THE ANZ HYDROGEN HANDBOOK VOL II

VALUE OF HYDROGEN

THE TRANSFORMATIVE POTENTIAL OF HYDROGEN ENERGY IN AUSTRALIA

CURRENT ENERGY ENVIRONMENT

The global shift to a net-zero world requires a significant change in how we generate and use energy. The Australian government has set a target through the Climate Change Act 2022[1] of reducing greenhouse gas emissions by 43% below 2005 levels by 2030[2] and net zero emissions by 2050. Thus, policymakers are eager to decarbonise the energy sector by introducing a wide range of policy and financial incentives to promote the adoption of wind and solar technologies.

While these initiatives provide optimism for reducing emissions, they simultaneously pose challenges to existing energy systems. The intermittency resulting from daily and seasonal variations in sunlight and wind availability can impact the stability of power grids. Moreover, the growing electric vehicle market and the increased power demands for charging can be expected to further strain the grid.

A further challenge to reaching targets is the recent projections that current renewable energy will not be sufficient to make Australia net zero by 2050[3]. Net-zero targets will force Australia to address sectors whose emissions are difficult to abate or can't be electrified. Hydrogen can play a key role in the last mile to net zero by potentially helping in decarbonising sectors such as power generation, heavy transportation, and manufacturing, where electrification is challenging to enforce or simply unfeasible.[4] Although the exact role of hydrogen as a decarbonisation solution is yet to be determined, promoting the inclusion of low emissions hydrogen in the energy mix is crucial for reaching zero-emissions targets.

While many of the current challenges relating to hydrogen include its costs and transportation limitations, hydrogen projects continue to progress globally. The NEOM Green Hydrogen Company (a joint venture between ACWA Power, Air Products and NEOM) announced the NEOM Green Hydrogen project in Saudi Arabia.[5] The project will be the world's largest utility-based hydrogen facility powered entirely by renewable energy. The project is on track to be completed by 2026, where it aims to produce 600 tonnes of green hydrogen per day.[6]

Many countries in east Asia suffer from scarcity of space, lacking in sufficient land masses to build future infrastructures or renewable energy plants.[7] Conversely, Australia has the resources and space to create a hydrogen industry that can both support domestic and international demand. Australia's natural advantages place it in a unique position with access to resources to export hydrogen to trading partners/countries who can't generate their own but are firmly committed to decarbonising.[8]

WHAT IS HYDROGEN?

Hydrogen (H_2) is the chemical element with the symbol and atomic number 1. Hydrogen is the lightest element in the periodic table and the most abundant chemical substance in the universe. At standard temperature and pressure, hydrogen is a colourless, odourless, tasteless, nontoxic, non- metallic, highly combustible gas.

Hydrogen is similar to natural gas in terms of its applications and handling, and from an energy perspective has two outstanding properties:

- Hydrogen is unique among liquid and gaseous fuels in that it emits absolutely no carbon dioxide (CO_2) emissions when the energy is released as heat through combustion, or as electricity using a fuel cell. In both cases the only other input needed is oxygen, and the only by-product is water.
- It is an excellent carrier of energy, with each kilogram of hydrogen containing about 2.4 times as much energy as natural gas.[9]

HYDROGEN IS BEING SEEN AS A CRITICAL COMPONENT OF AUSTRALIA'S ENERGY TRANSITION.

VALUES OF HYDROGEN

Hydrogen possesses the potential to fulfill a crucial role in addressing the energy storage demands necessary for reducing CO_2 emissions, particularly green hydrogen for Australia. As the most abundant element in the universe, its efficacy as a reliable energy carrier has been recognised for many years. Historically, hydrogen technologies have fallen short in delivering innovations that were financially feasible. Nonetheless, developers have persisted in addressing these shortcomings, resulting in significant technological advancements.[10] At present, technologies for producing, storing, transporting, and utilising hydrogen have progressed to a stage where hydrogen is emerging as a viable option for various applications.

Hydrogen is being seen as a critical component of Australia's energy transition. This is due to the values it can bring to the renewable energy landscape. Some of these values include:

1. Zero emissions

Hydrogen serves as a clean and versatile energy carrier. When burned to produce heat or converted to electricity in a fuel cell, it has the unique characteristic of only producing water vapour as a biproduct with no carbon emissions. If hydrogen is produced through the process of electrolysis (the use of electricity to split water molecules into hydrogen and oxygen) which is powered

by renewable energies such as solar and wind, it is called Green Hydrogen as the process emits zero emissions.

