We welcome your feedback on the questions outlined in this Green Paper.
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?**

- Green hydrogen generation via wind and solar power will generally not advantageously be done at or near major urban centres. Distribution 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 the encouragement of projects outside of major centres. PGF on steroids, with a clear nationally relevant purpose.
- As illustrated in [1], picking the low hanging fruit may not be the optimal way to meet government targets for decarbonization. Climate change requires long term, coherent planning, untrammeled by the quarterly report of the business sector.
- Hydrogen as a form of stored energy, distributed around the nation is a strategic resource. Beyond Civil Defence concerns, this can be relevant to the national Defence strategy.

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

- Very immediately, standards and equipment certification. A visible example is Hyundai's inability to put their Nexo fuel cell vehicles on the road, despite this process being in place in the US, Japan, Korea, Germany, Australia.... Clearly this applies also to hydrogen infrastructure, which must be technically acceptable before real rollout begins. Allied to that qualified inspectors and regulatory management.
- 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 molecules such as ammonia or methane invokes an energy conversion penalty, but in some cases, eg. large scale export, this may be desirable anyway for density improvement. An open research issue, as you are aware. [there is potential for a role reversal in exporting methane or another hydrogen-dense hydrocarbon form – leaving the carbon management issue with the receiving nation]
- Distribution is an interesting problem that will require more pipeline builds. Whether KiwiRail can step up to fill an intermediate role between trucking and pipelines is an interesting question, but having major hydrogen storage depots at (all?) railheads around the country can solve significant problems, not least of which is an early rollout of hydrogen dispensing facilities beyond KiwiRail's own needs to pull those trains. Anything other than electrified line or fuel cell hydrogen locomotives would be hypocritical/counter to the decarbonization mandate.
- 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. 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. 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.

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

- Storage/distribution is the fabric that enables NZ to pass through the threshold of 100% renewable electricity, to enable export of hydrogen.

- New jobs, lots of them, across many industries, and across the country, not just in large cities. An opportunity for many to upskill themselves.
- Distributed storage of hydrogen enables electrical network robustness against local systems failures. This should significantly simplify Transpower's role.

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

- Active deprecation/disincentivization of non-renewable electricity generation. Drive the nation toward 150% renewable electricity capacity.
- The ultimate authority for planning/managing hydrogen's role in load balancing esp. in the context of the imbalance of loads foreseeable with the introduction of large numbers of electric vehicles with expectations of overnight charging
- 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?**

- Enabling/leading large scale commitment to achieve cost efficiencies to make the hydrogen transformation economically tractable
- Unification of purpose/plan so that renewable energy providers, storage system providers, hydrogen distribution infrastructure builders and large scale users are working coherently to drive the business case for the large scale commitment. Witness the historical LNG example in Australia, ref. [2]

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

- Grid load balancing is the obvious opportunity
- A stable, robust distributed national grid, capable of absorbing local failures with no cascade effects. In the extreme event of a major sunspot event taking down the electrical grid nationwide, distributed hydrogen storage will be the key to restoration of some services. Appropriate storage of hydrogen will be immune to even massive EMP.
- Environmentally clean fallback power for emergency vehicles/hospitals in the event of earthquakes/tsunami etc. Clean water production from the same may also be realistic, TBD.

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

- Active participation in the national infrastructure rollout planning, including addressing regional needs as well as major centers to adopt fuel cell-based transport.
- Drive coherent planning and provide incentives for regional bussing to enable large scale purchase of fuel cell-driven transport, which in turn can create nodes of hydrogen dispensing for private vehicles and even trucking, where the business case is already viable.
- 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

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.
- Finding and training staff will initially be an issue.

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. It also has the advantage of being the most visible aspect of the decarbonization of the nation, ie. it can impact many residents on a personal level.
- The wider the spread of a new hydrogen infrastructure, the faster jobs and new small-to-medium enterprises will be created. Some of this will be offset by loss of jobs in present fuel distribution/maintenance companies, but there is at least as much market diversity possible from converting to hydrogen infrastructure, as is presently in fuel systems businesses.
- 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.
- For emergency situations (eg. earthquake/tsunami), a fuel cell locomotive can provide power in the event of longer term loss of electrical connections to outlying communities. Fuel cell powered ships 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.

