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MONASH ENERGY INSTITUTE

Submission to the Treasury's Hydrogen Production Tax Incentive Consultation

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The Australian Government has announced significant investments in its Future Made in Australia plan, which includes substantial support for renewable hydrogen through the Hydrogen Production Tax Incentive. This initiative, estimated at $6.7 billion over ten years, aims to accelerate the growth of Australia's hydrogen industry, positioning the country as a renewable energy superpower and strengthening its economic security while contributing to global decarbonization efforts.

Monash University welcomes the Australian Government's Hydrogen Production Tax Incentive. This initiative aligns closely with Monash's commitment to driving sustainable energy solutions and offers significant opportunities for research collaboration and innovation in the renewable hydrogen sector. Monash University is the largest university in Australia, and it has a global footprint that includes campuses in India, China, Malaysia, Indonesia, and Italy. Monash has committed to three global challenges: Climate Change, Geopolitical Security, and Thriving Communities. Its flagship Climate strategy, the Net Zero 2030 Initiative, was awarded the UN Momentum for Change Lighthouse award in 2018.

This submission is led by the Monash Energy Institute, the university's primary vehicle for promoting and facilitating Climate Change Mitigation and Energy Transition research. The institute, in addition to coordinating its basic research strengths in novel solar PV and storage materials, green hydrogen and ammonia production and storage, and a full range of AI research strengths, drives impact by bringing deep energy industry expertise to help accelerate the growth of Australia's hydrogen industry. Examples include high-impact initiatives such as the Monash-Geoscience Australia Hydrogen (and Green Steel) Economic Fairways Tool, which was awarded the 2023 Eureka Prize for Innovative Research in Sustainability, the Woodside Monash Energy Partnership (green hydrogen export), the Victorian Renewable Liquid Hydrogen Supply Hub, the Monash hydrogen life-cycle assessment (LCA) tool, leadership of the Electricity Networks Program in the RACE for 2030 Cooperative Research Centre, the industry-funded Monash Grid Innovation Hub. This submission draws upon our extensive research capabilities in hydrogen and energy transition to provide insights and recommendations for the Treasury's Hydrogen Production Tax Incentive consultation.

Hydrogen Production Tax Incentive Consultation Paper

Our response will address critical aspects of the HPTI's implementation, including emissions standards, grid integration, renewable energy requirements, and interactions with other support mechanisms. We will address several questions, drawing from our recent modelling studies on grid-connected hydrogen production, hydrogen certification and large-scale off-grid hydrogen project design and optimization. Our previous related public consultation submissions are also attached to the end of this document.

Q.7 Feedback on the proposed emissions intensity threshold of 0.6kg CO2-equivalent up to the production gate, Q.11 The requirement for grid-connected electrolyser projects to match hydrogen production with electricity generated by the same grid *and* Q.26 Specific interactions with other support programs that should be considered.

The proposed emissions intensity threshold of 0.6kg CO2e/kg H2 is a stringent target aimed at promoting low-emission hydrogen production. This benchmark, which measures direct Scope 1 and 2 emissions based on renewable Power Purchase Agreements (PPAs) and annual production matching, has already been met by several projects in Australia. Zero Carbon Hydrogen Australia has independently certified three such initiatives: the ActewAGL hydrogen refuelling station in Canberra, Yara's green ammonia plant in the Pilbara region, and Frontier Energy's Bristol Springs Green Hydrogen plant under development south of Perth in Western Australia.

However, it is important to examine the feasibility and practical implications of achieving this threshold with grid-connected hydrogen projects using more stringent hourly matching certification methodologies.

Our recent research investigates the implications of grid-connected hydrogen electrolysis in Australia's transitioning NEM electricity market. For this submission, we focus on contrasting case studies in Victoria and South Australia. These states were chosen for their differing levels of renewable energy penetration, allowing us to examine how time-varying grid prices and emission intensities impact the cost and carbon intensity of hydrogen production in diverse grid contexts.

We used our electricity system simulation and optimisation model (MURIEL [1, 2]) to explore grid-connected hydrogen production scenarios [3]. The study modelled four operational strategies to evaluate costs and emissions. These simulations were undertaken using hourly historical data and allowed us to evaluate wholesale and network costs, as well as carbon emissions.

1. **Baseline:** The baseline reference scenario involved running the electrolyser at a constant full load, ignoring price and emissions impacts.

2. **Tariff (least cost):** This scenario was optimized to minimize total electricity costs, including both wholesale and network costs.

3. **Spot (least cost):** Similar to the Tariff strategy, this scenario evaluated full costs, but the model focused on minimizing wholesale costs only (i.e., real-time market signal) to determine if optimizing wholesale costs (for the benefit of the grid) would result in the lowest overall costs.

