Australian National University

HYDROGEN STRATEGY REVIEW CONSULTATION

Submission by ANU Hydrogen Fuels Project, part of the Zero Carbon Energy for the Asia Pacific research initiative.

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How can Australia enable decarbonisation through the development of a hydrogen industry?

1. *Is prioritising the decarbonisation of ammonia production the most prospective way to achieve both hydrogen industry growth and industrial decarbonisation in the short-term?*

Focusing on ammonia is a good strategy:

- it is a valuable commodity in its own right, and is already handled, stored and transported at scale.
- displacing fossil fuels in chemical production is seen as a high-priority hydrogen application as there are no other decarbonisation alternatives[1].
- analysis suggests that it is the lowest cost hydrogen vector for export[2].
- it provides a good transition pathway: there is the opportunity to decarbonise existing ammonia production capacity in Australia, as well as expanding capacity to meet demand for new applications.
- a decarbonised domestic ammonia industry could position Australian producers to supply export demand as it arises, recognising that there is still uncertainty in the competitiveness of Australian hydrogen, and its derivatives, as discussed further below.

2. *What other actions in the other sectors, will have the greatest decarbonisation impacts?*
3. *What sectors are best placed to be early adopters of hydrogen?*

i) A focus on decarbonising existing export industries, and enabling new ones, would likely bring the biggest emissions reduction benefit.

Given that the present technologies for hydrogen storage and transport are either commercially immature, expensive or both, there is a key question around whether the focus should be on production of hydrogen and for export, or instead on end use applications (green iron/steel, ammonia, chemical feedstocks etc.) that are co-located with the hydrogen production site and therefore need no/minimal storage or transport. This will significantly influence the type and location of hydrogen infrastructure development, which may or may not coincide with existing commodity export terminals as a result. There is an evolving realisation that the technological/economic issues faced by storage and transport is shifting the emphasis towards co-location of hydrogen production with end use.

In addition, there is significant uncertainty in future hydrogen applications, and the applications that are competitive will likely vary globally: what makes sense domestically for Australia will not necessarily work elsewhere, and vice versa. While hydrogen can be used in a variety of ways, not all applications will be competitive with other decarbonisation options. The key issue is the significant energy efficiency penalty for converting renewable electricity to hydrogen in a storable form: a half to two thirds of the energy will be lost during the process (~30% during electrolysis[3], 20-40% on conversion to derivative or storable form[4]). A recent analysis estimated that e-fuels require twice as much electricity to provide high temperature heat than directly using electricity.[5] This means that in Australia, where there is abundant potential for renewable electricity, electrification will be much cheaper and will be the preferred option where possible. Notably, Germany's recently updated National Hydrogen Strategy states that using renewable energy directly is preferable and "should be used where possible if it is the most economical option in terms of overall system efficiency and security of supply, as well as from an economic and environmental perspective," (https://www.cleanenergywire.org/factsheets/germanys-national-hydrogen-strategy).

It is worth highlighting that there is also a growing global consensus that natural gas for heating and cooking in homes should be replaced with all-electric appliances rather than using hydrogen or other renewable gases. Analysis have repeatedly found the electrifying energy use in houses is the cheapest option, with the largest emissions reduction potential, and is better for health[6, 7].

Instead, there is an opportunity for Australia to use its renewable resources to develop new energy intensive export industries focused on value-added commodities. This would include the on-shore processing of metal ores, the production of zero carbon chemicals, and provision of synthetic aviation and bunkering fuels. There is growing consensus globally that these are priority hydrogen applications[1]. In addition, Australia has the potential to be a provider of critical minerals needed for the energy transition[8], which could drive demand for hydrogen for the mining sector.

In particular, transitioning from iron ore export to green pig iron or hot briquetted iron exports would greatly reduce emissions associated with Australia's metal industry. Even a partial solution in this sector can far exceed the impact of addressing Australia's domestic emissions. Eventually, steel will be produced with hydrogen, unless very major advances are made in the challenging area of direct electrolytic ironmaking. Australia has the iron ore and can produce the hydrogen for reduction.

Our analysis has shown that the use and processing of Australia's current energy exports results in 3.7 times more emissions than Australia's domestic emissions, accounting for 5% of the total global greenhouse gas emissions[9]. This implies that Australia has the potential to contribute to regional decarbonization by suppling zero-carbon commodities to our trading partners, primarily in the Asia Pacific.

ii) <u>Integrating hydrogen-based export industries into the domestic electricity grids could support Australia's transition to net-zero by 2050.</u>

Grid-connected hydrogen production could play a role in reducing the cost of providing secure, reliable and zero-emission electricity supply in Australia. Electrolysers can provide highly flexible loads in response to real-time energy balance requirements in the domestic electricity grids. Therefore, integrating hydrogen-based export industries into the domestic electricity grids could provide low-cost, large-scale demand flexibility on timescales ranging from seconds to seasons. Instead of storing electricity, hydrogen can be stored locally in pipes, tanks or underground lined rock or salt caverns to provide a constant input to industrial processes, providing a buffer against variations in renewable energy supply.

