CCIWA SUBMISSION TO THE NATIONAL HYDROGEN STRATEGY TASK FORCE

RESPONSE TO THE NATIONAL HYDROGEN STRATEGY DISCUSSION PAPER

APRIL 2019

Response to discussion questions

What are the two or three most significant recent developments in hydrogen?

1. Declines in the cost of renewable energy and electrolyser technology

The price of energy used in the hydrogen production process is the primary driver of the cost of hydrogen. Consequently, the high cost of renewable energy has previously prevented hydrogen from being considered an economically viable option for low emissions energy supply. This situation is changing as the rapid decline in the cost of solar photovoltaic and wind power over the last decade has substantially improved the cost-competitiveness of hydrogen.

Over the period 2009 to 2018, the average levelised cost of energy (LCOE[1]) produced from utility-scale solar photovoltaic generators is estimated to have declined by 88 per cent from US$359/MWh to US$43/MWh. Over the same period, the average LCOE for onshore wind generation is estimated to have declined by 69 per cent from US$135/MWh to US$42/MWh.[2]

The cost of electrolysers used to convert water into hydrogen is following similar reductions in cost trajectory that solar photovoltaics have experienced in recent years. Under a best-case scenario, CSIRO is anticipating the levelised cost of hydrogen (LCOH) produced from proton exchange membrane (PEM) electrolysers to decline from A$4.78-$5.84 to $2.29-$2.79 per kilogram between 2018 and 2025. The LCOH produced from alkaline electrolysis (AE) is forecast to reduce from A$4.78-$5.84 to $2.54-$3.10 per kilogram over the same period.[3]

While decreases in the cost of renewable energy and electrolyser technology have improved the viability of hydrogen for domestic applications and international export markets, there must be a whole-of-supply-chain approach to driving down the cost and efficiency of hydrogen production, storage and transport to ensure it becomes a cost-competitive energy option.

2. Development of potential international markets

Potential hydrogen export markets are emerging as a response to the need to decarbonise and diversify energy supplies. In particular, targets and policy settings in South Korea and Japan have been identified by proponents as a major opportunity to establish a Western Australian hydrogen export industry. China is also emerging as a potential major export market, with Chinese Premier Li Keqiang publicly discussing hydrogen energy opportunities at the Boao Forum in March 2019.[4]

These emerging markets are unlikely to be self-sufficient in production and will look to international producers to reliably supply cost-competitive and clean hydrogen in sufficient quantities to meet anticipated increases in demand. Western Australia is well positioned to leverage its well-established trade relationships with countries developing hydrogen economies and existing supply chains geared towards servicing these markets.

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[1] NOTE: While LCOE is a useful indicator of the *cost* of energy production, it does not indicate the *value* of energy output from a given source. The value of electricity is primarily derived from being able to match supply with demand.

[2] Lazard, 2018. *Lazard's Levelized Cost of Energy Analysis – Version 12.O*, pp.7. Accessed from: https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.

[3] CSIRO, 2018. *National Hydrogen Roadmap – Pathways to an economically sustainable hydrogen industry in Australia.*

[4] Xinhua, 2019. *Chinese Premier holds dialogue with representatives at Boao Forum for Asia*. Accessed from: http://www.xinhuanet.com/english/2019-03/29/c_137934809.htm.

As emerging international markets are a key driver for establishing Australia's hydrogen industry, the National Hydrogen Strategy must be customer-focused. This means Australian hydrogen must be produced and delivered at a competitive price, with an emissions profile that meets customer expectations and at sufficient quantities to meet customer demand.

3. Buy-in from governments, businesses and research organisations

Reductions in the cost of renewable energy and electrolyser technology, combined with the emergence of potential export markets, have led to a renewed interest in hydrogen from governments, businesses and research organisations.

