XODUS

AUSTRALIAN HYDROGEN MARKET STUDY
SUPPLY CHAIN READINESS ASSESSMENT

OCTOBER 2024

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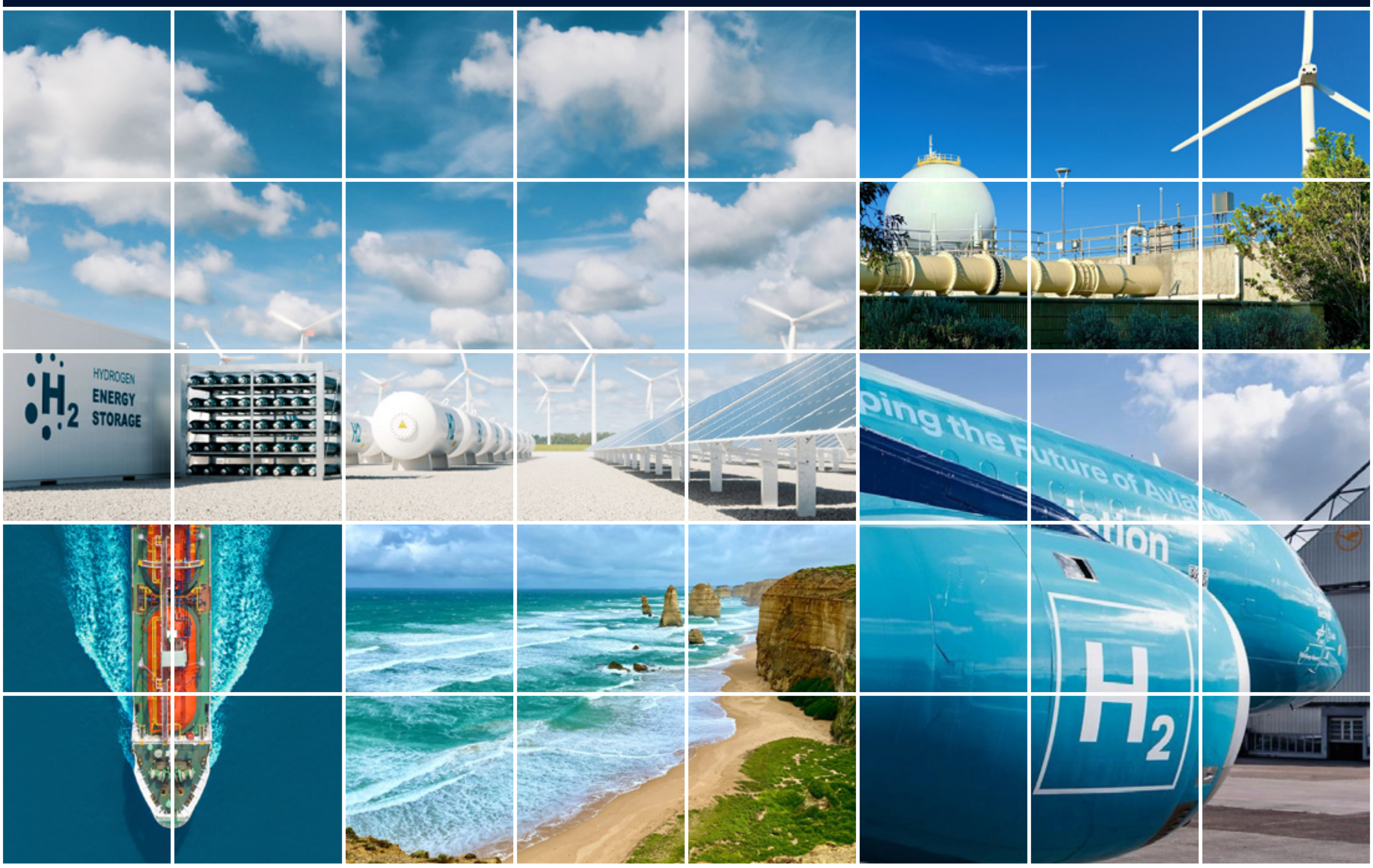

Foreign, Commonwealth & Development Office (FCDO)

UK Government

Xodus Group acknowledges the Traditional Owners of Country throughout Australia. We pay our respects to Elders past, present, and emerging, and recognise the pivotal role they hold in preserving our environment.

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FOREWORD

The UK has long been at the forefront of tackling climate change and decarbonising its economy. We were the first major economy to commit to Net Zero by 2050.

Achieving this goal requires an unpreceded transitional change in energy generation, storage and transmission. Our domestic achievements demonstrate that the UK is in a prime position to support and partner with international markets like Australia to help deliver their energy transition. The UK is amongst the countries leading the world's development of low carbon hydrogen, aiming for up to 10 GW of production capacity by 2030, providing greener, more flexible energy across power generation, transport, and industry.

According to International Energy Agency's (IEA) Global Hydrogen Review, total global hydrogen use was 95 Mt in 2022, while less than 1% of all hydrogen produced came from low emission sources – implying that hydrogen production and use was linked to more than 900 Mt of CO_2 emissions. This is almost three times the total CO_2 emissions for the UK in 2022.

More positively, the number of projects for low-emission hydrogen production is rapidly expanding. If all the projects announced globally are realised, then annual production of low-emission hydrogen could reach 38 Mt in 2030.