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 [3]
- 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?**

- Individual process requirements will not make this a government playground, unless requisite CRIs play lead roles. Driving proactivity from the CRIs may be useful to the decarbonization agenda.

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.
- Water quality is a problem this country must address. For a hydrogen-driven approach, ref. [5]

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 this can pay for New Zealand's hydrogen infrastructure must be a key starting point.
- The German government recognized mid last century that a people's car would be a key factor in reviving the wartorn 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. There is a segment of the NZ voting population which would raise a huge hue and cry at corporates missing such a large earnings potential, 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 stated timelines, with a reasonable prospect of recovery of the investment, never mind the additional jobs and small-to-medium enterprises that are required to support it.
- Retaining NZ ownership (at least initially) of this major asset would not be seen well by the Business Round Table (there are a lot of New Zealanders who have a different perspective) but it would also increase the bankability of projects beyond the equity injected. Furthermore, from a long term perspective, getting government involvement coordinating this stage is almost certainly to be massively less expensive than cleaning up a mess made by uncoordinated commercial efforts, or multinationals with no imperative for the national decarbonization agenda.
- Additional support comes via active support for mitigating the regulatory, social and technical hurdles in transferring large quantities of hydrogen across borders, but clearly this underpins the agreement recently signed with the Japanese government.

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. There are lab prototypes extant in research groups around the world. GNS is looking for meaningful ways to get into the hydrogen game – they have research staff of the requisite capability. Across the road from GNS, the Callaghan Innovation team has been shepherding Hylink toward production for over a decade. This is a natural marriage, needing only commercial partners (which is in negotation, and needs perhaps a boost via the Hydrogen Association). I am not an employee of either GNS or CI, although clearly I have been in communication with both on this theme.
- 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 [4]

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

- Ensuring that all New Zealanders benefit from the hydrogen transformation of the economy, would be an excellent start.
- Maximizing New Zealand's head start on getting beyond 100% renewable electricity generation must be a marketing tactic of the highest order for shipping hydrogen internationally. 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.
- My recollection when I last looked into it, is that the annual expense to the nation for petroleum product imports was very similar in size to the national debt. With our increasing use of petroleum, that may no longer hold, but suffice to say that significantly reducing our import

liabilities by replacing those needs with hydrogen, impacts on the interest payments of the nation, and hence the national economy. Getting to the point where the hydrogen export income exceeds the payment for importing petroleum products will take time, but must be seen as a worthwhile goal in itself. Whether this can reverse the national balance of payments is not something I've looked into.

- Reducing the petroleum imports in the long run may mean that using Marsden Point for cleaner synfuel generation from hydrogen (ie. absorbing CO_2 = carbon neutral) for the remaining requirements for hydrocarbon fuels, should reduce the stranglehold Big Oil has over the nation. Letting Big Oil take ownership of the national hydrogen resource would defeat that purpose.
- Repurposing Tiwai when the global aluminum market has tanked (further), also fits the picture. Large scale renewable power is already supplied to that location. A large scale hydrogen export facility at Bluff will go a long way to replace the employment lost through Tiwai's repurposing, and probably do more for the national balance of payments in the form of hydrogen exports.
- 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 there. Reducing the West Coast dependence on income from exporting coal addresses Climate Change issues indirectly too. With the Chinese commitment to hydrogen, the markets for that coal will soon dry up.

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.
- 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. Similarly "waste water" produced from fuel cells is pure H_2O at source.
- The earlier example citing Graforce [5] may be relevant to Maori *and* Pakeha in locations where water quality is particularly problematic.

Arnim Littek, 12 Sept. 2019
Foxton Beach

References:

[1] https://climatepolicyinitiative.org/publication/climate-investment-research-collaborative-on-long-term-effectiveness-circle/ Too bad they've overlooked hydrogen's potential to be the biggest single technology lever enabling the planetary decarbonization process, otherwise, very cogent w.r.t. financing the transformation.

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

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

[5] https://graforce.de/en/applications/automotive-and-transport-industries
I have no vested interest in this company, but am impressed.