4. **Mitigation (lowest emissions):** In this scenario, the model aimed to minimize carbon emissions, even if the resulting solutions were higher in cost.

The main conclusion of this study is that grid-connected hydrogen production faces significant challenges in contributing to decarbonization goals until Australia's regional grids are significantly decarbonized. This conclusion derives from modelled grid flows and are therefore based on a physical-flow analysis using an hourly time step. In contrast, Australia's proposed Tax Credit Incentive Scheme prescribes annual time matching, which requires only that sufficient renewable energy be procured over a year. As such, zero-emission claims depend solely on renewable energy procurement and not on physical flows.

Our modelling shows that an operational strategy based on minimizing emissions (Mitigation strategy) can only marginally reduce emissions from the baseline, given the current grid configuration and generation suite. Even in the best-case scenarios, the emissions intensity of hydrogen production remains substantial. For example, the South Australian (SA) Mitigation scenario resulted in a 18.5% reduction in CO_2 emissions compared to the Baseline. Despite the relatively high renewable energy penetration in SA, the resulting intensity of 7.38 kg CO_2/kg H_2 is still far above the proposed threshold of 0.6 kg CO_2e/kg H_2. The result for Victoria was much higher, with emissions of 40.9 kg CO_2/kg H_2 based on the Mitigation strategy.

These results align with our other recent research examining the role of certification schemes on the full life cycle carbon intensity of grid-based hydrogen production (see our online tool, H2LCA.org). Surprisingly, even the Tasmanian grid, which is dominated by hydro-power but which exchanges power with the mainland via Basslink, leads to relatively carbon-intensive hydrogen production. Although lower than the conventional hydrogen production route via steam methane reforming (SMR) of natural gas (9 to 12 kg CO_2/kg H_2), we found an emission intensity that is typically around half of this, depending on operational strategy.

Turning to costs, the introduction of a $2 per kilogram tax credit for hydrogen production would significantly improve the economics of grid-connected electrolysis. Based on our study's findings, in Victoria for 2021, the modelled cost was 6.66 AUD/kg H_2 under the Tariff (least cost) strategy. In South Australia, the equivalent modelled cost was 8.13 AUD/kg H_2. With the $2 tax credit, these costs would be reduced to 4.66 AUD/kg H_2 and 6.13 AUD/kg H_2 respectively.

Network costs constitute a substantial portion of electricity expenses, so addressing these costs could significantly enhance the economics of grid-connected hydrogen production. One example of a state-based policy targeting these costs is the New South Wales 90% concession for network use of system charges. Implementing a comparable policy in the Victorian and South Australian case studies – eliminating volumetric network charges, demand charges, and fixed charges while retaining environmental policy charges – would decrease hydrogen production costs by 1.47 AUD/kg and 2.17 AUD/kg, respectively.

In theory, combining both the federal tax credit and potential state-based network charge exemptions could lead to significant cost reductions:

- **In Victoria:** From 6.66 AUD/kg down to approximately 3.18 AUD/kg
- **In South Australia:** From 8.13 AUD/kg down to approximately 3.95 AUD/kg

While financial incentives could significantly improve the economic viability of grid-connected hydrogen production, they do not directly address the challenges of emissions intensity noted above. The environmental impact still depends on the grid emission intensity and the operational strategies employed by producers. These findings underscore the critical importance of continued and accelerated grid decarbonization efforts.

The tension between the need to produce low carbon hydrogen and the higher costs this entails is expected to diminish as the NEM (and SWIS) decarbonizes over the next 10 to 20 years. During this transition period, it is crucial to strike a balance between environmental goals and industry viability. This requires navigating a spectrum of considerations, including compliance costs and measurement uncertainty.

Off-grid, integrated hydrogen production facilities

Given the relatively high emission intensity of grid-connected hydrogen production, when measured using a physical flow approach, notwithstanding the sufficient procurement of renewable energy over the course of a year to meet the Guarantee of Origin standard, policymakers could consider targeted support for off-grid (or behind-the-meter) hydrogen production.

Off-grid (or behind-the-meter), integrated hydrogen production facilities offer several advantages:

- **Zero-emission electricity supply:** A direct physical connection between the generator and the hydrogen production facility ensures a zero direct emission electricity source. This ignores emission that are embodied in plant and equipment (upstream scope 3).