Like the UK, the Australian low carbon hydrogen production market is still in its formative stages. However, the Energy and Climate Change Ministerial Council (ECMC) has ambitions for Australia to be a global hydrogen leader by 2030, both for export and the decarbonisation of Australian industries. We are ready to support the development of a low carbon hydrogen sector in Australia. The UK Government commissioned Xodus to undertake a high-level overview of existing domestic capabilities in Australia that support the low carbon hydrogen sector, potential gaps where UK supply chain companies could provide support, and any barriers which could slow the roll out or impede UK industry participation.

It gives me pleasure to launch this report and to amplify the points outlined in the Executive Summary "The hydrogen industry in the UK is well established and UK companies are at the forefront of research and development of hydrogen technology. This strength means that UK companies are well positioned to export their products and services to growing hydrogen markets."

Louise Cantillon
British Consul General and Deputy Trade Commissioner Asia Pacific

1. EXECUTIVE SUMMARY

Australia stands out as a major player in the global hydrogen market, boasting the second-highest production capacity in development. With a multitude of potential projects and development opportunities, the country is poised for substantial growth beyond 2030, projecting an annual market revenue of $24 billion (£13 billion).

Recent commitments made during the Federal Budget to launch a hydrogen production tax credit of A$2/kg, further funding for the acceleration of large-scale green hydrogen projects through the Headstart Program, along with funding to attract investment in renewable hydrogen through the "Future Made in Australia Act", reiterate the importance of the industry to the country.

Several of Australia's strengths create a favourable landscape for hydrogen investment, including its proximity to key importing regions, very low sovereign risk, abundant renewable energy resources and the vast availability of low-intensity land, which allows for large-scale hydrogen infrastructure development.

This presents not only domestic opportunities but also invites mature international supply chains to participate in Australia's hydrogen success. The UK boasts an established hydrogen industry, with companies at the forefront of research and development. Leveraging this strength, UK companies are well-positioned to export their hydrogen-related products and services to growing markets like Australia.

To fully realise Australia's hydrogen potential, collaboration between the UK government, its supply chain, and Australian counterparts is essential. By working together, both nations can drive innovation, investment, and sustainable growth in the hydrogen sector.

1.1 Australian Hydrogen Landscape

As of 2024, Australia stands out as a leader in the global landscape for hydrogen production. The country possesses the second-highest capacity in development for the global market and is leading in the number of potential projects and development opportunities. Market projections indicate substantial growth by and beyond 2030 to a market worth $24bn in annual revenue (£13bn). Most of this growth and opportunity relates to green hydrogen production. Australia's hydrogen strengths are fortified through the proximity to key importing regions, very low sovereign risk, world class renewable energy resources and abundant low intensity land (minimising environmental impacts).

Australia benefits from a highly skilled work force, in areas such as liquified natural gas (LNG). Aside from the transferable skills and technical expertise, there are potential existing infrastructure that can be harnessed to accelerate the growth and development of hydrogen industry. The country also possesses abundant critical minerals crucial for manufacturing, positioning it favourably in the global supply chain. The majority of hydrogen developments are concentrated in Western Australia and are positioned for the supply of green hydrogen through electrolysis targeting export markets. This regional focus underscores the state's commitment to sustainable practices and positions it as a pivotal player in Australia's hydrogen industry.

Despite these strengths, Australia faces challenges with several gaps present in its hydrogen supply chain. There are limited manufacturing capabilities, attributed in part to the high cost of domestic labour, and a fiscal regime geared towards early innovation rather than scale. The small domestic market compounds this challenge, highlighting the need for strategic planning to bolster production. Additionally, as traditional supply routes across Europe and Asia encounter increasing constraints in their own energy transitions, Australia must navigate potential disruptions to ensure the continuity of its hydrogen production.

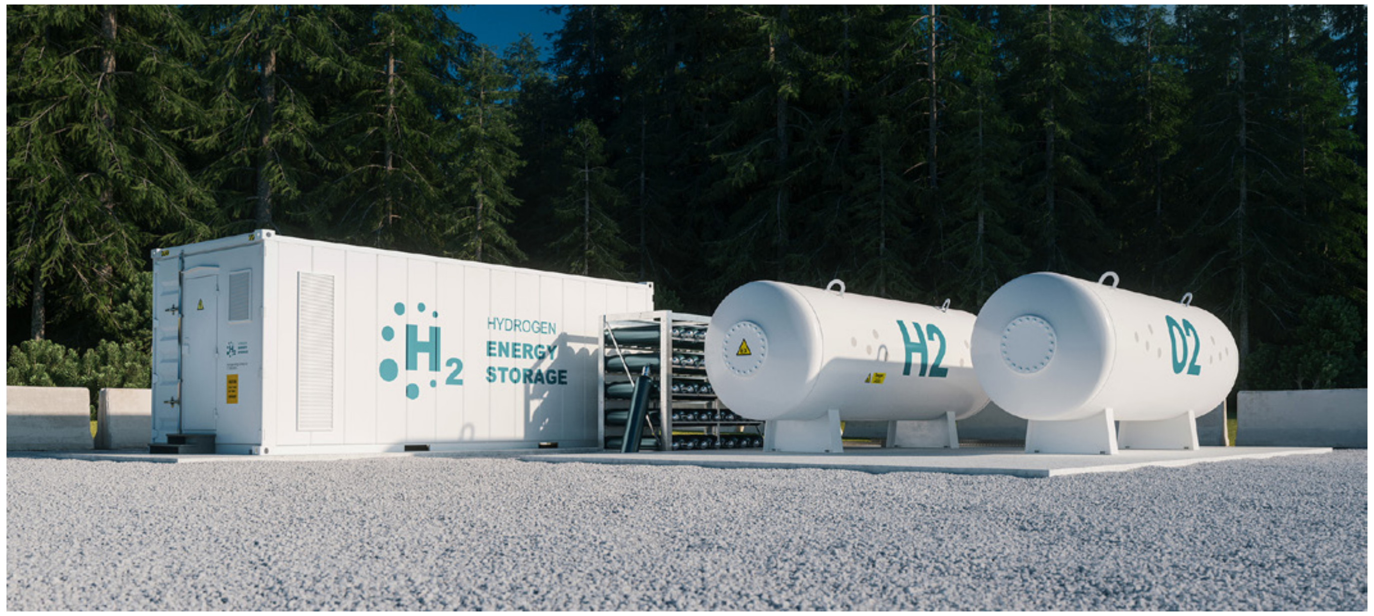
Despite this, Australia's attractiveness for developing energy infrastructure cannot be overstated, and it's rise to one of the world's largest LNG exporters in under two decades highlight the ability to achieve its potential as a major producer and exporter of hydrogen.