Green hydrogen can significantly reduce CO_2 emissions far beyond the electricity sector. This is why it can potentially play a key role in decarbonising industries by making them less reliant on fossil fuels.

2. Versatile

Clean and low-emission hydrogen has emerged as an important tool for decarbonising sectors which have historically been hard to abate.[11] These sectors, encompassing aviation, shipping, long-distance trucking, and concrete and steel manufacturing, pose a challenge for decarbonisation due to their reliance on high energy density fuel or intense heat.[12] Hydrogen emerges as a viable solution to address these specific needs. It can help industries that find it challenging to decarbonise based on solar and wind renewable energies alone.

Hydrogen energy is versatile and can be used in various sectors including the energy industry, grid firming, chemicals, and metals production. Hydrogen can be transformed into electricity or synthetic gas and used for commercial, industrial or mobility purposes, such as hydrogen fuel cells for vehicles or an alternative chemical feedstock for industries such as aluminium, cement and steel.[13] Hydrogen can also be used for processing heat in industry but also as a feedstock for ammonia or for calcination in aluminium production[14]; while also being used to heat buildings and homes.

Furthermore, hydrogen can add flexibility to the power industry by enabling seasonal grid storage and balancing growing renewable energy generation shares.[15] By utilising hydrogen, there will be a reduced reliance on traditional fossil fuels, contributing to energy security and promoting diversification.

3. Energy storage

Despite the swift growth in adoption of renewable energy, its progress has been impeded by intermittency issues caused by environmental, seasonal, and daily cycles that can significantly limit their use or efficiency.[16] To complete the final stretch of decarbonisation, these renewable sources require a reliable and firm source for periods when the sun isn't shining, and the wind isn't blowing.

Hydrogen is a valuable energy storage medium that has the potential for large-scale energy storage. Hydrogen can allow excess energy from intermittent renewable sources to be stored for later use, offering a potential solution to the current renewable energy storage challenges. Hydrogen can be stored for a long period of time and can travel long distances, which allows it to be used subsequently for other purposes and stockpiled for future uses.[17] Hydrogen has the flexibility to be stored in tanks as a gas under high pressure or as a liquid at very cold temperatures. However, for cost-effectiveness and safety in large-scale storage, the most economical option is underground in salt caverns, saline aquifers, depleted gas fields or engineered hard-rock caverns.[18] Additionally, hydrogen can also be transported, aiding in balancing the intermittent renewable energy sources.

As such, hydrogen can diversify the energy mix, reducing reliance on fossil fuels and enhancing energy security.

4. Export opportunity

Australia has long been involved in hydrogen development. Its approach is guided by the National Hydrogen Strategy published in November 2019[19], which outlines actions for the country to become a major player in global hydrogen production and trade by 2030. The International Energy Agency (IEA) further forecasts Australia will become the second largest net-exporter of low-emissions hydrogen by 2050.[20]

Australia has plenty of land capacity and access to natural wind and solar power resources. Australia's proximity to major growth markets in big energy importing nations such as Singapore, Japan and Korea will help position Australia to be a superpower of Hydrogen. The export of hydrogen adds value by helping to generate income, diversify export structures and support the decarbonisation of importing countries. Hydrogen stands as a crucial factor in expediting the expansion of clean and renewable energy, holding significant potential in this transformation.

5. Firm source of renewable energy

Renewables such as wind and solar face intermittency and storage challenges.[21] Their main disadvantage is unpredictability due to their reliance on intermittent sources of energy, which makes maintaining a stable supply of electricity complex.

Battery Energy Storage Systems (BESS) and pumped hydro are currently the leading zero emissions technologies being utilised for firming and managing frequency in the National Energy Market (NEM).[22] However, hydrogen also has the potential to aid in smoothing out the variations in renewable supply. Hydrogen can help support grid stability by providing power during peak demand periods where other renewable sources are insufficient.[23]

Hydrogen's ability to provide continuous power generation and serve as a reliable energy storage medium can complement the intermittency of renewables.