Industrial hydrogen storage refers to the storage of hydrogen for hydrogen-based industries, including green ammonia production (hydrogen as a feedstock), green steelmaking (hydrogen as a reducing agent) and the manufacture of carbon-neutral transport fuels (e.g. hydrogen, synthetic fuels). Industrial hydrogen storage is distinct from the storage of hydrogen for power generation. The stored hydrogen in the hydrogen-based industries is utilised for industrial processes, rather than converted back into electricity. Storing hydrogen on an industrial scale requires a relatively low energy input, roughly 10% of the energy embedded in the hydrogen (assuming hydrogen compression requires 2.88 kWh/kg of H_2). Stationary hydrogen storage costs are not yet well understood but are likely to be relatively low. Estimates in the literature include $5/kWh for hydrogen in a salt cavern salt

cavern to $50/kWh for hydrogen in a storage tank[10, 11]. Consequently, coupling hydrogen storage with electrolysers in the hydrogen-based export industries could provide significant demand flexibility and is well positioned for large-scale stationery energy time-shifting. CSIRO's Renewable Energy Storage Roadmap estimated that the technical potential for hydrogen storage is 2165 GWh, far exceeding Australia's energy storage requirement of 950 GWh for balancing zero-carbon electricity grids.

4. *Are there specific barriers that may limit hydrogen uptake in each of these sectors?*

i) <u>The level of future demand for Australian hydrogen exports is uncertain.</u>
While there are many projections of future global hydrogen demand, most rely on top-down approaches to estimating hydrogen usage, and do not take into account the full technoeconomic, social and geopolitical complexities of the energy transition. More detailed analysis requires understanding competition between other decarbonisation technologies in different regions (mostly electrification and energy efficiency measures), as well as the aspirations that countries hold to become more energy independent. Unlike fossil fuel reserves, most countries have access to renewable resources, and it is possible that we could see countries moves to develop their own energy resources in the future. Notably, Germany's recently updated National Hydrogen Strategy doubles the domestic hydrogen production capacity in a bid to reduce reliance on exports (https://www.cleanenergywire.org/factsheets/germanys-national-hydrogen-strategy).

At the same time many countries are positioning themselves to be hydrogen exporters and Australia will face competition as preferred supplier. Recent analysis by CSIRO ranked the cost of industrial renewable electricity as a proxy for competitiveness[12] and found Australia ranked between 3-5th behind China, India and Western Europe. A German analysis found local production costs of gaseous green hydrogen are particularly low in Australia and Brazil as compared to competitors, and that 'transport costs could be decisive' but not a 'knock-out criterion'[13]. However, given the uncertainty and difficulty around the cost of transporting hydrogen and derivatives by ship it is likely that countries that can supply consumers via pipelines will have an advantage[14]. This implies that it would be beneficial to diversify Australia's exports by developing industries producing value-added commodities on-shore (as indicated in response to Q2 above, in section i).

ii) <u>Delays in upgrading electricity transmission infrastructure and lack of incentives will hamper investment in grid-connected hydrogen for grid balancing.</u>
Delays in priority transmission projects is a key barrier hampering investment and deployment of large-scale renewable energy projects. (https://www.energy.gov.au/government-priorities/energy-supply/delivering-priority-transmission-projects). Such delays will impact the deployment of grid connected hydrogen production, as well as driving up the cost of electricity. Grid-connected hydrogen projects may offer the potential for cheaper hydrogen, and enable electrolysers to provide low-cost grid balancing services (as discussed above).

At the same time, energy market reforms will need to incentivise operating electrolysers to provide flexible demand/load shifting for the grid(https://esb-post2025-market-design.aemc.gov.au/). The cost of hydrogen is strongly influenced by the capacity factor at which the electrolyser is run. Grid connected electrolysers could offer higher capacity factors and lower costs[15]. For this reason, it is important to consider the integration of hydrogen

production with the wider energy system in Australia when making decisions about future market operation and regulation.

5. *What are the actions required to overcome those barriers and realise the opportunities? For instance, what supply chain risks need to be addressed and overcome?*

i) Supporting industry-led research collaborations to identify and mitigating risks

Cooperative research centres could play an important role in de-risking the uptake of hydrogen and derivatives in these critical areas. The HILT CRC is already actively working to develop technologies for industrial decarbonisation with key industry player. Similarly, the Scaling Green Hydrogen CRC proposal in the current CRC round brings together key stakeholder in the emerging hydrogen industry, including incumbent energy providers, chemical producers, and heavy transport industries to collaboratively solve the cross-sector challenges facing industries aiming to adopt hydrogen and derivatives in Australia, including the provision of water, infrastructure, and integration with the broader energy sector. Such industry led research cooperatives represent a cost-effective way to support innovation in industrial decarbonization.

ii) First Nations led development and industry partnerships

As with all infrastructure developments in Australia, project proposals need to be informed by and engage First Nations peoples' rights and interests. In addition to this, DCCEEW has responsibility to encourage industry partnerships with First Nations groups and their institutions in these industry developments. This is pertinent to the Commonwealth Government's commitment to the United Nations Declaration on the Rights of Indigenous Peoples, principally the right for informed consent to any activity occurring on First Nations lands. It also aligns to the Commonwealth Government's commitment to the National Agreement on Closing the Gap.

Hydrogen production and distribution infrastructure, at different scales, will very likely be built on First Nations lands and waters (under native title or land rights legislation). Both these scenarios provide opportunity for First Nations people to provide skilled construction labour through established First Nations supply chains (i.e. Carey Group Holdings based in Perth is a 100% owned First Nations company: https://careygroupholdings.com.au/) and leverage existing infrastructure assets (refer to the East Kimberley Clean Energy Project below).

The success of government procurement policy regarding First Nations employment is evident. DCCEEW has opportunity to build on and strengthen this policy to include First Nations supply chains. Engaging First Nations supply chains will support joint ventures, partnerships, contracting, employment, business development and First Nations leadership in business development.