1.2 Infrastructure Challenges

Connecting Green Hydrogen

Green hydrogen is achieved through a process of electrolysis powered by renewable energies such as wind or solar. While Australia's energy system is rapidly transitioning towards a higher concentration of renewables, driven by significant solar and wind generation, grid infrastructure, particularly in the National Electricity Market (NEM), which covers all states except for Western Australia and the Northern Territory, will be hard-pressed to meet the transition. Planned transmission upgrades are also likely to face delays due to environmental and stakeholder approval challenges. Compounding this is the accelerated retirement of coal-fired generation and large increase in demand from electrification, both adding pressure to grid infrastructure.

While not a part of the scope of this study, the challenges with developing the upstream energy infrastructure in both renewable generation and energy transmission represent a large undertaking. Australia's Electricity Independent Market Operator (AEMO) has identified growth in electricity generation capacity in the National Energy Market under the "Hydrogen Superpower" scenario of 7.5x the current capacity by 2050.[1] This is likely to be beyond the capacity of current domestic operators and represents another opportunity for UK businesses to support the energy transition. This is true for the Western Australian (WA) electricity grid, where much of the Hydrogen capacity is planned and which has a maximum generation capacity of approximately 4 GW. This is as compared with an electrical capacity associated with green hydrogen developments of 35 GW expected by 2050. It is worth noting that some of the hydrogen production projects will generate their own power, either fully or partially.



[1] *Australian Energy Market Operator - 2022 Integrated System Plan*

1.3 Barriers to UK Businesses

Regulatory Challenges

Among the most significant barriers for UK developers wanting to enter the Australian hydrogen market are the current regulatory and policy uncertainty and in particular, the absence of a clear position on topics such as the minimum requirement for renewable energy to support hydrogen production and the certification process. Precedents set by the US, UK and Europe, requiring hourly matching of renewable energy and hydrogen production to qualify as green, could have a significant bearing on the bankability and international competitiveness of Australian Hydrogen.

Revenue Certainty

The US based Inflation Reduction Act's provisions for hydrogen[2] could also pose a risk to the pace of project development within Australia. At present, the availability of Australian production-based subsidies is limited, which may lead to funding of projects being heavily reliant on international demand side support such as through the "Price Gap Mechanism" under Japan's current energy transition policy.[3] Securing initial revenue certainty through long term Contracts for Difference (CfDs) are a prerequisite for securing the financing needed for large scale projects. Australia's Headstart Funding of $2bn is not likely to support more than a 1 GW of production capacity, which represents just over 1% of developments planned.

Carbon Policy

In the long-term, a meaningful carbon policy that establishes a higher tax or price on carbon emissions is needed for hydrogen projects to be self-sustaining, such that alternative fuels with higher carbon emissions are appropriately priced against green alternatives such as green hydrogen. This is an area where work is needed within Australia, as at present, the penalties for emissions are behind Europe's carbon trading market and provide no position beyond 2030. A greater catalyst for the development of Australian green alternatives, such as green hydrogen, is if Australia's largest energy trading partners of Japan and South Korea pivot towards a carbon border tax similar to the European Union's Carbon Border Adjustment Mechanism (CBAM).[4]

Additional Challenges

For UK product and manufacturing businesses with an interest in the Australian market, key challenges include the domestic fiscal regime, with Australia having the one of the highest corporate tax rates among aspiring hydrogen exporters. The regulatory framework for the hydrogen industry is evolving slowly, with efforts underway to establish a national strategy and framework. However, compliance with local regulations and standards can pose challenges for companies seeking to enter the Australian market. In particular, the differing approaches to Environmental approvals between States and Territories, in addition to the interaction with Federal Legislation, introduces further time and complexity for developers. Additionally, Australia's geographical distance, lack of existing infrastructure, and unique environmental conditions such as high levels of biodiversity and extreme weather conditions from state to state present logistical and operational hurdles for companies.

