# Submission on the *Interim Hydrogen Roadmap*

| | |
|---|---|
| **Name** | Waipapa Taumata Rau \| University of Auckland (Contributors: Emilson Silva, Brent Young, Le Wen, Peng Cao, Jenny Hung) |
| **Organisation (if applicable)** | Waipapa Taumata Rau \| University of Auckland |
| **Contact details** | |

## Release of information

Please let us know if you would like any part of your submission to be kept confidential.

☒ I would like to be contacted before the release or use of my submission in the summary of submissions that will be published by MBIE after the consultation.

☐ I would like my submission (or identified parts of my submission) to be kept confidential, and **have stated below** my reasons and grounds under the Official Information Act that I believe apply, for consideration by MBIE.

| |
|---|
| N/A |

[To check the boxes above: Double click on box, then select 'checked']

## Responses to questions

| Section 1: Hydrogen is emerging as an important part of the future global energy system | |
|---|---|
| | **Are there other issues we should be considering in our assessment of the strategic landscape for hydrogen in New Zealand?** |
| 1 | In assessing the strategic landscape for hydrogen in New Zealand, several vital domestic contexts and developments have been addressed, including commitments to emissions targets, the role of electrification, energy resilience, the economic and social impacts of climate action, and the growing hydrogen ecosystem. However, some other considerations could further shape our perspective:<br><br>• The cost of producing and deploying hydrogen will play a critical role in its adoption. Are we tracking the market dynamics and pricing models of hydrogen to ensure its competitiveness with other options?<br><br>• As hydrogen emerges as a potential energy carrier, the need for robust infrastructure, from production facilities to transportation and storage solutions, becomes paramount. How will we efficiently and safely transport and store hydrogen, especially considering its unique properties and safety requirements?<br><br>• The success of new technologies often hinges on public acceptance. How are we ensuring that communities are informed and comfortable with the introduction of hydrogen technologies? What education and engagement strategies are in place?<br><br>• As research and development continue, there could be breakthroughs that significantly alter the landscape for hydrogen. Are we staying abreast of global technological advancements and ensuring that New Zealand is positioned to take advantage of them?<br><br>• Clear regulatory guidance is essential for the safe and efficient deployment of hydrogen technologies. Are our current regulations suited for the rapid deployment of hydrogen solutions?<br><br>• While New Zealand is making strides in the hydrogen sector, collaboration with international partners can expedite growth and knowledge transfer. How are we fostering these international ties? Does New Zealand want to consider taking the lead in this space?<br><br>• As the hydrogen ecosystem grows, it will have economic implications. Have we adequately modelled the potential economic impacts of a substantial hydrogen sector in New Zealand?<br><br>• While hydrogen, especially green hydrogen, has a reduced carbon footprint, its production and usage might have other environmental implications. Are comprehensive environmental impact assessments being conducted? |