6. Job Creation

Hydrogen has become an integral part of the plan to attaining Australia's carbon neutral goals. The 2019 National Hydrogen Strategy[24] was reviewed in 2023 and sets a vision for Australia to develop a Hydrogen industry and become a global superpower for hydrogen production and trade by 2050. The development and implementation of hydrogen technologies can stimulate economic growth and create employment opportunities in the renewable energy sector. From production to infrastructure development, the hydrogen industry can create long-term jobs through new career pathways and establishing a highly skilled workforce.[25]

BANKABILITY

Hydrogen production projects have large upfront capital expenditure requirements for development and construction, followed by long asset lives with relatively low ongoing maintenance capital expenditure requirements. Based on these characteristics, project financing is expected to be a suitable approach to sourcing the capital required to facilitate development, construction and operation of these projects. While some hydrogen projects will be financed via the relevant sponsor's corporate debt facilities, project financing is expected to be an attractive alternative, as it is for projects with similar characteristics in the infrastructure, energy and mining sectors.

PROJECT FINANCING IS EXPECTED TO BE AN ATTRACTIVE ALTERNATIVE, AS IT IS FOR PROJECTS WITH SIMILAR CHARACTERISTICS IN THE INFRASTRUCTURE, ENERGY AND MINING SECTORS.

Project finance is the financing of long-term infrastructure, industrial projects, and public services using a non-recourse financial structure. The debt and equity used to finance the project is repaid solely from the cash flow generated by the project. The project assets are owned by a Special Purpose Vehicle (SPV). The SPV is the Borrower and lenders only have recourse to the SPV, the project assets and the cash flows they generate. For many project sponsors, project finance is an efficient means of securing capital because the debt is supported solely by project cash flows, as opposed to leveraging the sponsor's balance sheet.

For project financing to be viable, the project's commercial structure must be structured in a manner that enables the project to generate stable and predictable cash flows that can be forecast over the project life with a reasonable level of confidence. The following attributes would enable a project to achieve this:

- Contracted Offtake: Long-term offtake agreements with reputable investment grade counterparties that have the capabilities to fulfil their obligations. Price and volume terms that sufficiently minimise uncertainty in relation to forecast project cash flows.
- Contracted Feedstock Supply: Long-term feedstock (renewable electricity and water) supply agreements with capable and creditworthy counterparties. Price and volume terms that eliminate gap risk (with respect to offtake terms) and minimise uncertainty in relation to forecast project cash flows.
- Operations and Maintenance: Long-term, fixed price (to the extent possible) Operations and Maintenance Agreement with a reputable, experienced, creditworthy and highly capable operator.
- New Technology Risk Protections: Sufficient contractual mitigants in relation to project components that are not commercially proven at scale. For example, a long-term performance warranty from a reputable, experienced and creditworthy electrolyser OEM.
- Construction Contracting Arrangement: Well considered construction contracting arrangement, with responsibilities / risks allocated to creditworthy contractors that have the required experience, capability and capacity to manage them. Fixed price, date certain EPC contracts with appropriate delay and performance protections.
- Simplicity: Unnecessary complexity could limit the volume of liquidity available for financing. Noting many proposed hydrogen projects will require multibillion dollar financings, maximising available liquidity will be critical to ensure successful execution.

In addition to the attributes listed above, the following attributes relating to a project's location are likely to determine its attractiveness to financiers:

- Well Considered Location: The project's location has been optimised when taking into account:
  - Proximity and access to high quality renewable energy resources;
  - Proximity and access to water supply of sufficient volume and quality;
  - Required enabling infrastructure (including electricity transmission and water pipeline) is in place or will reach completion well before it is required;
  - Required transport and logistics infrastructure; and
  - Proximity to hydrogen and ammonia buyers, domestic and/or export.

- **Stable and Predictable Legal and Regulatory Environment**: A quality of many jurisdictions globally, including Australia and New Zealand.
- **Favourable and Supportive Government Policy Environment**: This is a benefit for projects in Australia, where there are a multitude of federal and state government policies aimed at developing a globally competitive hydrogen industry.
- **Availability of Skilled Labour**: Local workforce has the required technical expertise to facilitate the successful construction and operation of a project of this nature.