Services businesses will likely face challenges securing local skilled labour due to Australia's small and competitive domestic labour force and high cost of employment.

Despite these challenges, there is a significant scale of opportunity in Australia for UK companies willing to invest the time in understanding the regime and positioning their businesses to enter the market.

[2] *Inflation Reduction Act 2022 (Section 45v)*

[3] *Green Transformation (GX) Ministry of Economy, Trade and Industry Japan. The Hydrogen "Price Gap Mechanism" is a Government funded scheme which aims to cover the difference between the commercial cost of production and the price buyers are willing to pay, generally driven by grey hydrogen or the cost of the alternative fuel depending on the end use of hydrogen.*

[4] *'Carbon Border Adjustment Mechanism', European Commission, https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en*

1.4 UK Strengths

The hydrogen industry in the UK is well established and UK companies are at the forefront of research and development of hydrogen technology. This strength means that UK companies are well positioned to export their products and services to growing hydrogen markets.

Several prominent UK-based companies are actively engaged in electrolyser manufacturing and deployment, with ITM Power, Ceres, and Johnson Matthey leading the market. ITM Power has established itself as a major player, developing large-scale electrolyser systems for industrial and renewable energy applications. Through its Australian subsidiary, ITM Power Pty Ltd, set up in 2017, the company has contributed to various projects in Australia, including the Christmas Creek Renewable Hydrogen Mobility Project and the Renewable Hydrogen Production and Refuelling Project at Bulwer Island. Meanwhile, the Pure Energy Centre, based in Shetland, has a notable track record in off-grid hydrogen electrolyser systems and has installed systems globally.

According to a report commissioned by the Intellectual Property Office,[5] over 300 patents have been filed in the UK relating to low carbon hydrogen. Furthermore, the same report indicates that of the low carbon hydrogen patents invented in the UK many have been registered in the US and China among other countries, suggesting the export of patents for use in manufacturing. Given Australia's relatively high cost as a destination for manufacturing, this should be considered a key strategy for exporting skills and knowledge in addition to physical products to support the Australian Hydrogen Industry. By way of example, Intelligent Energy, headquartered in the UK, has accumulated over 800 patents, primarily focused on hydrogen fuel cell development and various aspects of the hydrogen supply chain.

[5] *Intellectual Property Office UK – "Low Carbon Hydrogen" 2021*

1.5 Key Opportunity Areas Identified

The study consisted primarily of a desktop analysis of existing suppliers and opportunities in Australia based on the agreed hydrogen supply chain taxonomy. A Red, Amber, Green (RAG) assessment was delivered to quantify and highlight these opportunities by systematically assessing the gaps in the current Australian supply chain capability for hydrogen and subsequently assessing the UK's relative strengths in these areas.

This analysis was also supplemented by input from a variety of stakeholders through direct interviews, informal discussions, and survey results in relation to the Australian hydrogen supply chain including the following groups:

- Australian hydrogen developers
- Development engineers
- Manufacturers
- Policy makers