| | |
|---|---|
| | • Transitioning to a hydrogen-centric economy will require workforce shifts and training. How are we ensuring that the current workforce is equipped with the necessary skills and that job displacements are minimally disruptive?<br><br>Incorporating these considerations, alongside the provided insights, will give a more holistic assessment of the strategic landscape for hydrogen in New Zealand. We must also be mindful that a role for hydrogen is to be part of, but not the sole contributor to, a diversified portfolio of future energy production. |
| **Section 2: The role for hydrogen in New Zealand's energy transition** | |
| 2 | **Do you agree with our assessment of the most viable use cases of hydrogen in New Zealand's energy transition?**<br><br>Based on the information provided, hydrogen appears to hold potential in certain sectors, especially in industries with large and hard-to-abate emissions and transport sectors where electrification poses challenges. Given New Zealand's unique geographical and economic contexts, the emphasis on decarbonising industries such as fertiliser, steel, and chemical production, seems particularly relevant, as they likely represent significant carbon-emitting activities. Similarly, the applicability of hydrogen in heavy transport, aviation and marine applications resonates with global trends and thinking on where hydrogen might have advantages over battery electric options. Additional applications may also exist in smaller scale operations such as generation in remote communities or for small scale portable electricity supply. |
| 3 | **Do you support some of these uses more than others?**<br><br>While all the uses mentioned have potential benefits, the emphasis may be dictated by areas more contextual to New Zealand:<br>• Industrial Processes: The decarbonisation of strategic industries such as fertiliser, steel and chemical production is crucial. Not only does this reduce significant carbon emissions, but it also ensures that these vital industries can thrive in a decarbonised economy given that they represent hard-to-abate sectors. The use of hydrogen in these sectors is promising and may be more immediate and achievable in the short to medium term.<br><br>• Transport Applications: Hydrogen's role in heavy road transport, aviation, and marine transport is promising. However, the deployment in these areas might face challenges ranging from the development of infrastructure, the availability of technologies at commercial scale, and the current competition from battery-electric solutions, especially in road transport. Marine and aviation sectors, however, are areas where batteries might not be as feasible, making hydrogen a potentially more viable solution. |
| 4 | **What other factors should we be considering when assessing the right roles for hydrogen in New Zealand's energy transition?**<br><br>Given that the efficiency of producing hydrogen from electrolysis is a concern, the source of that electricity becomes crucial. New Zealand has significant renewable energy resources (e.g., geothermal, wind and hydro). Leveraging these renewables for green hydrogen |

| | |
|---|---|
| | production could be an advantage, but it is essential to ensure it does not lead to increased demand pressures that raise electricity prices for other consumers.<br><br>Deeper exploration of the interplay between green hydrogen and offshore wind technologies is required as a potential mechanism for green hydrogen production, given New Zealand's geography (as an island that experiences strong winds) lends itself to this form of hydrogen production.<br><br>Concurrent or sequential deployment of these technologies from a regulatory standpoint, and potential incentives or support to developers who integrate green hydrogen and offshore wind technologies, may be something for governments to consider.<br><br>The establishment of hydrogen infrastructure, from production to refuelling and transport, is a critical factor. The costs, logistical challenges, and environmental impacts of this infrastructure need thorough consideration.<br><br>Beyond the direct job creation in the hydrogen sector, understanding the secondary economic effects, such as those on the local communities and ancillary industries, is vital.<br><br>Community engagement is vital. Public understanding and acceptance can be a make-or-break factor for new technologies, especially when infrastructure development impacts local communities.<br><br>A supportive and clear regulatory framework can provide certainty for investors and developers in the hydrogen space.<br><br>While hydrogen can help in decarbonisation, it is essential to consider other environmental impacts, such as water usage in electrolysis, especially if derived from freshwater sources.<br><br>Consideration of these additional factors will provide a holistic view of the potential and challenges of hydrogen in New Zealand's energy transition. This must be complemented with a research response – the key to our understanding of how to manage these various factors and challenges (such as efficiency of hydrogen production, and hydrogen storage and transport). |
| | **Do you agree with this assessment of the potential for hydrogen supply and demand in New Zealand?** |
| 5 | In principle, the various scenarios appear to be reasonable test cases for future hydrogen supply and demand. One item potentially unclear in this modelling is the impact of the Tiwai Point aluminium smelter, which currently draws approximately 570 MW from the national grid. The uncertainty surrounding the smelter's potential closure influences developers' motivation to invest in renewable energy. It is not clear whether the assessment takes into account the potential closure of the smelter, as this would have a direct effect on electricity prices and, consequently, on the cost of hydrogen production. |
| 6 | **Do you agree with the key factors we have set out that are likely to determine how hydrogen deployment could play out?** |