Additionally, building in social vectors, beyond accounting for emissions and economic gains, is essential to ensure best practice and take account of lessons from past practices in extractive industries. DCCEEW has opportunity to incorporate vectors that measure environmental, social, cultural and well-being benefits of communities to showcase the overall benefits the hydrogen industry is contributing to the region. Drawing on the Carey Group example, this company is using PowerBI to report ESG outcomes to guarantee its industry social licence to operate and sustainability practices. DCCEEW could account for

these measures in both the National Closing the Gap report and DCCEEW's State of the Environment Report.

How could Australia further activate its hydrogen and related industries?

6. *Should Australian governments adopt a more sector driven approach to hydrogen industry development?*

Drive demand for low emissions fuels and feedstock in Australian export-oriented industries. Domestic demand for hydrogen in export focused industries like mining, chemicals, and metals processing, could help drive the emergence of an Australian hydrogen industry. Domestic emissions reduction schemes could be targeted at building demand for low carbon alternatives to chemicals and feedstocks in industry processes, encouraging investment in renewable energy and low emissions hydrogen capacity in the short-term. Key to this would be including the embedded emissions in feedstock – i.e. upstream scope 3 emissions-reporting requirement for aluminium, cement, ammonia and other chemicals. This would mean that industry is incentivised to not only switch from fossil fuels to hydrogen to provide high temperature heat, for example, but also to ensure that the hydrogen itself has a low emissions intensity. Such Green Industrial Policy should take a holistic approach to include all forms of decarbonisation and not be centred on hydrogen alone.

Note that we do not recommend distortive policies to encourage hydrogen use by end consumers. The evidence shows that electrification is a more efficient approach to household decarbonization. In addition, Australia's population is relatively small, hence consumer demand is not going to give us the economies of scale we need to compete with large population centres in the US and Europe. In contrast, hydrogen use in export-oriented industries (as recommended above) can be efficient and has the potential to achieve globally competitive economies of scale.

Targets and mandates

7. *Should Australian governments adopt national hydrogen production and/or use targets for hydrogen?*

A combination of incentives and targets are adopted by many countries as policy tools to support hydrogen deployment. This was also recommended by the IEA. However, practices for the target setting vary from country to country in terms of the scope for hydrogen targets (whether for renewable hydrogen, or for clean hydrogen, or incorporating renewable hydrogen as a component for overall renewable energy targets), the levels hydrogen targets are set (whether at the national or state level). The principle of additionality also needs to be taken into consideration when designing the targets.

However, targets are not necessarily a priority for Green Industrial Policy. The correct target can be hard to predict, and if wrong, highly distortive. It is also unclear exactly what market failure targets would be addressing this case. According to OECD Best Practice Policy, it is important to clearly identify what market failure/s is/are being addressed, and to target interventions as directly as possible at addressing those failures. For example, information failures/asymmetry can limit growth in both output and finance markets as customers/investors cannot be sure of the emissions benefits of the product/project. To

address this market failure, the Australian Government's Guarantee of Origin efforts are to be applauded. Similarly, credit constraints can limit new industry expansion due to risk aversion and imperfect information on behalf of investors. ARENA, CEFC and Hydrogen HeadStart funding are well-targeted responses to address this market failure.

In terms of market failures, a target could be seen as a means of providing information to the market about the intended size of the industry in Australia, allowing investors to estimate the external economies of scale that would be associated with that size. While this is a defensible targeting of market failure, it depends on how credible markets view the signal to be. Well-designed interventions to address other market failures may well instil greater investor confidence than a target that is viewed as either unrealistic or too lacking ambition.

8. *If targets are adopted, what type of activities and/or sectors should this target be tailored towards? For example, production targets, demand targets for sectors such as transport, renewable gas target. Please describe how such targets would attract investment.*

9. *Should Australian governments use regulatory mandates to drive demand for hydrogen? If mandates were adopted, what type of activities and/or sectors could mandates be directed towards? Please describe how such mandates would attract investment.*

As per point 5 above, Australian Governments should definitely not use regulatory mandates to drive demand for hydrogen use by end consumers (households, passenger cars, etc). The economies of scale necessary for us to become competitive depend entirely on the share of the global market that Australia can capture. Our domestic end-consumer demand for on-shore hydrogen use is too small. The correct policy for large economies like the US and EU is not always the best answer for smaller economies.

However, regulation may be a worthwhile intervention in export-oriented industries where internationally competitive scale economies can be achieved. However, hydrogen issues in these industries may be best dealt with as part of the development of Green Industrial Policy for those industries, not as part of a hydrogen strategy. It is important that hydrogen mandates do not slow down or make more expensive the decarbonization of these industries.

Addressing Supply Chain Risks

10. *What are the most significant supply chain barriers being faced by Australia's hydrogen industry? Where should Australian governments focus efforts on securing elements of supply chains needed to enable the accelerated growth of the hydrogen sector?*

Recent analysis has highlighted that the high investment cost of capital for hydrogen production, storage and transport; lack of availability of electrolysers; and policy and regulation development were the most important supply chain risks, as ranked by 20 experts[16]. A probabilistic feasibility study of global demand for electrolysers found that 'even if electrolysis capacity grows as fast as wind and solar power have done, green hydrogen supply will remain scarce in the short term and uncertain in the long term'[5].

11. *Should Australia develop and support local manufacturing capabilities to secure the hydrogen supply chain? What are the specific areas of opportunity (e.g. fuel cell or electrolyser manufacturing or hydrogen transportation related manufacturing)?*

12. *What are the barriers to developing and supporting local manufacturing capabilities?*

13. *What is the role of industry and governments to ensure the hydrogen industry has access to an appropriately sized and skilled workforce?*

14. *In addition to electrolysers, where do you see a role for domestic hydrogen related manufacturing to address supply chain risks and ensure Australia meets its decarbonisation targets such as hydrogen buses/heavy vehicles?*

How can we ensure our hydrogen industry attracts the necessary investment?