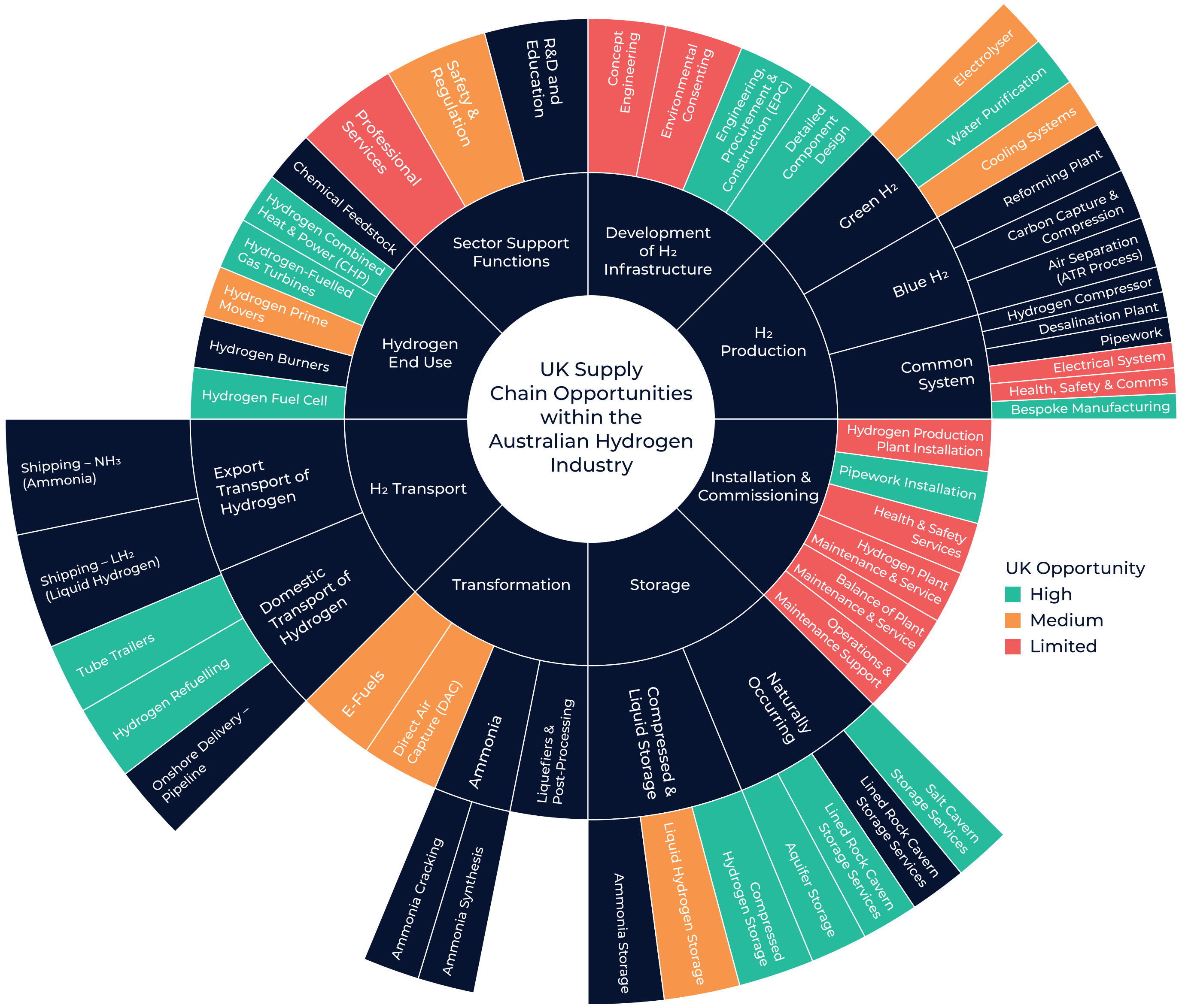


Figure 2-1 Supply chain map

From the RAG assessment of the UK and Australian hydrogen supply chains, four main areas of opportunity in Australia for UK companies have been identified:

OPPORTUNITY AREA	UNITS	OPPORTUNITY
1. Hydrogen electrolysis manufacturing	$/£	A$180bn / £100bn
2. Hydrogen Fuelled Gas Turbines	MW	14,600 MWs Gas Turbines
3. Hydrogen Fuel Cells	#	Discussed in section 4 Supply Chain Analysis
4. Transportation	#	

Table 2-1 Priority UK opportunity areas

The additional second order priority areas were identified during the RAG assessment:

5. Refuelling stations for H_2 vehicles
6. Detailed component design
7. Conversion of existing gas infrastructure for Hydrogen use and transportation.
8. Hydrogen storage.

2. INTRODUCTION

2.1 Background

Australia's attractiveness as a destination for producing low carbon hydrogen export is widely recognised by investors and developers alike. This is owing to its world class onshore renewables, history of developing large complex export industries such as LNG, low sovereign risk, abundant low intensity land and trade relations with key hydrogen markets and energy import dependent countries.

As evidence of Australia's hydrogen potential, it currently ranks first globally in terms of quantity of developments, with over 150 projects, and second in terms of global production capacity, with over 12,000 ktpa (90 GW) in progress[6]. Based on the National Hydrogen Roadmap[7] and a long-term price target of $2.0/kg (£1.1/kg), the estimated market size could reach $24bn per annum (£13bn) in revenue. The investment in green electrolysis equipment alone to meet market demand is estimated at $180bn (£100bn) notwithstanding the capital needed to develop supporting upstream and downstream infrastructure.

Hydrogen projects in Australia are also being developed with several domestic applications in mind, such as the production of ammonia nitrate for agriculture and the mining sector along with long-distance heavy haulage, where the use of hydrogen could compare favourably with electric vehicles. Additionally, highly industrialised countries such as Japan, South Korea, and Singapore are all actively pursuing strategies to reduce their carbon emissions and hydrogen is seen as a promising alternative to fossil fuels in sectors such as transportation, industry, and power generation, where decarbonisation is particularly challenging. Hence, Australia's largest hydrogen opportunity lies in export to those markets relying on it to assist with their decarbonisation commitments under the Paris Agreement.

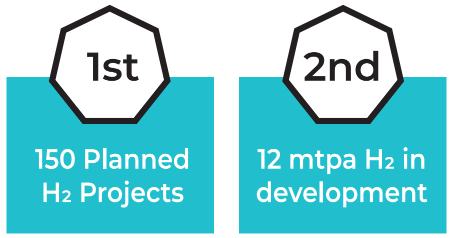
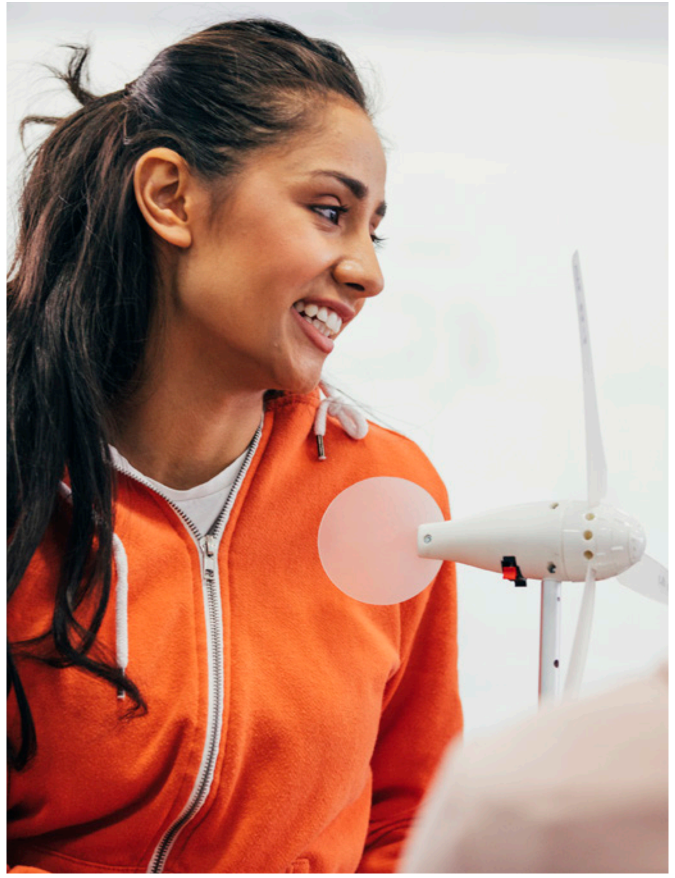