The key factors set out in this section provide good coverage on determinants of hydrogen deployment. Given that electricity prices account for a significant portion of hydrogen production costs, the volatility and trends in these prices will undoubtedly influence the feasibility of hydrogen deployment. Like any emerging industry, the availability of a skilled workforce is crucial. The construction, operation, and maintenance of hydrogen infrastructure will demand a plethora of trained professionals, making this a pivotal factor for the deployment timeline. A clear demand trajectory is essential for producers. Without an established market and effective delivery mechanisms, the efforts in production might not see the desired uptake. The possibility of linking to export markets can serve as a significant demand booster. The current interest in combining renewable electricity generation with hydrogen production is noteworthy. The ability to diversify revenue streams – from producing hydrogen, selling renewables, and offering demand response services – offers a buffer against market volatilities. Additionally, the emphasis on the optimal capacity factor for electrolysers underscores the importance of balancing renewable energy sources and electrolyser capacity for economic viability. The factors presented provide a comprehensive framework to determine the future of hydrogen deployment. However, it's crucial to note that these factors are interconnected, and the play-out of one will invariably affect the others. Continual reassessment and adaptability will be key as we move forward.

**What do you think needs to happen to address these factors?**

7

Addressing these factors crucial to hydrogen deployment involves a multi-faceted approach.

The following could be undertaken to address each of the factors:

- **Electricity Prices:**
  - Invest in Renewable Energy: An increase in renewable energy generation will help in decreasing electricity costs. This involves funding and promoting solar, wind and geothermal projects.
  - Encourage Energy Storage: Investing in energy storage systems can help in stabilising the grid and potentially reducing the cost of electricity by providing supply during peak demand periods. Green hydrogen offers a promising solution in this regard.
- **Capital Costs:**
  - R&D Investments: Directing funds towards research and development can drive technological advancements, reducing the costs of equipment over time.
  - Economies of Scale: Promoting and incentivising large-scale hydrogen production can lead to a reduction in unit costs.
  - International Collaborations: Partnering with countries with advanced hydrogen technologies can help in importing and adapting cost-effective solutions.
- **Optimising Production, Transport, Storage and Conversion Costs:**
  - Infrastructure Development: Building dedicated infrastructure for hydrogen transport and storage will reduce associated costs.
  - Localised Production: Wherever possible, producing hydrogen close to the point of consumption can minimise transport and storage costs.
  - Innovative Solutions: Invest in research for efficient methods of hydrogen conversion and transport, including pipelines, high-capacity storage solutions and improved conversion technologies.

- **Available Workforce:**
  - Training and Education: Introduce dedicated training programs and courses in educational institutions that focus on hydrogen technologies.
  - Immigration Policies: Adjusting immigration policies to attract skilled labour from countries with more mature hydrogen industries can bridge the immediate skill gap.
  - Public-Private Partnerships: Collaboration between industries and academic institutions can drive research and provide practical training, leading to an industry-ready workforce.
- **Demand:**
  - Government Policies: Introducing incentives for industries that use hydrogen can stimulate demand.
  - Public Awareness: Launch public awareness campaigns that highlight the benefits of hydrogen as an alternative fuel, potentially driving consumer demand.
  - Export Strategies: Establishing trade agreements with countries that have a high demand for hydrogen can open new markets.
- **Value Stacking:**
  - Flexible Grid Systems: Encourage the development of grid systems that can seamlessly integrate with hydrogen production units, allowing them to respond dynamically to electricity prices.
  - Diverse Revenue Streams: Educate producers about the potential benefits of diversifying their revenue streams, such as selling excess renewable energy back to the grid or offering grid balancing services.
  - Regulatory Frameworks: Update regulatory frameworks to accommodate and incentivise multifaceted hydrogen production-business models.

By comprehensively addressing each factor with these solutions, we can pave the way for a successful hydrogen deployment that is both economically viable and sustainable in the long run.

**Do you have any evidence to help us build a clearer picture?**

8

The following references are recommended as a starting point and conducting further research to gather the most recent data and findings in the field:

**Hydrogen production close to point of consumption:** Wind and solar are already among the cheapest sources of new power generation. According to the International Renewable Energy Agency (IREA), the costs of both have declined significantly over the past decade (IREA, 2020). A study published in "Energies" journal outlined how large-scale production can significantly reduce the unit costs of hydrogen production (Abdul Ali et al., 2019). A study from the National Renewable Energy Laboratory (NREL) highlights the benefits of producing hydrogen close to its point of consumption (NREL, 2013).