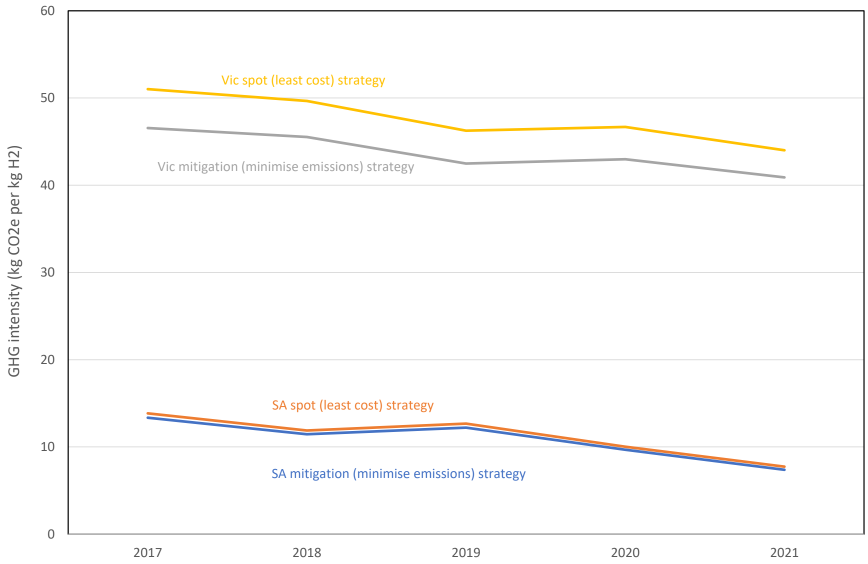

Figure 1: Modelled emission intensity of hydrogen production for Victoria and South Australia using historical price and emission data. This figure shows two operating strategies for each state - one using a least cost strategy and one using a least emissions strategy. The main finding is that the underlying emission intensity of the respective grids dominate, irrespective of the electrolyser operation strategy. For more detailed insights, refer to [3].

- **Simplified carbon accounting:** Avoids the complexities associated with assessing grid flows and related carbon accounting.
- **Increased bankability:** A single entity owning both the generator and the hydrogen production facility can sometimes enhance the project's financial attractiveness.
- **Operational cost savings:** Eliminates grid connection and network charges, which typically account for 30 to 40% of electricity costs.
- **Lower operational costs:** Reduced OPEX (operational costs) compared to grid-connected hydrogen production.

However, off-grid integrated facilities also face certain challenges:

- **Technical challenges:** Managing renewable energy variability requires effective storage or buffering solutions.
- **Higher CAPEX:** Increased CAPEX (capital expenditures) can present funding challenges.
- **Location constraints:** Site location is determined mainly by access to renewable resources and land availability, which may not align with typical industrial siting requirements, such as access to ports and infrastructure.

By addressing these challenges and leveraging the benefits, off-grid hydrogen production could become a viable and environmentally friendly alternative, supporting the overall goal of reducing emissions in the hydrogen production sector.

Given that off-grid facilities tend to have higher CAPEX and lower OPEX than equivalent grid-connect facilities, tax credits, which primarily benefit operational costs, may be less relevant for these projects. To effectively support low-emission hydrogen production, policymakers could consider:

- **Tailored tax incentives:** Design tax incentives targeted towards off-grid or behind-the-meter configurations.
- **Direct CAPEX support:** Implement or expand programs like Hydrogen Headstart that provide direct capital expenditure support.

