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Water requirements for use in hydrogen production in Australia:

Potential public policy and industry-related issues

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The authors pay respect to the Traditional Owners and their Nations of Australia. We acknowledge their deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

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1. INTRODUCTION

The renewable energy industry contributed 32.5 % of total electricity generation in 2021 in Australia (74,679 GWH) (Clean Energy Council, 2022). This was an increase of 5 % on the previous year. Australia seeks to take up a leadership role in global clean hydrogen production, underpinned by this investment and interest in renewable energy infrastructure (Beasy, 2022). In this context, there will be a continuous demand for water in the near term (and beyond) from hydrogen production. Interest in this new energy source has gained significant momentum recently due to the realisation of significant role it could play in decarbonizing the energy mix, especially in hard-to-abate sectors such as heavy industry, long-distance transportation, and the production of liquid fuels.

Given the role of good quality water in the production of green hydrogen, it is relevant that such water is increasingly subject to a range of competing demands from industry, commercial and residential uses. These demands are being driven by the needs of a growing population and the requirements of increasing economic activity, made more pressing because of the destabilising impacts of climate change. This scenario leads to intensified water stress in many regions, particularly those with significant water supply variability (Water Services Association of Australia, 2021). Thus, large-scale hydrogen production, which will require secure, long-term access to water, will add to these challenges. While the demand for the Australian hydrogen industry appears to be strong, a level of uncertainty remains as to whether Australia's domestic water resources can reliably support long-term, commercial-scale hydrogen production (Bergman and Johnstone, 2021).

Indeed, because industrial hydrogen production will depend on guaranteed water availability, a key consideration will be how to manage the available water supplies in a sustainable manner so that it does not exacerbate existing regional water stresses. Australia will therefore need to consider how to balance the demands of hydrogen production with other essential water priorities (Environment Centre NT, 2022). In this context, understanding the extent and nature of water needs for future hydrogen production is of critical importance. While hydrogen producers, who will probably be mainly private companies, will clearly need to identify and establish claim on their particular water resources, much of the overall information and management of water, together with the drafting of regulations regarding its use, will lie in the hands of Governments. In this respect, it will not be easy for individual private sector concerns to confidently identify and ensure reliable water sources in many places, particularly in light of the current paucity of information availability and uncertainty regarding local water use regulations.

Exacerbating this problem is that, in practice, water requirements for hydrogen production will vary depending on several factors. These factors include (i) the particular production method and technology chosen for the process, (ii) the purity of the input water supply, and (iii) the need for additional water for indirect production requirements such as cooling, input water purification and other minor uses (COAG Energy Council, 2019).

Hydrocarbon reforming and pyrolysis of natural gas and coal (typically referred to as ‘grey hydrogen’) are currently the most developed hydrogen production methods and meet almost all the current demand for elemental hydrogen. Notwithstanding the advanced status of this process, hydrogen produced via electrolysis of water (referred to as ‘green hydrogen’ when the required electricity is produced with renewable sources), is poised to become the main production method by 2050 (International Renewable Energy Agency, 2022). It is important to note here that, in this regard, different electrolysis technologies have differing water consumption requirements.

Given this background, the purpose of this paper is to explore and identify the potential public policy and industry-related issues and examine questions which will relate to future water use for hydrogen production in Australia. The paper is organised in the following manner. Section 2 briefly discusses the current outlook for hydrogen production in Australia, noting the anticipated demand and the cost of hydrogen production. Section 3 focusses on the water requirements for hydrogen production, commenting on the state of water availability and its use in Australia today. The possible implications of failure to plan and guarantee the constant flow of water to hydrogen production is discussed in Section 4. The final section highlights potential public policy and industry-related issues in progressing hydrogen production in Australia.

2. PRODUCTION, COST & DEMAND OUTLOOK FOR HYDROGEN PRODUCTION

According to the Department of Industry, Science, Energy and Resources (2021) report entitled *State of Hydrogen*, private sector investment in this area is continually growing, with committed investment already exceeding A$1.6 billion. In parallel with this, public sector investment reached $1.27 billion in June 2021, and project announcements have indicated that hydrogen production could reach over 100 MW by 2025. Whilst gigawatt-scale projects have been announced and are expected to start operating in the second half of this decade, a final investment decision on these projects has not yet been made. However, a PwC (2022) analysis has indicated that there are over 90 hydrogen projects at present in Australia, with a conservative collective estimate of over $250 billion in investments (PwC, 2022).