- Abdul Ali, A., Ahmad, N., Mohamad Nor, N., Reffin, M., & Amanina Syed Abdullah, S. (2019). Investigations on the Performance of a New Grounding Device with Spike Rods under High Magnitude Current Conditions. *Energies*, *12*(6), 1138. MDPI AG. Retrieved from http://dx.doi.org/10.3390/en12061138
- IREA, 2020, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_Power_Generation_Costs_2019.pdf
- NREL, 2013, https://www.nrel.gov/docs/fy13osti/56487.pdf

**Co-design of offshore wind with green hydrogen:** This approach will lower the cost of hydrogen and ensure a stable electricity system, especially as intermittent wind generation becomes more prevalent.

- Offshore wind and green hydrogen: What opportunities lie ahead? https://www.perkinscoie.com/en/news-insights/offshore-wind-and-green-hydrogen-what-opportunities-lie-ahead.html
- The world's first offshore wind-green hydrogen pilot just triumphed. https://electrek.co/2023/06/30/worlds-first-offshore-wind-green-hydrogen-pilot/
- https://www.hydrogeninsight.com/innovation/europes-first-offshore-green-hydrogen-produced-off-france-with-20m-grant-lined-up-for-second-project/2-1-1475481

| | |
|---|---|
| 9 | **Do you agree with our findings on the potential for hydrogen to contribute to New Zealand's emissions reduction, energy security and resilience and economic outcomes?** |
| | Hydrogen's role in contributing to emissions reduction, energy security and resilience, and economic outcomes depends on multiple factors:<br>• **Emissions Reduction:**<br>o Hydrogen, especially green hydrogen (produced using renewable energy), has the potential to significantly reduce emissions if it replaces fossil fuels in various sectors, such as transportation and industry. This potential is recognized globally, with multiple countries investing heavily in hydrogen research and infrastructure. If New Zealand's electricity grid continues to lean heavily on renewable sources, the production of green hydrogen can indeed align with the country's emissions reduction targets.<br>• **Energy Security and Resilience:**<br>o Hydrogen can act as an energy storage medium, making it an excellent candidate to balance intermittent renewable energy sources such as wind and solar, thus enhancing grid reliability and resilience. Being an energy-dense carrier, hydrogen can be stored for longer periods and used in scenarios where electricity storage might be less feasible, further contributing to energy security.<br>• **Economic Outcomes:**<br>o Developing a hydrogen industry can lead to job creation in research, development, infrastructure, and other related sectors. Countries like Germany and Japan are already investing significantly in hydrogen, recognising its economic potential. New Zealand, with its abundance of renewable resources, can potentially become an exporter of green hydrogen, tapping into the growing global demand.<br><br>Based on global trends and available knowledge, hydrogen does hold promise in the mentioned areas for New Zealand. It's essential to ensure that strategies are aligned with technological advancements, and that there's a balance between domestic use and potential exports. |
| 10 | **Do you have any insights we should consider on what is needed to make hydrogen commercially viable?** |
| | **Cost Competitiveness:**<br>• Reduction in Electrolyser Costs: One of the significant costs associated with green hydrogen production is the cost of electrolysers. Continued research and scale-up of |

production can drive down these costs, similar to how solar PV costs decreased over the past decades.
- Electricity Prices: Green hydrogen's cost is significantly influenced by electricity prices. Access to cheap, renewable electricity is crucial. Dynamic pricing, where electrolysis is conducted during periods of low electricity cost, can help in making production cost-effective.

**Infrastructure Development:**
- Distribution and Storage: Hydrogen storage and transport require new infrastructure. Investments in reliable pipelines, storage tanks, and shipping methods (such as liquid hydrogen or ammonia) are crucial.
- Refuelling Stations: For hydrogen to be viable in the transport sector, a widespread network of refuelling stations is necessary.

**Technology Advancements:**
- Efficiency: Improvements in the efficiency of electrolysers, fuel cells and internal combustion engines designed for hydrogen can enhance commercial viability.
- Safety: Since hydrogen is flammable, robust safety mechanisms need to be integrated into its production, storage and transport systems.