15. *What in addition to the commercial cost gap is preventing Australian hydrogen projects progressing beyond a financial investment decision?*

16. *What signals are effective overseas and can apply to unlock greater investment?*

17. *Are there any other measures needed to unlock investment in the development of the Australian hydrogen industry including from international and Australian institutional investors?*

Hydrogen is one promising area that can attract institutional investors such as pension funds or sovereign funds as part of their portfolios of "sustainable investment" "climate investment "or "green investment". However, there are certain work to be done for hydrogen to fulfil the green and sustainable standards. In Australia, the Australian Sustainable Finance have already started to develop technical screening criteria for sustainable finance taxonomy. While a sustainable finance screening criteria for hydrogen at the national level is desirable, it is not enough. To attract international investors for hydrogen, possibility for interoperability needs to be embedded in Australian substantial finance taxonomy in its inception. A related issue is information disclosure. Investors, to verify their green investment, may request comprehensive information on environmental (and social) impact. Regulatory framework and standards such guidelines for hydrogen specific information disclosure needs to be developed.

18. *When would it be appropriate to take a 'tech neutral' approach to developing hydrogen, and when would a more directed approach be warranted?*

There are reasons to preferentially drive investment in renewable or green hydrogen production over fossil-fuel based blue hydrogen. Firstly, as hydrogen production methods have substantially different emissions intensities, decisions about which technologies to deploy at scale will have a significant influence on GHG emissions over the next three critical decades[17]. Producing low-emission fossil-fuel based hydrogen and derivatives will increase emissions in Australia, potentially by significant amounts, depending on the technologies used and the processing emissions associated with the fossil fuel feedstock[18]. Secondly, cost projections suggest that there could be a narrow window of opportunity for blue hydrogen before green hydrogen becomes cost competitive[19, 20] Our recent analysis shows that blue hydrogen assets deployed within the next three decades are likely to be

significantly underutilised, unless the cost of green hydrogen remains at the high end of projections. These findings imply that there is a substantial risk that investments in blue hydrogen will lead to stranded assets, which could occur without high-quality information and clear policies. They also suggest that the "least regrets" pathway for hydrogen investment and policy incentives is to focus on driving rapid and deep cost reductions for green hydrogen technologies, while also building up manufacturing capability and supply chains[1]

19. *What further regulatory work is required as we accelerate the development of the hydrogen industry? What barriers do you currently see?*

i) New electricity market reforms and regulations should include provision and incentives for grid connected electrolysers to act as flexible demand and provide grid balancing services.

ii) The Guarantee of Origin Scheme for the certification of hydrogen and low-carbon commodities needs to take into account the true embedded emissions of grid-connected electrolysers and other grid-provided electricity use. The concept of 'additionality' is useful here: unless hydrogen is powered exclusively by behind the meter renewable electricity, diverting other renewable electricity resources on the grid to generating hydrogen could increase overall grid emissions. If the renewable electricity that is nominally used to power electrolysers (purchased by PPA or LGC) is not generated at the time of hydrogen production, and/or cannot feasibly reach the electrolyser due to grid congestion, and/or comes from renewable generation that was not constructed additional to existing capacity on the grid, then there is a risk that the additional demand on the grid from running electrolysers would increase emissions intensity of the grid. For example, if electrolysers are run at periods of low renewables generation, additional natural gas generation will need to be brought online to balance supply and demand on the grid while the electrolyser was running. An electricity guarantee of origin alone, like a PPA or an LGC, does not provide any insights on the degree to which this displacement of renewable electricity use may occur in grids, and as such will not provide sufficient information for accounting of true embedded emissions in a kilogram of hydrogen from electrolysis fed by the grid. The new REGOs being developed by DCCEEW can support this as they require records of the hour within which generation occurs, but the LGCs currently in use do not have the necessary level of timescale resolution.

iii) Proposed regulatory changes should ensure respect for and give preference or 'first option' to First Nations landholders.
Nationwide there are currently a number of legal and regulatory changes in various stages of planning and implementation, aimed at facilitating the states' economic diversification and activation to enable net zero by 2050. Examples include the *Land and Public Works Legislation Amendment Bill 2022* (WA) which introduces the potential for diversification leases on Crown land under the *Land Administration Act 1997* (WA) in Western Australia; the *Electricity Infrastructure Investment Act 2020* (NSW) in New South Wales; the *Hydrogen and Renewable Energy Act* (SA) in South Australia, (among others). These changes introduce risks of social-economic, cultural and environmental impacts as well as potentially presenting opportunities for relevant native title holders to participate more effectively in the transition to a clean energy economy. The Department has a crucial role to

[1] Fazeli, Longden, and Beck, *Dynamics of price-based competition between Blue and Green hydrogen with net zero emissions targets*, under review. A draft copy can be provided on request to fiona.beck@anu.edu.au

play in ensuring the cumulative impacts of these changes legislate for the fair distribution of risk and gain. With appropriate partners, DCCEEW could proactively undertake cross-jurisdictional comparative analyses of the extent to which these changes adequately resource, ensure respect for and give preference or 'first option' to First Nations landholders with respect to obtaining tenure under relevant changes (provided they meet baseline criteria). This could be done for the purpose of informing both the Department and First Nations landholders.

iv) There needs to be regulation alignment with—environment protections (i.e. the Environmental Protection and Biodiversity Conservation Act) such as through environmental impact assessments, provisions of the Native Title Act and other land rights, state and territory governments regulations under respective water acts with respect to water access, and heritage protections laws relevant to cultural heritage protection.