Many of the proposed hydrogen projects will require multibillion dollar debt financings, requiring liquidity that is beyond what the commercial bank market will be able to provide alone. As with previous financings of mega projects, Export Credit Agencies (ECAs) will be a critical source of liquidity for debt financing. ECAs are sovereign backed institutions that can share risks with commercial banks either by guaranteeing or lending alongside bank loans. In Australia, ECAs have helped finance LNG, iron ore and wind projects. ECAs can support projects where overseas companies are to supply goods or services into construction or operation. Certain ECAs can support projects where there is equity investment from its home country and/or offtake from the project to its home country. In addition, Australia's ECA, Export Finance Australia, can support projects that intend to export in the future.

REFERENCES

1 International Energy Agency. (2023). *Australia 2023 Energy policy review*. https://iea.blob.core.windows.net/assets/02a7a120-564b-4057-ac6d-cf21587a30d9/Australia2023EnergyPolicyReview.pdf

2 Department of Climate Change, Energy, the Environment and Water (DCCEEW). (2022, December). *Australia's emissions projections 2022*. https://www.dcceew.gov.au/sites/default/files/documents/australias-emissions-projections-2022.pdf

3 Nnabuife, S. G., Oko, E., Kuang, B., Bello, A., Onwualu, A. P., Oyagha, S., & Whidborne, J. (2023). *The prospects of hydrogen in achieving net zero emissions by 2050: A critical review.* Sustainable Chemistry for Climate Action, Volume 2, Page 100024. https://doi.org/10.1016/j.scca.2023.100024

4 State of the Planet. (2021, January 11). *Why we need green hydrogen*. https://news.climate.columbia.u/2021/01/07/need-green-hydrogen/

5 Martin, P. (2023, August 9). *Neom's 2.2GW green hydrogen and ammonia complex will meet 'high bar' EU definition of renewable fuel. Hydrogen Insight*. https://www.hydrogeninsight.com/production/interview-neoms-2-2gw-green-hydrogen-and-ammonia-complex-will-meet-high-bar-eu-definition-of-renewable-fuel/2-1-1498120

6 Smart Water Magazine. (2023, July 7). *NEOM green hydrogen project on track for 2026 completion*. https://smartwatermagazine.com/news/smart-water-magazine/neom-green-hydrogen-project-track-2026-completion

7 Arup. (2019, November). *Australian Hydrogen Hubs Study*. COAG. https://www.dcceew.gov.au/sites/default/files/documents/nhs-australian-hydrogen-hubs-study-report-2019.pdf

8 Bailey, A., Coulter, D., & Trueman, D. (2023, July 24). *How can Australian developers capitalise on the hydrogen export opportunity to East-Asian markets?* Baringa. https://www.baringa.com/en/insights/low-carbon-futures/hydrogen-export-opportunity-from-east-asia/

9 CSIRO HyResource. (n.d). *Hydrogen*. https://research.csiro.au/hyresource/about/hydrogen/#:~:text=As%20an%20energy%20carrier%2C%20hydrogen%20,as%20electricity%20using%20fuel%20cells

10 Lindsey, T. (2021, May 12). *Why hydrogen may be renewable energy's best bet*. IndustryWeek. https://www.industryweek.com/technology-and-iiot/emerging-technologies/article/21163897/is-hydrogen-the-answer-to-renewable-energys-shortcomings

11 IEA. (2023, September). *Global Hydrogen Review 2023*. https://iea.blob.core.windows.net/assets/8d434960-a85c-4c02-ad96-77794aaa175d/GlobalHydrogenReview2023.pdf

12 Nault, K. (2022, October .3). *Clean Hydrogen: A long-awaited solution for hard-to-abate sectors*. Harvard School of Engineering and Applied Science. https://seas.harvard.edu/news/2022/10/clean-hydrogen-long-awaited-solution-hard-abate-sectors

13 Geoscience Australia. (2023, October 24). *Hydrogen*. https://www.ga.gov.au/scientific-topics/energy/resources/hydrogen#:~:text=Hydrogen%20can%20be%20produced%20as,%2C%20cement%20and%20green%20steel

14 Hren, R., Vujanović, A., Van Fan, Y., Klemeš, J. J., Krajnc, D., & Čuček, L. (2023, March). *Hydrogen production, storage and transport for renewable energy and chemicals: An environmental footprint assessment*. Renewable and Sustainable Energy Reviews, Volume 173, Page 113113. https://doi.org/10.1016/j.rser.2022.113113