Figure 1-1 Australian hydrogen development global ranking

Despite Australia's potential, the largest electrolyser for green hydrogen currently operating in the country has a capacity of 1.25 MW only and is used for blending hydrogen into the natural gas network in South Australia. Australia is also one of a handful of aspiring hydrogen exporters, along with the USA, Canada, Chile, The Middle East and parts of Africa all looking to supply key markets in Asia and Europe. For this reason, Australia must recognise that its current dominance in LNG export may not directly translate to a similar position in hydrogen export without the necessary development of the hydrogen supply chain. The challenge remains therefore for Australia to develop domestic capability and establish a hydrogen supply chain to meet the market demand for global hydrogen. This will require a combination of far-reaching domestic policy support and assistance from other countries to supplement existing capacity.

[6] *GlobalData – Low Carbon Hydrogen Database*

[7] *CSIRO - National Hydrogen Roadmap*



The UK and Australia share a long-standing trade relationship as members of the Commonwealth and a free trade arrangement that exempts over 90% of imported goods from the UK to Australia from import duty. The UK also holds a strong track record in exporting knowledge, skills and intellectual property to the rest of the world holding over 300 of the world's low carbon hydrogen patents according to a study prepared for the UK Intellectual Property Office[8]. In the adjacent electricity sector, Octopus Energy (UK) have successfully secured a partnership with Origin Energy to harness the use of its technology platform "Kraken", and partnerships of this nature represent the level of innovation and cooperation that can be realised when companies from both countries collaborate.

[8] *Intellectual Property Office UK – Low-carbon Hydrogen*

3. HYDROGEN IN AUSTRALIA

3.1 A Global Perspective

Hydrogen is forecast to become a prominent part of the global future energy mix by 2050 and will account for as much as 12% of the world's energy use compared to just 0.1% today[9]. The vast majority of this expected to be produced as green hydrogen. With this shift towards green hydrogen in coordination with the broader tilt towards a largely renewable energy system, energy supply will see a geographical shift. Energy supply and trade routes have historically been dictated by the coal, oil, and gas commodities, with their abundance constrained by specific geological locations. Hydrogen supply will be distributed by the ability of regions to harness strong renewable resources, which is uncorrelated to coal, oil, and gas abundance.

Australia is poised to play a significant role in green hydrogen supply, with 20% of global electrolyser capacity development being planned in the country[10]. With its advantages of high renewable resource potential, proximity to some of the largest energy consumers and existing trading partners, namely Japan and South Korea, and overall stable, low geopolitical risk, Australia recognizes the potential to expand its role even further in the hydrogen economy. Geographical cost competitiveness analysis echoes this advantage in the long-term. However, realising this potential will be a significant undertaking, necessitating proactive government policies, active collaboration with the industry, and major foreign investment.

[9] 'A Quarter of Global Hydrogen Set for Trading by 2050', IRENA, https://www.irena.org/news/pressreleases/2022/Jul/A-Quarter-of-Global-Hydrogen-Set--for-Trading-by-2050

[10] 'Global Hydrogen Review 2023', IEA, https://www.iea.org/reports/global-hydrogen-review-2023.

[11] 'The Green Hydrogen Economy', PwC, https://www.pwc.com/gx/en/industries/energy-utilities-resources/future-energy/green-hydrogen-cost.html

3.2 Australian Hydrogen Potential

Australia has over 150 hydrogen projects in development, which total over 12 million tonnes of annual hydrogen production and represents a potential market of A$24 billion annually by 2032 based on current cost of hydrogen guidance by ARENA[12]. As illustrated in Figure 3-1, most projects in development are planning green hydrogen production and are situated close to the coast to capitalise on Australia's high renewable resource and export advantage. By production capacity, Western Australia has the largest development interest with over 70% of all projects located in the state.

Estimated projections indicate that green hydrogen production in Australia is becoming increasingly cost-competitive as compared with blue hydrogen. Electrolyser costs are expected to see a significant reduction of 40% by 2030, due to improvements in technology and higher learning rates[13]. Additionally, the cost of solar and wind electricity generation is also expected to decrease by 20% by 2030[14]. Electrolysers and electricity components comprise over 50% of green hydrogen project costs, therefore these expected decreases highlight the growing economic viability of green hydrogen production in Australia, given the limited cost reductions expected for blue hydrogen which is more established technology. Steam methane reforming (SMR), which is one of the production methods expected for blue hydrogen, is not forecast to undergo large cost reductions, given it is the predominant method for most of the hydrogen used globally today.