How can we ensure our hydrogen industry develops in a way that benefits all Australians?

20. *What actions do you view as being critical to build and maintain community support for Australia's developing hydrogen industry?*

ii) Proactively addressing community concerns early in order to gain (and maintain) a social licence to operate.

Delays in the deployment of critical grid infrastructure have been driven by community opposition, including a challenge before the Supreme Court. (https://www.afr.com/policy/energy-and-climate/they-will-fight-to-the-death-farmers-revolt-at-victorian-power-plan-20230713-p5do1k). AMEC has recently responded by updating its rules for community engagement to ensure that consultation occurs sooner, and engagement is continued throughout the project. (https://reneweconomy.com.au/aemc-sets-new-rules-of-engagement-for-community-consultation-on-transmission-projects/)

The Federal government has an important role to play in proactively ensuring that social license issues for large scale renewable energy, hydrogen, and zero-carbon commodity projects are front and centre in planning processes. Key to this is being able to articulate the relative benefits and costs for local communities and Australia broadly, particularly if public money is to be invested. The newly announced Net Zero Authority is an excellent vehicle for such an activity. A recent article by ANU's Dr Bec Colvin highlights the need for the Net Zero Authority to commit to understanding and respecting community concerns, particularly in communities most effected by the energy transition[21].

Tying government incentives for industry scale-up to the provision of local benefits for communities will also be important to secure social license to operate for the industry in question. This is particularly crucial in the context of the energy transition, which will involve large disruptions to those working in fossil-fuel based industries. Local benefits in this context include 1) benefits to local businesses (inclusion of regional contractors and labour force), 2) developing relevant training programs for local workers, 3) stimulating productive research partnerships, 4) growing business footprints to bring income to local communities, and 5) building local capacity to make informed investments and decisions regarding renewable energy development. This flexible range of options including training programs is in line with best practice for delivering local benefits.

First Nations people are in a unique position to participate in the governance and development of the hydrogen industry nationally, inclusive of international markets. The proposed development of a large-scale green hydrogen industry in Australia will occur on land belonging to First Nations' peoples. First Nations' communities hold legal interests to greater than 57% of Australia's land mass under various Commonwealth legislation[22]. The emergence of a large-scale green hydrogen industry presents both opportunities and challenges for First Nations' people, their organisations and businesses, with respect to recognizing their legal rights and interests in these significant projects and based on past experiences, including with extractive industries[23, 24]. As identified in Canada's 2020 Hydrogen Strategy, to secure benefits from the unique position of First Nations communities and businesses, will require ongoing engagement of First Nations to plan, track progress and identify emerging opportunities[25].

Early and meaningful engagement with First Nations people and their organisations on all aspects of hydrogen production, distribution and deployment will be essential, as described above. First Nations communities and businesses are already identifying hydrogen as a new opportunity for economic development, with environmental, social and cultural benefits. For example, the East Kimberley Clean Energy project will be the first 100% green energy, hydrogen, and ammonia export project in Australia to date (https://aboriginalcleanenergy.com/). It has been designed to utilise the existing infrastructure in the region, including electricity transmission lines, roads, airport and the Port of Wyndham. This project has created an opportunity for Traditional Owner groups to co-develop, co-decide and self-determine how the development and operation will work on their Country. This partnership model places First Nations as shareholders, not just stakeholders.

The project involves a 2,000-hectare solar farm developed on MG Corporation freehold land near Kununurra. The resulting solar energy (approximately 1,000 megawatts) will be combined with water and hydro energy from the existing Ord Hydro Power Plant at Lake Argyle to produce green hydrogen. The green hydrogen will be transported by pipeline to Balanggarra Country in Wyndham where it will be converted to green ammonia. The green ammonia will be sold locally as a fertiliser for irrigated agriculture and exported to support the decarbonisation of food production and fertilisers. This partnership model could be viewed as relevant to similar hydrogen industry developments in other parts of Australia. By leveraging existing commercial facilities owned and operated by First Nations businesses, this could foreseeably lead to new hydrogen opportunities elsewhere.

Collaborative, strategic partnerships are essential for growing the production and use of hydrogen across Australia. Partnerships that emphasise environmental protection, cultural recognition, community energy planning aligned with cultural values, economic development, and project participation, will be essential to maximize benefits for First Nations peoples in the hydrogen economy. A holistic approach to understanding the potential role of hydrogen as part of broader energy pathways, in support of national reconciliation, will be critical going forward.

The scale of First Nations clean energy leadership and ownership has the capability to grow over the short and long-term. This is inclusive of scoping the potential and interest for the hydrogen industry in remote and regional areas where economic opportunities are limited for First Nations communities. Jordan et al's (2020) identifies 1,200 small, discrete

Indigenous communities in regional and remote Australia with a total population of around 120,000 or 30% of the total estimated Indigenous population[26]. The report, which was commissioned by the Organisation for Economic Co-operation and Development (OECD) identifies that First Nations participation and business development are critical to self-determination and unlocking the potential of regional economies. Accordingly, policies should be informed using bottom-up approaches that enable First Nations to design and implement local solutions based on local capacity, needs and interests.