In WA, this is evident in the State Government hosting the Renewable Hydrogen Conference in 2018 and establishing the Renewable Hydrogen Council, which comprises of government and industry representatives. The WA State Government also recently announced $10 million in support for the 'LNG Futures Facility'[5], a microscale LNG plant that is intended to integrate a hydrogen production capability.[6]

Businesses with a Western Australian presence and operations actively involved in the development of hydrogen technology and projects include (but are not limited to):

- The Asian Renewable Energy Hub project is led by a consortium that includes the Macquarie Group and will involve the development of over 11,000MW of renewable generation capacity in the Pilbara region. 3,000 MW of this capacity is to be directed to supplying electricity to large local energy users, with the remaining capacity to be directed to green hydrogen production for domestic and export markets. The project has been granted 'Lead Agency' status by the WA Government and a final investment decision is scheduled for 2021-22.[7]
- ATCO Australia, with support from the Australian Renewable Energy Agency (ARENA), is delivering the Clean Energy Innovation Hub at Jandakot. This project is testing hybrid energy solutions involving the integration of natural gas, solar photovoltaics, battery storage and hydrogen production.
- BHP is considering the potential role of green hydrogen in its operations. BHP is currently compiling a "Green Hydrogen Opportunity Assessment and Roadmap," which includes a global technology scan, a dynamic cost model and potential implementation options.
- Fortescue Metals Group has entered a $20 million partnership with CSIRO to develop a metal membrane technology that will enable ammonia to be used as a carrier for hydrogen storage and transport.[8]
- Woodside Energy is pursuing the development of export markets and hydrogen refuelling infrastructure based on hydrogen derived from natural gas with bio-sequestration and from renewable sources. They have invested in the Korean HyNet consortia to deliver 100 refuelling stations, and signed memoranda of understanding with Korea Gas Corp (KOGAS) and Busan National University to collaborate on research and development of hydrogen fuel.
- Yara Pilbara is collaborating with ENGIE (another global energy player) on a feasibility study for a demonstration-scale (100MW solar, 66MW electrolyser) pilot project to produce renewable ammonia for export-based on hydrogen from solar electrolysis using the company's existing ammonia production and export infrastructure in the Pilbara.

[5] https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/04/Premier-announces-plans-for-a-world-first-LNG-plant-in-WA.aspx
[6] https://lngfutures.edu.au/lng-futures-facility/
[7] The Asian Renewable Energy Hub, 2019. *The Asian Renewable Energy* Hub. Accessed from: https://asianrehub.com/.
[8] CSIRO, 2018. *Hydrogen partnership to benefit R&D, jobs, exports*. Accessed from: https://www.csiro.au/en/News/News-releases/2018/hydrogen-partnership-to-benefit-rd-jobs-exports.

What are the top two or three factors required for a successful hydrogen export industry?

CCIWA broadly agrees with ACIL Allen's assessment[9] of the factors that will determine Australia's ability to develop a successful hydrogen export industry. The cost-competitiveness, emissions profile and production capacity of Australia's hydrogen industry will all work hand-in-hand to determine our sustained success as a major hydrogen exporter.

1. Cost-competitiveness

Australia will need to produce and deliver hydrogen to key markets at a price that is competitive with other aspiring hydrogen export jurisdictions. As hydrogen is not yet a commercially-viable energy source, the National Hydrogen Strategy will need to prioritise driving cost reductions in the production, storage and transport of hydrogen. Australia will need to continually focus on efficiency and cost improvements to ensure its hydrogen supply establishes and maintains a competitive position on the international hydrogen cost curve.

2. Emissions

Decarbonisation of energy supplies to support emissions reduction targets is the primary driver behind the development of key hydrogen export markets. Australia's hydrogen production capability must therefore be directed towards meeting the emissions requirements of key international customers. This will ultimately require Australia to establish and pursue a clear pathway to develop a zero-emissions hydrogen supply chain.

CCIWA members have articulated two differing views on the likely pathway to a zero-emissions hydrogen supply chain:

- **Transition from 'blue' to 'green' hydrogen:** This would involve initially establishing a 'blue' hydrogen production capacity utilising natural gas as a feedstock for conversion to hydrogen, with emissions requirements being met through carbon capture and storage or emissions offsets. This would be followed by the full transition to 'green' hydrogen using renewable energy sources for production in the medium term.
- **Proceed straight to 'green' hydrogen production:** This option would focus primarily on developing a 'green' hydrogen production capacity using renewable energy sources to meet zero emissions requirements of export markets. This pathway would likely bypass the intermediate step of establishing a blue hydrogen production capability.