Embracing green hydrogen aligns with Australia's commitment to sustainable development and reducing carbon emissions. By harnessing abundant renewable energy sources like wind power for hydrogen production, Australia can mitigate environmental impact, enhance energy security, and position itself as a global leader in clean energy innovation. Therefore, transitioning to green hydrogen represents a strategic and forward-thinking approach for Australia's sustainable future.

Despite the significant push by industry to move forward with the development of hydrogen projects, challenges exist which will impede some project's ability to succeed and at a pace that may differ to developer optimism. Clear known unknowns include the pace of infrastructure development, such as transmission and ports, as well as the availability of key resources such as water for green electrolysis and renewable generation capacity, as required by 96% of projects.

[12] 'Australia's pathway to $2 per kg hydrogen', ARENA, https://arena.gov.au/blog/australias-pathway-to-2-per-kg-hydrogen/

[13] 'GenCost 2023-24', CSIRO, https://www.csiro.au/-/media/Energy/GenCost/GenCost2023-24Consultdraft_20231219-FINAL.pdf

[14] Ibid.

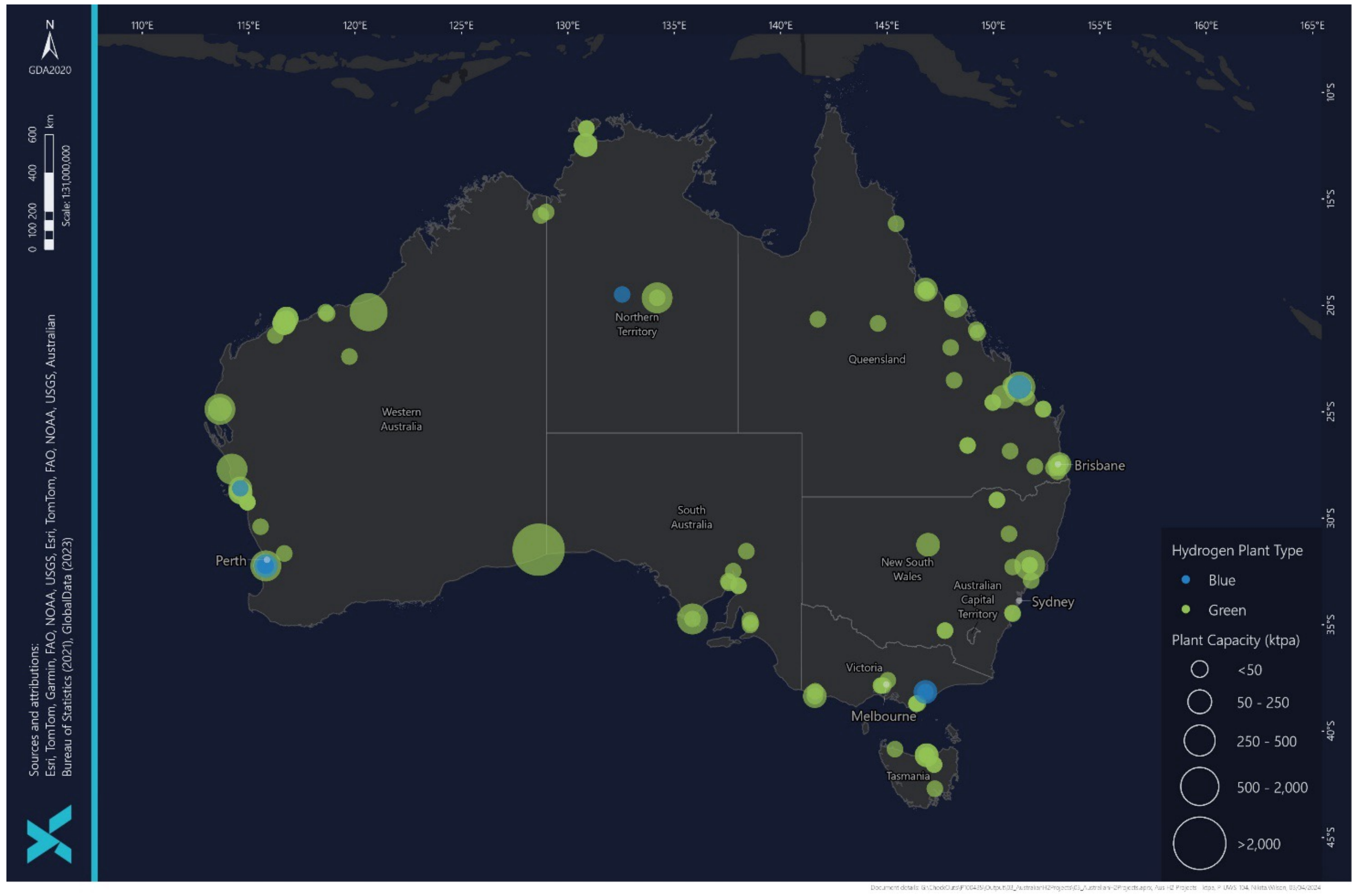


Figure 3-1 Map of Australian hydrogen projects

State Analysis

Each Australian State Government has announced plans for developing hydrogen industries for both domestic and export purposes. Collectively, State Governments have issued hydrogen related funding of over A$13 billion[15]. Figure 3-2 and Figure 3-3 summarise the key funding and hydrogen targets for each state.