The Investor Group on Climate Change (IGCC) (2022) expects the hydrogen market to grow rapidly by 2050, and there are indications of strong demand prospects in Asia. Indeed, it is anticipated that the major export opportunities for Australian hydrogen will be within the Asia-Pacific region, specifically Japan, South Korea, Singapore, and China in the long-term. Within Australia, the key sectors expected to transition to hydrogen will be different due to differences in energy use patterns and the cost and availability of energy. In this regard, the CSIRO forecasts (Figure 1) illustrate two key issues. First, in the near-term (during the 2020s), hydrogen demand is expected to come from domestic sources, including chemical production, industrial processes, flexible power generation, hydrogen fuel-cell vehicles and displacing some natural gas in existing gas pipelines and existing gas appliances by using a hydrogen-natural gas blend. Second, the demand for Australian hydrogen production is expected to be predominantly driven by global demand in the medium and long-term, with export demand increasingly dwarfing domestic demand and relying on technology improvements and economies of scale in Australia (IGCC, 2022).

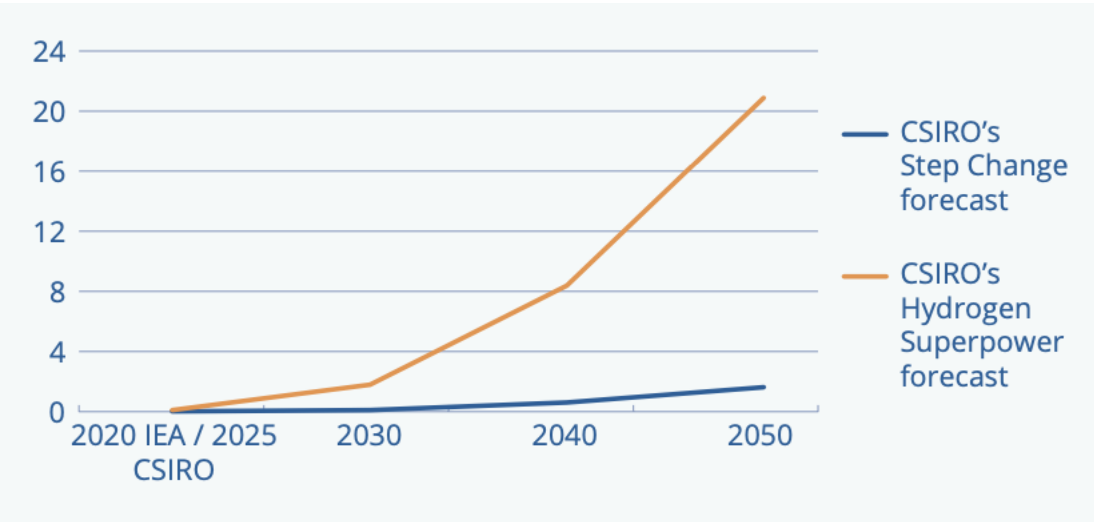

Figure 1: Projected Australian hydrogen production (Mt)

Source: The Investor Group on Climate Change (2022; p. 7) based on CSIRO forecasts

A steep drop in Australia's green hydrogen production costs is anticipated by 2040 (PwC, 2022). In fact, green hydrogen is expected to become the joint-lowest cost fuel globally, becoming cost-competitive with grey hydrogen between 2030 and 2040. The Clean Energy Finance Corporation's *2020-21 Annual Report* shows that current electrolyser costs of $1.1 million per megawatt are expected to drop to around $500,000 per megawatt by 2050 (Clean Energy Finance Corporation, 2022). According to Lazard (2021), electricity represents 40% – 70% of the levelised cost to produce hydrogen from electrolyzers with a capacity of 20+ MW, while cost and utilization of the electrolyzer is the second biggest cost component (Lazard, 2021).

3. WATER NEEDS, AVAILABILITY AND USE FOR HYDROGEN

According to Percy (2022), if the government aim of a $50-billion green hydrogen industry is to be achieved, it is possible to estimate the required water consumption. Calculations indicate that about 225,000 megalitres will be needed, which is around 4% of the amount of water used for Australian crops and pastures in 2019-20 based on recent ABS data (ABS, 2022). The likely impact of this water requirement is somewhat context dependent. For example, in an area where the water needed must be diverted from irrigators, it would have considerable economic and farm production implications.

However, most coastal areas of Australia have considerable potential for hydrogen production from electrolysis. There is an unlimited supply of desalinated seawater and the availability of electrical and port infrastructure make these areas very favourable for hydrogen production. Furthermore, in certain areas, Australia has extensive freshwater resources which means inland hydrogen production from electrolysis is possible. However, water availability is not equally distributed across the country. This presents a challenge for inland production in some regions, particularly relying on access to groundwater. It is possible that harvesting water from industrial water production or urban wastewater might be a ‘game changer’ in such locations (Feitz et al. 2019, pp. 34-35).