Both pathways acknowledge that reducing the emissions intensity of energy supplies is the primary driver for the development of hydrogen export markets. However, customer preference (combined with price) will ultimately determine which pathway is the most viable for Australia's hydrogen industry. Project proponents will be best placed to understand how they will meet the emissions requirements of customers and direct their investment accordingly. Government must be mindful of the risk associated with 'picking winners' in terms of specific technologies and production methods as the private sector is best placed to manage these risks. Assessment and management of these risks will be enabled by negotiations with key international customers.

3. Production capacity

Increasing the scale of production will help drive down costs and meet demand from key hydrogen markets – this will subsequently improve Australia's competitive position as a hydrogen producer. Australia will need to develop

[9] ACIL Allen for ARENA, 2018. *Opportunities for Australia from Hydrogen Exports*, pp.15.

the capability to reliably produce and deliver sufficient amounts of hydrogen to meet demand from international customers at a competitive price. The National Hydrogen Strategy should therefore focus on facilitating the rapid scaling-up of Australia's hydrogen production capacity to achieve economies of scale and service international markets.

What are the top two or three opportunities for the use of clean hydrogen in Australia?

1. Supporting the electricity grid

Hydrogen technology could potentially play a role in supporting Western Australia's main electricity grid, the South West Interconnected System (SWIS) as the role of intermittent renewable generators becomes more prominent.

There has been exponential growth in the number of residential rooftop solar photovoltaic (PV) systems installed in the SWIS, with the installed capacity of these systems increasing from virtually zero ten years ago to over 1,000 megawatts (MW) in 2019. The combined capacity of rooftop solar PV is now three times greater than any other single generator connected to the SWIS. This is a substantial level of solar PV penetration in a system with a peak demand of around 4,000MW, average demand of 2,000MW and minimum demand of 1,200MW.[10]

The high level of solar PV installations is making management of the SWIS more challenging and is resulting in inefficiencies within the Wholesale Electricity Market (WEM), including:

- **Increased variability**: This necessitates the rapid ramping up and down of thermal generators to meet demand when solar output drops due to cloud cover or the sun setting in the afternoon. These fluctuations in output are increasing the maintenance costs and failure of conventional thermal generators, which are designed to run constantly at a relatively stable level of output.
- **Distorted price signals**: The WEM is experiencing an increase in the number of negative balancing price events as large amounts of solar PV production is decreasing electricity demand. As conventional thermal generators are limited in their ability to vary their output and there can be substantial costs associated with shutting down, in certain circumstances they are willing to pay to continue generating. This results in negative balancing price intervals.[11]
- **Power quality:** High levels of uncontrolled solar PV being exported to the grid are making it increasingly difficult to maintain voltage and frequency across the system. This has implications for system security and cost.

The uptake of small and large-scale renewable energy sources is expected to continue for the foreseeable future. Under a 'business as usual' scenario, the Australian Energy Market Operator (AEMO) and the WA State Government's Public Utilities Office expect the combined share of rooftop solar and large-scale renewable (wind and solar) of the SWIS generation mix to increase from just over 16 per cent in 2018-19 to about 35 per cent in 2030. Conversely, the role of coal in the generation mix is anticipated to drop from its current share of 51 per cent to about 35 per cent in 2030, while gas is expected to remain relatively steady as its share moves from 33 per cent to 30 per cent over the forecast period.[12]

[10] A.Zibelman, 2019. *Managing the energy transition*. Accessed from: https://ceda.com.au/CEDA/media/Attachments/2019/PDF/03/W190308_Zibelman_Presentation.pdf.
[11] AEMO, 2018. Quarterly Energy Dynamics – Q4 2018. Accessed from: https://www.aemo.com.au/-/media/Files/Media_Centre/2019/QED-Q4-2018.pdf.
[12] Department of Treasury, 2019. *The Energy Transformation*. Accessed from: https://www.treasury.wa.gov.au/uploadedFiles/Site-content/Public_Utilities_Office/Industry_reform/Energy-Transformation.pdf.