15 Meares, T., Tyrrell, J., & Pendlebury, R. (2022). *Hydrogen: The role of the hydrogen production industry in providing system services to the NEM*. AEMC. https://www.aemc.gov.au/hydrogen-role-hydrogen-production-industry-providing-system-services-nem

16 Irvin Jr, W. (2023, September 25). *The business benefits of hydrogen energy and how to adopt it*. Forbes. https://www.forbes.com/sites/forbesbusinesscouncil/2023/09/22/the-business-benefits-of-hydrogen-energy-and-how-to-adopt-it/amp/

17 Iberdrola. (2021, April 22). *What is green hydrogen and its importance*. https://www.iberdrola.com/sustainability/green-hydrogen

18 CSIRO. (2022, September 13). *The lowdown on underground hydrogen storage*. https://www.csiro.au/en/research/technology-space/energy/energy-storage/underground-hydrogen-storage

19 COAG Energy Council. (2019). *Australia's National Hydrogen Strategy*. Department of Climate Change, Energy, the Environment and Water. https://www.dcceew.gov.au/energy/publications/australias-national-hydrogen-strategy

20 The International Energy Agency (IEA). (2023, October). *World Energy Outlook 2023*. https://www.iea.org/reports/world-energy-outlook-2023/executive-summary

21 Chomsky, R. (2023, August 20). *The reliability debate: Renewables*. Sustainable Review. https://sustainablereview.com/the-reliability-debate-renewables/

22 Gilbert + Tobin Lawyers. (2021, July 27). *Energy transition in Australia: The role of batteries, pumped hydro & the grid | G+T*. https://www.gtlaw.com.au/knowledge/energy-transition-australia-role-batteries-pumped-hydro-future-grid

23 Frankowska, M., Rzeczycki, A., Sowa, M., & Drożdż, W. (2022, December 22). *Functional model of power grid stabilization in the green hydrogen supply chain system—Conceptual assumptions. Energies*, Volume 16, Issue 1, page 154. https://doi.org/10.3390/en16010154

24 Department of Climate Change, Energy, the Environment and Water. (2023). *Australia's National Hydrogen Strategy*. https://www.dcceew.gov.au/energy/publications/australias-national-hydrogen-strategy

25 The State of Victoria Department of Environment, Land, Water and Planning. (2021). *Victorian Renewable Hydrogen: Industry Development Plan*. https://www.energy.vic.gov.au/__data/assets/pdf_file/0022/580621/Victorian-Renewable-Hydrogen-Industry-Development-Plan-compressed.pdf

IMPORTANT NOTICE

This communication is made by Australia and New Zealand Banking Group Limited (ABN 11 005 357 522) in Australia. It should not be forwarded, copied or distributed.

This communication:

- does not constitute advice and ANZ does not expect you to rely on it. ANZ does not provide any financial, investment, legal or taxation advice in connection with this communication;
- is not a recommendation and is not intended to influence you or any other person to make a decision; and
- is not an invitation, solicitation or offer by ANZ to you to acquire a product or service, or an offer by ANZ to provide you with other products or services.

The data and information in this communication was prepared in good faith from a variety of publicly available sources outside of ANZ, and while care has been taken in compiling it:

- ANZ has not independently verified the content of the underlying information;
- the information is high level, intended as a summary only and should not be relied on as being current, complete or exhaustive;
- ANZ does not undertake to update the information in this communication or notify you should any information contained in this communication cease to be current or correct; and
- no representation, warranty, assurance or undertaking, is or will be made, and no responsibility or liability is or will be accepted by ANZ in relation to its accuracy or completeness.

The emerging hydrogen industry is a constantly evolving topic, and this means information quickly becomes out of date. Information produced in this handbook was collated in May 2021 to November 2023. Make sure you keep yourself up to date and informed on updates and any issues using current information.

If this communication has been distributed by electronic transmission, such as e-mail, then such transmission cannot be guaranteed to be secure or error-free as information could be intercepted, corrupted or contain viruses. ANZ does not accept liability for any damage caused as a result of electronic transmission of this communication.