**Policy and Regulation:**
- Government Support: Incentives, subsidies, or tax breaks can stimulate initial investment in hydrogen technologies and infrastructure. Such interventions have been instrumental in the growth of other renewable energy sources in many countries.
- Standards and Certification: Establishing standards for green hydrogen ensures a consistent quality which can foster trust in the market. Certifications can also help consumers identify and opt for sustainable hydrogen products.

**Market Development:**
- Demand Generation: Before producers can scale up, they need clear signals that there is a market for their product. This could come from public transport fleets converting to hydrogen, industries shifting to hydrogen for heating, or even international contracts for hydrogen exports.
- Public Awareness and Acceptance: Educating the public about the benefits and safety of hydrogen can accelerate its acceptance and adoption.

**Integration with Other Sectors:**
- Sector Coupling: Combining hydrogen with other sectors like electricity and heating can open up new avenues for its use, for instance in power-to-gas systems or in combined heat and power plants.

**Research and Development:**
- Innovations: Continual investment in R&D can lead to breakthroughs that significantly reduce costs or increase the efficiency of hydrogen-related technologies.

**Environmental Impact:**
- Ensuring that the production of hydrogen, especially green hydrogen, does not have unintended environmental consequences is essential for its long-term viability and acceptance.

| | |
|---|---|
| | Commercial viability will ultimately be a balance of these factors, and success in one area can drive advancements in others. It's also worth noting that hydrogen's commercial viability may vary by region and application, so targeted strategies might be needed depending on the specific context. |
| | **Is there any further evidence you think we should be considering?** |
| 11 | When considering the commercial viability of hydrogen and its potential contributions to energy transition, it is essential to explore the latest findings and insights from diverse sources. Here's a list of areas of research:<br>• **Global Hydrogen Market Analyses:** Understanding the demand and supply dynamics at a global level can provide context for New Zealand's potential role in this market.<br>• **Case Studies from Other Countries:** Studying the experiences of countries that have adopted hydrogen strategies can offer insights into best practices and pitfalls to avoid.<br>• **Latest Technological Advancements:** This includes emerging methods of producing, transporting, and storing hydrogen.<br>• **Safety and Environmental Impact Studies:** Given hydrogen's unique properties, it's essential to understand its safety implications fully.<br>• **Economic Impact Analyses:** Assessments that predict job creation, GDP impact, and other economic metrics as a result of hydrogen adoption.<br>• **Local Renewable Energy Potential:** Given the importance of renewable energy in green hydrogen production, a detailed understanding of New Zealand's potential in solar, wind, and hydro can be enlightening.<br>• **Consumer Perception Studies:** How ready are New Zealanders to adopt hydrogen-powered solutions? How do they perceive the benefits and risks?<br>• **Comparative Analysis with Other Alternative Fuels**: It's essential to understand where hydrogen stands compared to other alternative fuels, both in terms of costs and benefits.<br>• **Geopolitical Considerations:** As global energy systems transition, there will be shifts in power dynamics, trade relationships, and dependencies.<br>• **Feedback from Industry Stakeholders:** Engage with key industry players, from energy producers to tech companies, to understand their perspectives and insights on the commercial viability of hydrogen. |
| **Section 3: Government position and actions** | |
| | **Do you agree with our policy objectives?** |
| 12 | The government's policy objectives appear to be well-considered and aligned with the overarching aim to optimise hydrogen's potential. Ensuring that supply can scale up is fundamental for any emerging industry. Prioritising safety and facilitating early projects can drive innovation, knowledge transfer, and experience in the sector. Promoting early demand is also crucial, as demand can stimulate production and supply chain development. Monitoring outcomes over time provides a mechanism to adjust and refine strategies as the sector evolves.<br><br>Further information on encouraging research and development, and collaboration with other countries would be welcomed, alongside mechanisms to prompt early demand. |