As the share of intermittent renewable generation on the SWIS continues to increase, so will the frequency and severity of the grid management challenges and market inefficiencies outlined above. A range of technological and market design solutions will need to be implemented by system planners, operators and other market participants to better integrate an increasing amount of intermittent renewable generation within the grid. Such solutions currently include but are not limited to: battery storage systems (including electric vehicles), synchronous condensers, direct load control and demand response incentives. Fast-response gas generators will also be crucial to managing the variability of renewable energy generation.

Stationary energy storage systems (usually lithium-ion and vanadium batteries) are touted by many to be a panacea that will solve all issues related to the integration of intermittent renewable energy with the grid. However, the current cost and sheer scale of the capacity that would be required for batteries in this context means their ability to be an effective method of bulk energy storage and arbitrage is still cost-prohibitive. To date, large-scale batteries such as South Australia's 100MW Tesla Hornsdale battery have been most effective at maintaining power quality and frequency control – not as a 'back-up' energy source.[13]

Batteries for stationary energy have not experienced the same cost reductions as electric vehicle batteries and consumer electronics, which have been the primary focus of product development and investment in manufacturing capacity. Battery storage will undoubtably play an increasingly prominent and critical role in the electricity grid, but there will still be a role for other technologies to provide grid support services, including hydrogen.

The use of electrolysers for hydrogen production could enable renewable energy to be stored as a hydrogen gas, which can then be later converted into electricity via a fuel cell, burned to produce heat or mixed with natural gas as a combustion fuel. Electrolysers also offer a flexible load that can provide grid support services, such as frequency control.[14]

Ultimately, hydrogen will only play a major role in supporting the electricity grid if it is cost-competitive with other energy sources and technologies. Research and development efforts must therefore focus on driving efficiency and cost improvements in the energy conversion, storage and transport processes so hydrogen can become a cost-competitive option for supporting the electricity grid. Western Australia's SWIS is an ideal environment for testing and refining the potential for hydrogen to support the electricity grid. This is already happening with ATCO's Clean Energy Innovation Hub project, but further projects will be required to drive down costs, achieve scale and understand how hydrogen services will interact with the market. The SWIS should be prioritised to host any subsequent projects intended to test and improve the performance of hydrogen for grid support services.

2. Natural gas blending

Blending hydrogen with natural gas in existing pipeline infrastructure could be an effective way to create a market for hydrogen gas, reduce the emissions intensity of domestic gas supplies, diversify fuel supplies and facilitate the scaling-up of domestic hydrogen production capacity. In pursuing opportunities for hydrogen-natural gas blending in existing network infrastructure, CCIWA recommends the Strategy considers potential price implications for end-users. Injecting hydrogen gas into existing networks will likely require a price premium until the cost of hydrogen

[13] M.Warren. *Blackout – How is Energy-Rich Australia Running Out of Electricity.*
[14] IRENA, 2018. *Hydrogen from Renewable Power: Technology Outlook for the Energy Transition*. Accessed from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Sep/IRENA_Hydrogen_from_renewable_power_2018.pdf.

reaches parity with domestic natural gas supplies. The Strategy must consider who bears these additional costs while hydrogen remains a more expensive fuel than natural gas. Likely outcomes include: end users paying additional costs, government subsidising the cost of adding hydrogen gas to natural gas supplies or producers absorbing the additional cost. The imposition of this additional cost must be equitable and not place an undue burden on gas users.

3. Industrial processes

The use of hydrogen gas for energy intensive industrial heat applications and downstream processing provides a promising avenue for reducing emissions. The viability of hydrogen for heat applications will partly be dependent on the associated NOx emissions. Hydrogen is already in use in Western Australia in downstream processing (for example at BHP Nickel West Kwinana Refinery). It has the potential to be used in a range of downstream processing applications, such as steelmaking.

This is a great opportunity area for hydrogen as it increases the market for hydrogen to be used by Australian industry, thus reducing domestic and international industrial emissions while increasing our export potential.