As well as participating in the national economy, First Nations people will also be seeking renewable energy solutions for their remote and regional communities. Similar to the Canadian experience, First Nations communities in Australia, particularly in remote parts of Northern Australia are not connected to integrated electrical or natural gas grids. They instead rely on costly and GHG emitting diesel generated electricity. Diesel is either transported long distances by road or shipped in on a barge. Diesel could be displaced with either imported or locally produced hydrogen. As described in the Canadian Hydrogen Strategy, hydrogen could be supplied using a microgrid system, either centralized, or distributed with cogeneration of heat and power. Renewable energy sources could be incorporated to produce hydrogen using electrolysis, reducing reliance on imported fuel.

The current activities of DCCEEW in developing the First Nations Clean Energy Strategy (Strategy) provides an integral foundation from which to inform First Nations engagement in developing the hydrogen industry. The Australian Government's investment of $5.5 million to develop the First Nations Clean Energy Strategy is a positive and key commitment under the Commonwealth's National Energy Transformation Partnership. This commitment is to both engage First Nations communities and their organisations in energy policy to transition Australia's energy to net-zero and to identify priority reforms and areas for future investment. This foundational work should be viewed as informing the development of the hydrogen industry.

Importantly, development of the Strategy is informed through the First Nations Clean Energy and Emissions Reduction Advisory Committee that provides guidance to DCCEEW on a range of clean energy and emissions reductions measures as they relate to First Nations rights and interests. The ongoing role of a First Nations Committee is viewed as necessary to provide ongoing leadership and to assist the Department in ensuring the Strategy is appropriately governed and implemented going forward. This could include advice on mechanisms for First Nations to participate at state and territory jurisdiction levels so that First Nations interests are being engaged at all levels of government.

As well as governments supporting mechanisms for First Nations participation in policy decisions at all levels of government, the development of regional strategies could be considered to support broad ranging stakeholder interests to generate strategic partnerships with multiple benefits, such as for the East Kimberley Clean Energy Project mentioned above. Better provision of ESGs in hydrogen industry development could also improve government accountability in developing large scale industries with respect to measuring benefits beyond decarbonisation and economic values to better consider social, cultural, environmental and health and well-being benefits to the region. As described earlier, measuring a broader range of benefits from hydrogen industry could be reported against national Agreements such as Closing the Gap and international agreements, such as

the United Nations Sustainable Development Goals and the Declaration on the Rights of Indigenous People.

Essential, with respect to providing agency to First Nations economic empowerment will be place-based approaches within regional frameworks for First Nations to self-determine innovative solutions based on local needs and interests. As summarised on the OECD webpage, activating a development process at the local level requires addressing multiple factors (human capital, infrastructure, innovative capacity) in an integrated way, aligned with local circumstances and cultures. As such, a place-based approach requires a long-term commitment by government and industry to draw from existing First Nation Supply Chains and strengthen First Nations capacities to promote economic development at the local level. This is inclusive of appropriate resourcing and through strong, meaningful agreements.

As identified in the DCCEEW's discussion paper, critical to First Nations participation will be raising awareness about the hydrogen industry, its benefits and how they can engage the technology in their community. This needs to be done in a participatory way that informs First Nations people's decision making. A First Nations Hydrogen Strategy could be developed to building on the work of the First Nations Clean Energy Strategy and complement a renewed National Hydrogen Strategy. A First Nations Hydrogen strategy could identify key principles and policy to guide state and territory Governments' engagement with First Nation communities and their organisations using regional and local approaches. The strategy should also identify policy to implement best practice, including funding to support First Nations people and their organisation to meaningfully participate in development decision making, community planning and engage in strategic partnerships. The strategy could also identify appropriate funding for First Nations institutions to participate in energy governance and to consult with their communities. They also need access to information to inform decision making processes, such as engaging expertise to undertake cost and benefit analysis to develop hydrogen, undertake planning and impact assessments, inform public policy and seek legal advice with regard to regulatory requirements on Aboriginal land and to engage in land use agreements. DCCEEW could consider a key program of funding to support place-based hydrogen business development using best practice engagement with First Nations communities and measure indicators of success and broad ranging benefits.

21. *How should the interests of the emerging hydrogen industry with respect to water security be balanced with other users?*

Water requirements for large-scale hydrogen production will be large. For example, a 50 MW electrolyser operating at 60% capacity factor will require around 700 ML per year (based on a requirement of 60 L/kgH2, including operational requirements, taken from GHD analysis of water requirements for hydrogen production by electrolysis, including cooling systems https://www.ghd.com/en/perspectives/water-for-hydrogen.aspx). Large-scale industry should not be reliant on natural water resources extracted from inland waters or ground water systems as this will put additional strain on communities and fragile ecosystems. Instead, desalination will be needed for large scale hydrogen-based export industries, and will add a small component to the energy cost of hydrogen production[9].

The hydrogen industry should support sustainable practices, that have negligible or no impact to the environment and its biodiversity and align to requirements under the EPBC Act, including the protection of Aboriginal cultural heritage, sacred sites and areas of

significance. Hence the need to consult early with First Nations groups. Should water be extracted from inland water sources (not preferable and could be avoided if reliant on desalination processes), hydrogen industries should account for water use the same as other water users, i.e., hydrogen business should not be exempt from applying for a water licence or permit and adhere to the same regulatory requirements as other water users apply. The Commonwealth government should require State and Territory Governments amend respective water acts and regulations for the hydrogen industry to apply for water access entitlements and meet regulatory requirements so that water extraction is accounted for, impacts are monitored and measured, environmental and heritage assessments are undertaken so that the industry does not impact the environment or the rights and interest of First Nations people. Clear definition and criteria of 'Green' and 'Clean' energy is needed to set industry standards in line with social and environmental licence. How industry are meeting these standards needs to be quantifiable and measured to mitigate negative impacts.