Timms et al., (2019) have compared the ‘joules per drop’, or the equivalent joules of energy per litre of water for selected energy sources that include unconventional gas and renewables. Their analysis has shown that typical unconventional gas has a much higher ‘joules per drop’ (up to 909 MJ/L) than that of solar thermal and biomass energy (only 8 and 0.02 MJ/L respectively). They argue that optimising the future portfolio of energy sources should include a goal of reducing the lifecycle of freshwater use. This is also relevant to water use in hydrogen production. Hydrogen fuel has moderate energy per drop of fresh water depending on whether ‘black’ or ‘green’ hydrogen (see Timms et al., 2019 and Mehmeti et al., 2018).

Feitz et al. (2019) (based on Mehmeti et al., 2018) suggest that water use figures range from 2.9 to over 300 litres per kg of hydrogen depending on the hydrogen production method employed. A typical water consumption figure for hydrogen production using alkaline electrolysis is 9 litres per kg of hydrogen. Australia’s current water resources include over 80,000 GL of surface water capacity with groundwater entitlements of over 8500 GL per year (Feitz et al., 2019). Because some parts of the country are more appropriate for supporting hydrogen production than others, this is an important consideration, particularly for supporting inland-produced hydrogen with carbon capture and sequestration (CCS) (typically referred to as ‘blue hydrogen’, or also ‘clean hydrogen’ and ‘low emissions hydrogen’). According to The Investor Group on Climate Change (IGCC, 2022), electrolysis to produce green hydrogen requires 9 kg of water to produce 1 kg of hydrogen compared to blue hydrogen, which requires 13–18 kg of water to produce 1 kg of hydrogen. However, it has been identified that, in practice, 12–14 kg of water was used per kg of green hydrogen, with the excess water being recycled.

It has been reported by Feitz et al. (2019) that The Hydrogen Strategy Group has estimated that replacing the equivalent of Australia’s 2019 total LNG exports with hydrogen using renewable hydrogen alone would require 279 GL of water per year, an amount which is less than half of what is currently consumed by the total Australian mining industry.

4. IMPACTS OF FAILURE TO PLAN WATER USE IN HYDROGEN PRODUCTION

Given the scarcity of water resources in many areas, hydrogen producers may face challenges in securing reliable, long-term access to the volumes of water required to support large-scale hydrogen projects. This could be particularly difficult for the production of green hydrogen since, in areas where solar power will be plentiful because of uninterrupted sunshine, water resources are often naturally scarce. Australia is the world's driest inhabited continent, with variable water availability and frequent widespread droughts. Competition for secure water resources is expected to intensify as the impacts of climate change accelerate, with ongoing demands from agriculture (which currently accounts for more than 65% of national water consumption), mining and domestic users, plus essential requirements to maintain environmental flows. Clearly, hydrogen production requires secure, long-term access to water, and this is made more problematic because water access regimes and trading schemes in Australia are complex, with different rules applying in each of the States and Territories. Water pricing, availability and use restrictions also differ between States, and between water sources within States. These factors should be considered when project planning and budgeting. Project developers should consider exploring alternative water sources for hydrogen production, and factor potential changes in water supply continuity into project planning and costs (Bergman and Johnstone, 2021).

The relatively intensive use of high-purity water has the potential to generate community uncertainty around additional demands for water use. Focus groups routinely indicate that water concerns are particularly significant for Australian farming communities in addition to the broader community, given frequent droughts and associated water restrictions in many parts of Australia. Accordingly, water security is a key issue that needs to be addressed by the industry to gain social acceptance and community support for Australian hydrogen projects that will divert water use from agricultural enterprises and other uses to hydrogen production for fuel and energy storage. The use of water as a feedstock in Australian hydrogen production will remain a key focus of the assessment of approval applications for new hydrogen projects, particularly for projects located in areas which often experience water shortages. The purchase of water allocations will add to baseline hydrogen production costs, which may fluctuate considerably depending on rainfall each year. Further, to maintain social license and community support for projects, it may be necessary for hydrogen producers to rely on non-potable sources of water to ensure they retain community acceptance and support. This may result in additional production costs to purify the water to a suitable standard for hydrogen production, which could be achieved via reverse osmosis or desalination processes.

In summary, it will be very important for any hydrogen producer setting up operations in Australia to carefully consider water availability and prepare detailed contingency plans to account for potential water restrictions and fluctuations in wholesale water prices during periodic droughts that can sometimes last for several years (Moir et al., 2020).

5. POTENTIAL PUBLIC POLICY & INDUSTRY-RELATED ISSUES

The key challenge now is to manage to get hydrogen produced in large quantities, in a cost effective and sustainable manner. It is currently more expensive than existing fossil fuel feedstocks, but if demand can be raised through new applications for hydrogen and industry can scale up such applications, this will reduce the costs of the technology and production through economies of scale. Making improvements to manufacturing processes for the relevant hydrogen technologies will make them much more efficient. It will also contribute to achieving the goal known as 'H_2 Under 2', which refers to hydrogen at A$2/kg. Whilst the current production costs, not including the supply chain costs, are probably around A$5/kg, the A$2/kg goal is eminently achievable (ECOS, 2022).