What are some examples where a strategic national approach could lower costs and shorten timeframes for developing a clean hydrogen industry?

1. Policy and investment certainty

The National Hydrogen Strategy is unlikely to succeed if the issue of national emissions policy is not resolved. The main value proposition for hydrogen is its potential to be a flexible zero emissions energy source in support of emissions reduction targets. The absence of a clear and stable national emissions framework that is subject to bi-partisan support will adversely affect the ability of hydrogen project proponents to plan and make informed investment decisions.

Aligning the Strategy with a national emissions policy framework will provide clarity around hydrogen's role in supporting Australia's international emissions target while giving certainty to international customers regarding the emissions profile of Australian hydrogen. The flexibility of hydrogen will open new opportunities for emissions reductions across multiple sectors, assuming it is cost competitive with other emissions abatement options.

2. Project facilitation

All levels of government must work to ensure current and future hydrogen developments have the greatest possible chance of proceeding. This includes expediting approvals processes, facilitating access to suitable land and infrastructure, as well as ensuring Australia's regulatory and tax regimes are competitive with other jurisdiction aspiring to be a hydrogen exporter.

Western Australia's Strategic Industry Area (SIA) framework provides a good basis for facilitating the development of major industrial developments. SIAs are areas of land in strategic locations that are designated for industrial use in order to attract investment in downstream processing, heavy industry and other industrial activity associated with the State's main upstream primary industries. They are generally located close to upstream natural resources industries and are connected (or intended to be connected) to important infrastructure such as road, rail or ports.

SIAs are also protected by planning buffer zones that provide some long-term certainty as to the viability of the area as an industrial site, regardless of other long-term developments in the area. Most SIAs form part of state regional planning strategies and are appropriately zoned within the relevant local government area. The zoning of SIAs and their surrounding lands is intended to provide projects with a degree of investment and operational certainty, as well as improved productivity through the provision of some infrastructure.

While clearly preferable to a greenfield development with regard to zoning, SIAs could be further optimised to ensure they are competitive with other 'turn-key' style industrial estates in many other jurisdictions. Projects can still encounter some uncertainty and delays in project approvals and require significant investment in head-works and other infrastructure. This is a situation that does not typically arise in international 'turn-key' industrial estates.

3. Competitive fiscal settings

The Strategy must consider how Australia will counter the generous fiscal incentives that will likely be used by international competitors to attract investment and develop their hydrogen production capacity. This will involve leveraging existing government bodies, including the Clean Energy Finance Corporation (CEFC), Australian Renewable Energy Agency (ARENA) and national export credit agency EFIC.

This appears to be the approach proposed under the Australian Labor Party's policy to allocate a combined $1.1 billion of CEFC and ARENA funding towards hydrogen developments. However, CCIWA notes this policy announcement has been very focused on supporting projects in Queensland to date.[15] The Coalition Government has supported around $100 million in hydrogen projects and research, including support for the Toyota Australia Hydrogen Centre project in Victoria and an additional $31 million in grants through ARENA.[16]

If the Federal Government is to use financial levers to support the development of an Australian hydrogen export capability, there is merit in directing funds to large-scale 'breakthrough' projects from quality consortia. The purpose of this should be create a step-change in production and export capacity so Australia can establish a foothold in international markets as soon as practicable. The Strategy should recognise and facilitate the role of Western Australia's mid-west and north-west regions as hydrogen export hubs to achieve this goal.

4. Innovation and thought leadership

To ensure the effective translation of research and innovation across the renewable hydrogen supply chain, the National Hydrogen Strategy should consider mechanisms to enable the transition of blue-sky research into to applied innovation. Once Australia is established as a major hydrogen producer, there will need to be a sustained effort to maintain the competitiveness of the industry through ongoing research and development activities.

An Australian hydrogen industry will need the capability and capacity that covers the entire hydrogen supply chain. This means that developing an effective sector-wide hydrogen innovation system that encompasses all supply chain participants will be crucial to reducing the time from discovery to application of new knowledge.