22. *How else can Australian governments ensure that First Nations communities are resourced to effectively participate, benefit and be empowered by the development of the hydrogen industry?*

The opportunities and challenges that the emerging hydrogen industry pose for First Nations groups and their organisations and the community more broadly should be considered holistically, as part of the broader renewable energy transition that is occurring in Australia. Under the Commonwealth's National Energy Transformation Partnership the Australian Government has committed $5.5 million to develop the First Nations Clean Energy Strategy together with the First Nations Clean Energy Network and the National Indigenous Australians Agency (https://www.fnces.org.au/). The strategy development will involve roundtables and consultations with First Nations communities and their institutions, led by the First Nations Clean Energy Network. While there will likely be important considerations for projects that generate hydrogen, its derivatives, and value-added commodities (discussed briefly below) it would be most effective to do so after the First Nations Clean Energy Strategy has been released.

Federal intergovernmental approaches are already being used to secure First Nations peoples self-determination through economic empowerment. For example, the National Indigenous Australians Agency (NIAA) and DCCEEW are working in partnership to improve First Nations peoples access to inland waters with respect to meeting Target 87 b of the Closing the Gap. As such, the Albanese Government, through these two portfolios have allocated funding to deliver water ownership for First Nations for their social, cultural and economic benefit. (https://minister.dcceew.gov.au/plibersek/media-releases/delivering-water-ownership-first-nations)

A similar arrangement between NIAA and DCCEEW in relation to the emerging Hydrogen industry could both support First Nations economic participation at the same time as ensuring the industry is socially and sustainably developed without negatively impacting the environment, First Nations cultural and heritage values and the interests of the broader community.

23. *Is there more information that First Australians would like to receive about the renewable energy and hydrogen sector? What information should be provided?*

First Nations' communities and their Institutions would benefit from a body that could develop and disseminate high-level information to ensure FPIC when engaging with large-scale hydrogen industry proponents. This could include:

- Helping to develop a baseline understanding of green hydrogen for Indigenous Australians.
- identifying opportunities to engage and/or receive benefit for First Nations' communities and people at each point in hydrogen value chain, not just production,
- developing an outcomes-based understanding of advantages and disadvantages of different models of engagement,
- understanding the risk profile of the industry in general, and
- First Nations undertaking risk assessments of any industry impact on their social, cultural and environmental value systems and the ongoing measuring and monitoring of benefits from the project.
- provide a space for traditional owners to employ their knowledge for the ethical development of a large-scale hydrogen industry.
- Undertaking planning, identify values to measure benefits from industry development.

There is room to think creatively about what engagement could look like within industry as well as communities. Government should enable development of new ways to engage by supporting the development of research capacity in this space. Transformative approaches to benefit sharing should have an emphasis on traditional owners taking on their own risks. First Nations' groups should be thought of as business/equity partners and innovators, with a range of expertise in bio-cultural issues and cultural heritage. This includes developing an understanding between communities and industry of possible engagement models for benefits sharing and agreement making.

24. *What regulatory barriers will become more prominent as we accelerate the development of the hydrogen industry?*

25. *How can Government/s ensure that the early strong investment in sector transitions to government revenue as the sector matures?*

Government could co-invest in projects. This simultaneously helps to lower risk and overcome credit constraints for first-movers, while ensuring all Australians benefit from the successes.

How should we develop the necessary infrastructure needed to support the development of our hydrogen industry?

26. *How can the next infrastructure assessment be delivered to maximise the value to governments and industry?*

27. *How can Australian governments ensure the efficient use of existing infrastructure, and delivery of new infrastructure, including common user infrastructure?*

28. *How should the infrastructure needs of the hydrogen industry be balanced with other infrastructure users including electricity generators?*

Increased load on the NEM

The manufacture of synthetic aviation fuels will add significant electric load to the National Electricity Market, the impact of which needs to be factored in the future AEMO Integrated System Plans. Directly electrifying air transport is difficult due to the low volumetric energy densities of lithium-ion batteries and hydrogen, which are only about 1/20 and 1/4 of that of conventional aviation fuels, respectively. Application of drop-in electrofuels is a promising way to indirectly electrify air transport. Electrofuels are produced via fuel synthesis, where carbon is sourced from direct air capture and hydrogen is produced through water electrolysis powered by renewable energy. As the technologies advance, an electrolysis efficiency of 70%, a direct air capture efficiency of 2 kWh/kg CO2 and a fuel synthesis efficiency of 1.4 kWh H2 and 0.28 kg CO2/kWh fuel are expected in the near future. Based on these figures, decarbonising air transport in Australia will require about 250 TWh p.a. of electricity and 4 Mt p.a. of hydrogen (as a feedstock in fuel synthesis) in place of the aviation fuel consumption of 349 PJ in Australia in 2018-19. The above figures include both domestic and international air transport, despite emissions from international aviation are not included in the National Emissions Inventory. Therefore, decarbonising air transport using synthetic aviation fuels can result in doubling of the existing electricity demand in the National Electricity Market. The impact of this potentially significant increase in electricity demand needs to be incorporated into the future AEMO Integrated System Plans.