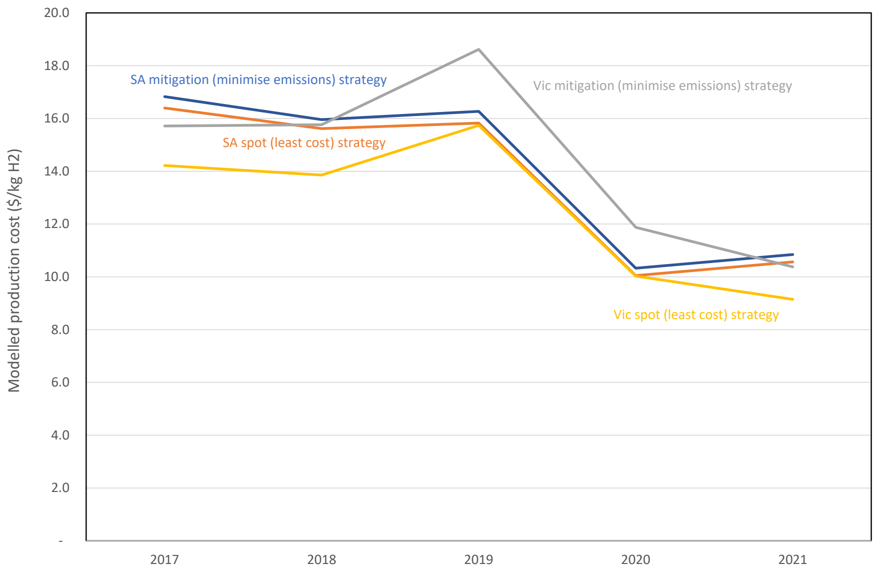

Figure 2: Modelled cost of hydrogen production for Victoria and South Australia using historical price and emission data. Includes wholesale market procurement, network charges, amortised electrolyser cost, and environmental policy costs. This figure shows two operating strategies for each state - one using a least cost strategy and one using a least emissions strategy. The main findings are that there is a relatively small cost premium for the least emissions strategy. Secondly, cost changes are driven by market-wide price dynamics in the NEM, rather than electrolyser operating strategy. For more detailed insights, refer to [3].

- **Loan guarantees and low-interest financing:** Offer loan guarantees or low-interest financing for high-CAPEX projects.
- **Incentives for co-located facilities:** Provide additional incentives for facilities that integrate renewable energy and hydrogen production, such as green ammonia and green iron production.

Conclusion

Our analysis of the proposed Hydrogen Production Tax Incentive reveals several key points. The emissions intensity threshold based on annual matching and renewable PPAs is achievable, with some projects in Australia already meeting this benchmark. However, our modelling shows that actual emissions from grid-connected production, when measured on an hourly physical flow basis, can be significantly higher than the proposed threshold, even under emission-minimizing strategies. The proposed tax credit would improve the economics of grid-connected hydrogen production, potentially reducing costs by a significant margin in different states.

The emissions intensity of grid-connected hydrogen production is primarily determined by the overall grid emissions, which highlighs the necessity for substantial grid decarbonisation to achieve truly low-emission hydrogen production from grid electricity.

Our analysis distinguishes between large-scale off-grid co-located projects and smaller-scale grid-connected projects. Off-grid configurations can more reliably achieve low emissions but face higher capital expenditure challenges, potentially benefiting more from capital-intensive support mechanisms. In contrast, smaller-scale grid-connected projects may require different types of incentives to encourage diverse industry participation and innovation.

The policy presents a trade-off between encouraging industry growth in the short term and ensuring real emissions reductions, with different implications for large off-grid and smaller grid-connected hydrogen production methods. As the grid decarbonizes over time, the relative advantages of different production strategies and scales will likely evolve, suggesting that policy considerations and incentives might need to be tailored for these varying project types and sizes to effectively support the development of a diverse and sustainable hydrogen industry.

References

[1] C. Wang, S. D. Walsh, T. Longden, G. Palmer, I. Lutalo, and R. Dargaville, "Optimising renewable generation configurations of off-grid green ammonia production systems considering Haber-Bosch flexibility," *Energy Conversion and Management*, vol. 280, p. 116790, mar 2023. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S019689042300136X

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[3] C. Wang, S. Hamilton, S. Walsh, and G. Palmer, "Optimising electrolysis operations under dynamic electricity tariffs: Implications for emissions and hydrogen certification," *Preprint available at SSRN 4673952*, 2023. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4673952

Related Monash Energy Institute (MuEI) Government Public Consultation Submissions

1. **Submission to Australia's National Hydrogen Strategy Review Consultation (2023)**
   - **Authors**: Wang, C., Walsh, S., Hughes, T., Hamilton, S., Palmer, G., Turner, L., Dargaville, R., Liebman, A.
   - **Link**: National Hydrogen Strategy Review Submission
2. **Submission to DCCEEW Guarantee of Origin (GO) Product Expansion & Prioritisation Survey Part I (2023)**
   - **Authors**: Wang, C., Walsh, S., Hamilton, S., Palmer, G., Dargaville, R.
   - **Link**: Ammonia Submission
3. **Submission to DCCEEW Guarantee of Origin (GO) Product Expansion & Prioritisation Survey Part II (2023)**
   - **Authors**: Wang, C., Walsh, S., Hamilton, S., Palmer, G., Dargaville, R.
   - **Link**: Iron/Steel Submission
4. **Submission to DCCEEW Carbon Leakage Review Consultation (2023)**
   - **Authors**: Wang, C., Palmer, G., Hamilton, S., Dargaville, R.
   - **Link**: Carbon Leakage Review Consultation Submission
5. **Submission to DISR's Green metals consultation Consultation (July 2024)**
   - **Authors**: Wang, C., Walsh, S., Wu, Y., Palmer, G., Hamilton, S., Wang, H. Dargaville, R.
   - **Link**: Upon request

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