The Strategy should also recognise the differences between small-to-medium enterprises and large businesses, and their capacity to invest in applied hydrogen research and development activities. Larger businesses generally have more capacity and resources available for research and development activities, whereas many SMEs are

[15] https://alp.org.au/media/1520/190121-factsheet-hydrogen-plan.pdf
[16] http://www.environment.gov.au/minister/taylor/media-releases/mr20190319.html

unlikely to have the capacity to invest in applied hydrogen research that has the potential to advance their ideas and products.

Industry-focused entities such as the Australian Industry Growth Centres could substantially enhance the growth of Australia's hydrogen industry with their business-first approach, strong linkages with academia and strategic approach to industry development. The Cooperative Research Centres (CRC) Program, with its focus on industry-led collaborations between industry and researchers also offers an avenue for ensuring continuous improvement and innovation in Australia's hydrogen industry.

5. International promotion

Government and industry should use an agreed narrative to promote Australia's prospects in the hydrogen supply chain that is evidence-based, realistically achievable and clearly linked to the National Hydrogen Strategy.

This narrative should highlight Australia's competitive advantages in hydrogen production. Western Australia's competitive advantages include: abundant and high-quality renewable energy resources; immense tracts of suitable land; substantial experience and capability in producing, storing and transporting large amounts of gas over vast distances to domestic and international markets; and existing trade relationships with potential international hydrogen markets. WA's energy and resources sectors also have a proven track record in innovation and technology development that can be applied to hydrogen production, storage and transport.

State Trade offices, Austrade and the Commonwealth Department of Foreign Affairs and Trade should work with the various nations with which Western Australia and Australia already have extensive trade relationships and existing or prospective facilitative trade agreements to optimise the supply of hydrogen to international markets and to attract foreign direct investment that builds our production capacity.

What workforce skills will need to be developed to support a growing clean hydrogen industry?

CCIWA members have advised that an Australian hydrogen industry will largely be reliant on electrical and plumbing trades, including the capability to work with high voltage electricity and high-pressure gas. While analysis by ACIL Allen suggests it is unlikely that a lack of appropriately skilled people will constrain Australia's ability to develop a hydrogen industry, it is crucial that government policy and funding for training and workforce development has a strategic, long-term view.

The hydrogen industry is relatively immature, with commercial viability not expected until around 2030. This could make it difficult for an emerging hydrogen industry to signal potential opportunities to current and future labour market participants and influence formal training opportunities that will directly meet the industry's needs.

To ensure hydrogen proponents can access the right talent, they must be able to articulate their needs back through the talent pipeline so education institutions can adapt their offerings. This includes the number of potential jobs on offer and the types of skills in demand. Initially, this will be challenging as it is unlikely that there would be significant demand to warrant industry-specific formal training options delivered within the universities or vocational education and training (VET) provider. A more likely scenario is that firms will initially rely on talent with sound general technical skills (such as engineers, designers, electricians and plumbers) sourced internally, with additional technical skilling specific to the industry being conducted in-house.

Regardless of training type, there is a case for greater government support in the development of a hydrogen workforce if significant structural shifts are occurring in the community and there is an economic case that supports the development of a hydrogen sector. It is vital that any shift is business-led with the government providing appropriate levels of policy and financial support. While it is important for businesses to communicate their talent needs to the market, care must also be taken not to oversell career opportunities in the hydrogen industry as over-stating career prospects tends to have an adverse effect on talent supply in the long term.

What areas in hydrogen research, development and deployment need attention in Australia? Where are the gaps in our knowledge?

Further to the issues already discussed, demonstration and trialling projects should seek to de-risk safety, establish regulatory regimes and demonstrate the successful export of hydrogen. This will help Australia become a centre for excellence and accelerate the global hydrogen market.

The development of safety standards for hydrogen use in existing pipelines, industrial applications, residential settings and storage will also be crucial for facilitating the widespread application of hydrogen in the domestic market.

Large amounts of water are required for hydrogen production, so the implications for water supplies must also be better understood if Australia is to scale-up and sustain a major hydrogen industry over the long term. This is particularly important given Australia’s status as the driest continent on Earth and the potential for hydrogen production to compete for water supplies with other industries, such as agriculture.