Current debate suggests that there are several public policy and industry-related issues and questions concerning water use in hydrogen production which need to be resolved. These are as follows:

First, water access regimes and trading schemes in Australia are complex, with different rules applying in each of the States and Territories. Water pricing, availability and use restrictions also differ between States, and between water sources within States. These factors should be considered when involved in hydrogen project planning and budgeting.

Second, it is necessary to determine how a hydrogen producing firm will ensure they have a sustainable water source. In this regard, the impact of future drought conditions must be considered.

Third, it needs to be estimated how much desalination or wastewater can be integrated in the water supply for hydrogen production, realising that at the industrial scale, water availability may rapidly become scarce. Depending on its production location, green hydrogen production may require a desalination or wastewater treatment plant to secure a supply of water, which will add additional capital costs. In this respect, many of the proposed hydrogen hubs and projects to date have been selected with an eye for confident water availability (IGCC, 2022).

Fourth, there are several relevant national scale datasets which currently do not exist, and hence need to be urgently developed. For example, a national scale land value dataset will be needed, which requires integration of data from State and Territory Valuer General Offices. These data would enable optimisation of the location of large-scale renewable installations with existing or planned supporting infrastructure, such as electricity networks and sub-stations. Also, a national scale groundwater use and quality dataset will be essential since groundwater management units are not necessarily tied to the most productive and utilised aquifers and can extend over vast areas with little groundwater productivity. It would additionally be very useful to develop a national dataset that quantifies volumes of groundwater currently extracted from mining and petroleum industry activities that are not necessarily covered by various Water Acts, although they may be covered by State mining and petroleum acts. Finally, there is a need for the development of a national scale hydropower potential development data layer (Feitz et al., 2019).

Fifth, desalinated water, recycled wastewater and stormwater are being explored as alternatives to relying on fresh water and the traditional water entitlements model for hydrogen production and other industrial applications. Project developers should therefore always consider exploring alternative water sources for hydrogen production, and factor potential changes in water supply into project planning and costs (Water Services Association of Australia, 2021).

Sixth, early and consistent dialogue and collaboration between the urban water industry and hydrogen industry stakeholders will be key to avoiding potential impacts on water security. It must always be kept in mind that, in addition to our future energy sources being decarbonised, our water supply also needs to be sustainable. In some areas, it may not meet contemporary community expectations to use drinking water to produce large amounts of hydrogen, especially for export, when sustainable alternatives such as recycled water are available. The water industry can play a significant role in achieving and indeed balancing all these goals (Bergman and Johnstone, 2021).

Seventh, there is a need to undertake early work to establish social licences to develop a national hydrogen infrastructure, which will include water access licensing, together with community, and worker benefits. Assistance for communities that are currently heavily dependent on employment in fossil fuel industries should be prioritised where possible, particularly when considering the location of hydrogen development and infrastructure (IGCC, 2022).

Finally, those interested in developing or investing in hydrogen projects should consider how their projects will obtain long-term and secure water access during initial feasibility studies. Given that water regimes differ between States, and individual water sources are subject to differing rules, restrictions and pricing, developers should familiarise themselves with the local water regimes when planning water supply for a hydrogen production facility. Regulations relevant to the hydrogen sector are still in their infancy, but the Federal Government is currently reviewing national legal frameworks with a view to supporting the development of the industry and facilitating regional hydrogen trade in the future. Developers must keep abreast of regulatory changes in this space and plan their projects accordingly (Bergman and Johnstone, 2021).

6. CONCLUDING REMARKS

Planned investment and interest in hydrogen production in Australia is likely to help us take a potential global leadership role in clean hydrogen supply. Australian water industry has a significant stake here, given the role of good quality water in the production of green hydrogen.

The need for long-term access to water to meet the potential demand for the Australian hydrogen industry will add some challenges and uncertainties. The challenges and uncertainties will revolve around issues such as managing the available water supplies in a sustainable manner, balancing the water demand for hydrogen production with other essential water demands such as for agriculture, urban water needs and environmental water requirements. Addressing these issues are further exacerbated by the complex and varying water access regimes, trading schemes, water pricing rules, and water use restrictions across the country.

Hence, to take advantage of the potential hydrogen demand opportunities, hydrogen producers will need to carefully consider water access and availability plans. Further, water and hydrogen industries in collaboration with the relevant public sector entities will need to address a range of issues highlighted in this paper. These include developing relevant data, information, and analysis to help better planning and getting the settings right for viable, sustainable, and cost-effective production of hydrogen, and ensuring long term water security for other priorities.

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