29. *What are the trade-offs (or synergies) of developing a hydrogen industry with other government goals?*

Given the massive expansion of renewable energy generation (and associated storage and transmission) that will be required to transition the domestic electricity sector which will have to expand by 200-300% to electrify the entire economy, there could be both competition and synergies for renewable electricity generation for hydrogen production in the domestic electricity grid. As mentioned above, coupling hydrogen production for large scale industrial processes with the domestic grid could provide low-cost, large-scale demand flexibility for the grid on timescales ranging from seconds to seasons. However, the large extra demand may increase requirements for grid infrastructure. The interplay between grid electricity prices and generator availability for hydrogen production may even shift the competitive advantage towards off-grid hydrogen generation using dedicated renewables. More work needs to be done to understand the opportunities and challenges in this space. The Scaling Green Hydrogen CRC proposal in the current CRC round brings together key stakeholder in the emerging hydrogen industry, including incumbent energy providers, chemical producers, and heavy transport industries to collaboratively solve the cross-sector challenges facing industries aiming to adopt hydrogen and derivatives in Australia, including the provision of water, infrastructure, and integration with the broader energy sector.

30. *How can existing gas infrastructure be repurposed to address priority use cases for hydrogen?*

In a full decarbonisation scenario, 100% blending of hydrogen into the existing natural gas transmission and distribution pipeline network will require significant re-sleeving/replacement with polyurethane of those components where particular types of steel are used that are subject to hydrogen embrittlement. In addition, a system-wide campaign would be needed to change over many appliances e.g. gas burners, to hydrogen-ready fittings.

Inevitably as with the natural gas pipeline network there will be leakages, and given the smaller molecular size of hydrogen, these might be expected to be greater in a 100% hydrogen network. Given that the Global Warming Potential (GWP) of hydrogen is significant (GWP_{20} ~ 33 and GWP_{100} ~ 11)[27], under an end-to-end hydrogen certification scheme this will result in emissions pricing imposts on fugitive hydrogen leakages that will increase the cost to the customer. In a no regrets scenario, remediation of the pipeline network will therefore be important to simultaneously address hydrogen safety, emissions and pricing[28].

How can we enable a hydrogen export industry (including the export of goods manufactured with hydrogen)?

31. *How can agreements with other nations best support Australia's hydrogen industry?*

International Green Economy Collaborations such as the SingAustGEA are an excellent initiative. Full discussion of their potential as tools of International Green Industrial Policy can be found here: https://iceds.anu.edu.au/files/AE%20manuscript%20Aisbett%204Feb23%20v2%20formatted.pdf#overlay-context=regulatory-frameworks-renewables-based-trade-and-investment-program

Bilateral exchange of information with the EU about the specific design of CBAM will be very important to understand first how the CBAM certificate would operate practically and how the Australian hydrogen carbon accounting could be used as a basis to claim deduction under CBAM.

32. *How should Australia ensure that the necessary foreign investment in hydrogen industry, and export projects leads to lasting benefits for all Australians?*

The recent case brought again Commonwealth of Australia by Clive Palmer for $300bn underlines the imperative of reducing Australia's exposure to being sued by "foreign" investors under international investment agreements. This can be done either by withdrawing from the agreements, or reforming them. Reforming them may well be the quickest and safest option given the speed and scale of investment required. Further discussion of options, including the awarding-winning reform proposal by Australian authors Aisbett and Bonnitcha can be found in the submissions to the OECD Future of Investment

Treaties consultation: https://www-oecd-org/investment/investment-policy/OECD-investment-treaties-climate-change-consultation-responses.pdf

33. *What other issues should Australian governments consider in relation to revising the National Hydrogen Strategy?*

34.

i) Green Industrial Policy for Australia

Australian governments should ensure that their Green Industrial Policies are developed in line with best-practice policy (a la OECD Guidelines) as well as recommendations specifically for Green Industrial Policy from authors such as Dani Rodrik. This will help to ensure that the policies are fair, efficient and in line with our international legal obligations (eg under the WTO).

Australian governments should also remain very aware that the best policies for "small" countries such as Australia are not the same as those for large economies like the US and EU. A point is case is that export subsidies are explicitly banned under WTO rules. Production subsidies in economies with large internal markets will not necessarily be deemed to be export subsidies under WTO rules. In an export-oriented industry such as that likely to develop in Australia, however, such subsidies are likely to be deemed in violation.

The World Economic Forum and IRENA have developed the Enabling Measures Roadmaps for Green Hydrogen (https://initiatives.weforum.org/accelerating-clean-hydrogen-initiative/our-work). One of the main outputs was the identification of top 10 objectives and supporting Enabling Measures and the timeline for implementation for Europe and Japan. It's crucial to make sure the timeline is defined carefully to be consistent with the overall objectives. For example, fiscal incentives, if considered effective, should be implemented for a few years to de-risk the investment and help achieving the desired goal. We can also learn from the list of identified enabling measures for Europe and Japan and their proposed timeline (https://www.irena.org/-/media/Files/IRENA/Agency/Collaborative-Frameworks/IRENA_Enabling_Measures_Roadmap_for_Green_H2_Jan22.pdf)

How can Australia enable decarbonisation through the development of a clean hydrogen industry",

Our analysis found that countries with national hydrogen strategies are prioritizing the scaling up of the hydrogen economy to meet their domestic or export demands. Climate objectives are part of the agenda, but their stringency is not guaranteed because of the lack of comprehensive and prescriptive regulatory measures. Our paper provides an analytical framework for green hydrogen regulatory stringency. We identified four parameters, including fossil fuel penalties, hydrogen certifications, innovation enablement, and the temporal dimension of coal phasing-out, as essential for green hydrogen regulatory stringency. As for policy implications, carbon pricing, fossil fuel phasing out, certification schemes and innovation enablement exclusively for renewable hydrogen are useful policy instruments.

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