| | |
|---|---|
| | **Do you agree with our positioning on hydrogen's renewable electricity impacts and export sector?** |
| 13 | From the provided information, specific details on the government's positioning regarding hydrogen's impact on renewable electricity and the export sector have not been stated. However, given that the government aims to match hydrogen production with electricity and other inputs, it suggests a recognition of the potential impacts on the electricity sector and a proactive approach to managing them. Again, the exploration of co-design of offshore wind and green hydrogen is necessary. |
| | **Do you agree with the proposed actions and considerations we have made under each focus area?** |
| 14 | Yes, the actions and considerations appear to be aligned with the objectives set out:<br>• Matching hydrogen production to electricity and other inputs seems to be a pragmatic approach to ensure a balanced growth without overstraining existing resources.<br>• Focusing on safety is always essential, especially for a sector dealing with a potentially hazardous substance. Facilitating early projects can provide invaluable learning opportunities and pave the way for more extensive initiatives in the future.<br>• Linking early demand for hydrogen to the most viable use cases and aligning this with other government priorities ensures that the hydrogen sector's growth aligns with the nation's broader goals.<br>• Regular assessments provide a mechanism to understand the evolving nature of the industry and make necessary policy or strategic adjustments. |
| | **Is there any evidence we should be considering to better target actions in the final Hydrogen Roadmap?** |
| 15 | To enhance the final Hydrogen Roadmap, consider:<br>• Learning from countries that have advanced hydrogen roadmaps or have made significant progress in the hydrogen sector.<br>• Engaging industry stakeholders, research institutions, and communities in consultations to gain diverse perspectives and feedback.<br>• Understanding the full lifecycle environmental impact of hydrogen production, distribution, and consumption.<br>• Assessing the potential economic benefits, including job creation, GDP contribution, and effects on local economies.<br>• Analysing the infrastructure requirements for a robust hydrogen ecosystem, including production facilities, storage, and transportation.<br>Incorporating evidence from these areas can ensure a more comprehensive, actionable, and effective Hydrogen Roadmap for New Zealand. |
| **General comments** | |
| Overall, regarding the potential of hydrogen as an energy source, particularly in the context of New Zealand, the following should be considered from a strategic perspective: | |

**1. Holistic Perspective:** Hydrogen is not just an energy source but a potential cornerstone of a broader energy ecosystem. Evaluating its viability requires looking not just at production costs but at the entire value chain: from production and transportation to end-use applications and potential market demand.
**2. Green vs. Blue vs. Grey Hydrogen:** The source of hydrogen is crucial. 'Green' hydrogen, produced from renewable energy sources, offers the most significant emissions reduction potential and is the focus of the Interim Hydrogen Strategy. Given New Zealand's strong renewable energy portfolio, there's a unique opportunity to lead in green hydrogen production.
**3. Infrastructure Development:** Making hydrogen a commercially viable fuel will require substantial infrastructure investments, from refuelling stations to adapted power plants and transport networks. These investments should be planned strategically and in coordination with existing infrastructure.
**4. Education & Awareness:** For hydrogen to be widely adopted, the general public and stakeholders need to understand its benefits, safety, and uses. An informed public can make better decisions and support hydrogen-related initiatives more actively.
**5. Regulations & Incentives:** Governments play a crucial role in the commercial viability of new technologies. Regulations that favour clean energy, incentives for research & development and tax benefits for hydrogen-related activities can significantly boost the sector.
**6. Collaboration is Key:** The path to hydrogen's commercial viability will require collaboration across sectors and stakeholders, from academia and industry to governments and communities. International partnerships can also provide valuable insights, shared R&D costs and market opportunities.
**7. Monitoring Global Trends:** As with any emerging industry, there will be global trends, breakthroughs and policy shifts. Staying updated and responsive to these changes will ensure New Zealand remains at the forefront of hydrogen innovation.
**8. Economic Diversification:** Hydrogen presents not just an energy solution but an economic opportunity. From job creation in new industries to potential export markets, the economic implications are vast and should be explored thoroughly.

**9. Risk Management:** While the promise of hydrogen is great, potential risks, from market volatility to technological setbacks, should be anticipated and managed. Scenario planning and strategic foresight can help in this regard.