can fill the demand off-the shelf. Making this economically competitive may be incentivized.
- Where gas is used for home heating, achieving >100% renewables for electricity generation means electricity costs must be competitive with gas. Whether that means disincentives for gas usage, or incentives for conversion to electricity is open. Increasing taxation on all hydrocarbon consumption can discourage petrol/diesel/gas usage for combustion.

6a **What is the role of Government in producing hydrogen in sufficient volume for export?**

- Recognizing that export of hydrogen can pay for New Zealand's hydrogen infrastructure build must be a key starting point.
- Mid last century the German government correctly recognized that a people's car would be a key factor in reviving the war-torn economy. The fact that the German government still owns a large share of VW (despite Dieselgate) ensures that the company must be particularly attentive to social and environmental impact of its work. A segment of the NZ voting population would raise a hue and cry at Government ownership of hydrogen infrastructure, but if the Government is motivated to actively drive decarbonization, this may be the single best choice to invest large $$$ to achieve decarbonization in the target timelines, with a reasonable prospect of recovery of the investment, never mind the additional jobs and small-to-medium enterprises required to support it.

- Government ownership increases bankability of projects beyond the equity injected.
- Government involvement coordinating this stage will almost certainly be massively less expensive than cleaning up an uncoordinated commercial effort, or multinationals with no imperative for the national decarbonization agenda.
- An Australian government report highlights prospective hydrogen producing regions clearly targeting export[10]. The Government can take a proactive role in the marketability of green export hydrogen with New Zealand branding.
- Direct Government support for mitigating the regulatory, social and technical hurdles in transferring large quantities of hydrogen across borders enables the income potential. Hopefully the agreement signed early this year with the Japanese government underpins this role. To what extent does this agreement equate to [5]?

6b **What are the challenges for hydrogen if produced for export?**

- 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. This should also make an easier fit to the Iwi perspective. There are lab prototypes extant in research groups around the world. GNS is looking for meaningful ways to participate in the hydrogen transformation – they have research staff of the requisite capability.
- The Australian government has recently inked a deal with the Japanese government for safety standards shipping liquid hydrogen [5]. Government proactivity in this domain is also relelvant.
- The techological challenges will be manageable. The social/environmental challenges will be larger – maintaining the social and environmental equity at the same time. CSIRO has a paper addressing this from the AU perspective [6]. Auastralian academics have likewise engaged on this topic, again in evidence at the recent Hydrogen Safety conference.

6c **What are the opportunities for hydrogen if produced for export?**

- Hydrogen is the new Oil, dressed in green.
- The national debt was as of Dec. 2018 cited at $158B and growing. Oil imports for the year to Aug. 2019 are cited at 7.3B. For every dollar reducing the oil import total by replacing it with a dollar of hydrogen export, the balance of payments improves by two dollars. A net positive position is foreseeable in the timespan of the decarbonization programme. What does this mean to Treasury? What does this prospect do for justifying the national investment in hydrogen infrastructure?
- Treasury will also be interested in reducing or eliminating the “energy security insurance premiums” paid to oil companies annually in the form of subsidies,

once the national dependence on oil imports is being reduced. This change is likely to be popular with a large segment of the voting public.

- Maximizing New Zealand's head start on getting beyond 100% renewable electricity generation must be a marketing tactic of the highest order for smoothing the path to market. There can be no better way to assure the greenness of the source. Achieving this can translate into a long term advantage to make it more difficult for second-comers to break the NZ position.
- Long term reduction of petroleum imports can lead to using Marsden Point for cleaner synfuel generation from hydrogen (ie. absorbing CO_2 = carbon neutral) for the remaining requirements for hydrocarbon fuels. A desirable outcome is reduce the hold Big Oil has over the nation.
- Government involvement can optimize the likelihood that all New Zealanders benefit from the hydrogen transformation of the economy and environment.
- Production of liquid hydrogen optimizes density for shipping internationally. Large scale is required to justify this. The same large scale infrastructure used for export hydrogen can be used to make internal hydrogen transport and usage more economical and pragmatic.
- Tiwai is once again headline news. Repurposing Tiwai when the aluminum refinery is no longer economically viable, nicely fits the hydrogen export picture. A large scale hydrogen export facility at Bluff can replace the employment lost through Tiwai's repurposing, with potential to do more than Rio Tinto/Sumitomo ever did for the national balance of payments.
- Likewise, Westport must be a potential location for green hydrogen production for export, to replace industry that has since departed. Finding the right entrepreneur or corporate interest will be required. Reducing the West Coast dependence on income from exporting coal directly addresses Climate Change issues. With the large scale Chinese commitment to hydrogen, the markets for that coal will not improve. Leaving the coal in the ground is an optimal contribution to global decarbonization. CCS au naturel.
- It is the dependence on optimal locations for renewable energy which provides potential for economic development in the regions. Nothing drives this harder than high volume hydrogen production for export. Potential to leverage these regional locations for commercial/industrial diversification based on the availability of low cost renewable energy and hydrogen, needs further consideration.

In addition, we welcome your feedback about the opportunities of hydrogen to Māori and how this will support their aspirations for social and economic development.

- Beyond Tuaropaki Trust, there will be other sources of untapped renewable energy around New Zealand, under Iwi control. Leveraging the learning from Tuaropaki Trust may be an easy example to hold up. Bootstrapping others may also be an agenda item.

- Many of the processes involved in the hydrogen transformation/decarbonization of New Zealand will produce waste heat. This may have specific application to Maori concerns and ambitions. Similarly the output produced from fuel cells is pure H_2O at source.
- The earlier example citing Graforce [9] can be relevant to Maori *and* Pakeha in locations where water quality is particularly problematic. Lake Horowhenua is an egregious example, as the destination for 4 of the dirtiest flows in the country. Using the Graforce equipment to turn it into a source for biofuel may be a welcome opportunity for the Iwi in that location.

Richard Coxon, 25 October 2019
Managing Director, Gallagher Fuel Systems

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[2] p6 of "Attracting hydrogen investment". National Hydrogen Strategy, COAG Energy Council, Australian Government. Further lessons from this example are cited on p10.

[3] https://reneweconomy.com.au/is-angus-taylor-on-a-one-man-mission-to-stop-wind-and-solar-30126/

[4] https://www.nationalgeographic.com/news/2011/3/110302-solar-flares-sun-storms-earth-danger-carrington-event-science/

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and many more.

[5] https://www.amsa.gov.au/news-community/news-and-media-releases/australia-and-japan-develop-safety-standards-shipping-liquid

[6] https://www.en-former.com/en/hydrogen-revolution-steel-production/

[7] https://research.csiro.au/hydrogenfsp/social-science-for-a-hydrogen-energy-future/ This can be improved upon, not least in the NZ context.

[8] http://www.energy-transitions.org/mission-possible

[9] https://graforce.de/en/applications/automotive-and-transport-industries

[10] https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/130930