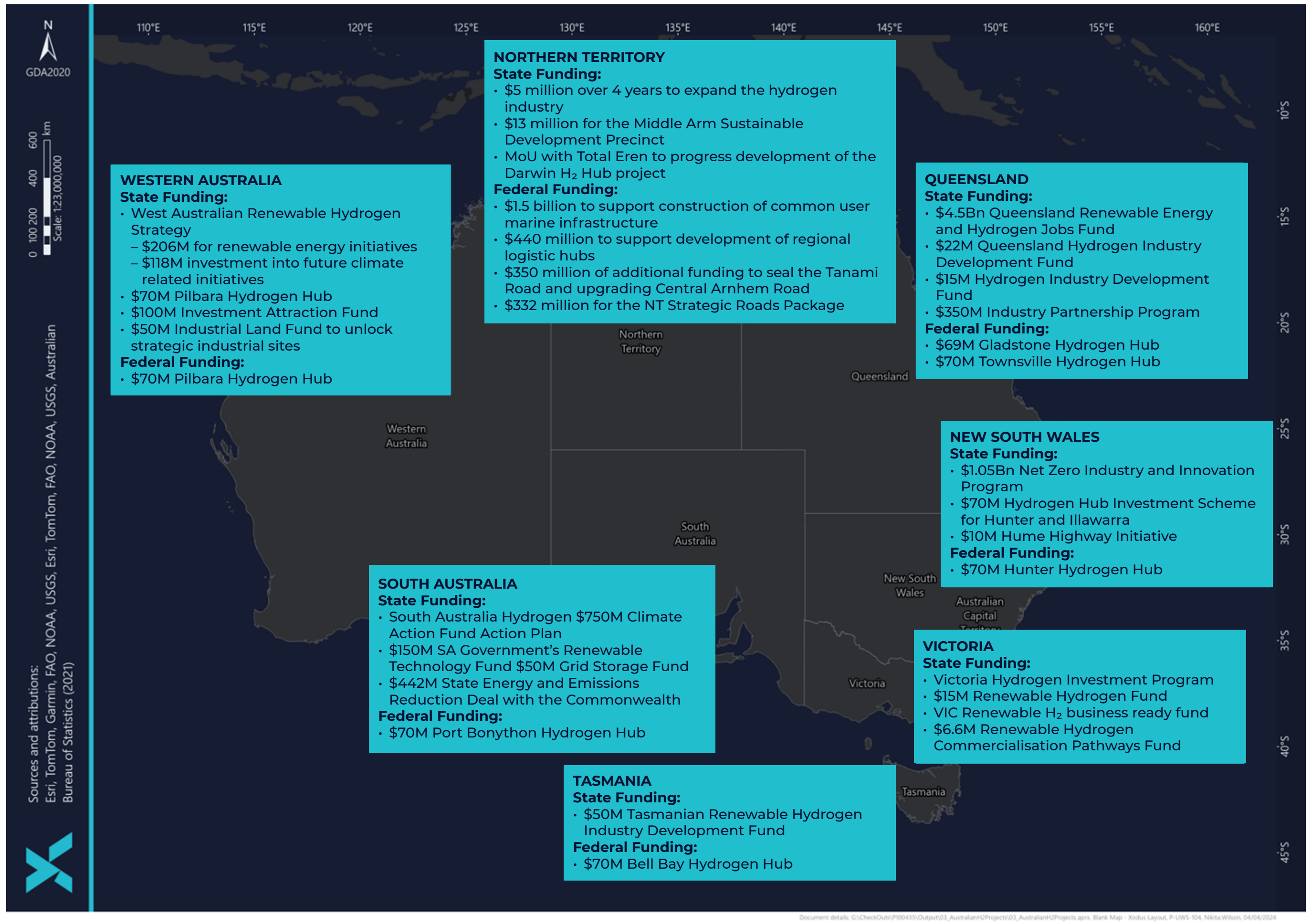


Figure 3-2 State and Federal Government funding by state

[15] www.dcceew.gov.au/sites/default/files/documents/state-of-hydrogen-2022.pdf

Figure 3-3 State government hydrogen targets

Hydrogen Developments

To better understand the timing around emerging hydrogen production in Australia, Xodus has analysed the development pipeline of publicly announced hydrogen projects. GlobalData's Low Carbon Hydrogen Database was used in this process to provide a single data source to build the analysis from. The database includes key project information including operational start dates, development status, production size, hydrogen type, project ownership, locations and project costs where available.

Timing of Hydrogen Development

Industry is signalling a fast development of hydrogen projects with ambitious timelines to first production. Dates for Final Investment Decisions are not realistic for several projects anticipating first production in the short to medium-term. Xodus applied its knowledge of development processes and decision stage gates to adjust the outlook for first hydrogen production.

Figure 3-4 illustrates first hydrogen production commencing in 2027, with long-term production increases to occur beyond 2030. This results in a smaller development pipeline in the short to medium term compared to industry's ambitions and decreases the size of the opportunity for supply chain services and over the same time horizon.

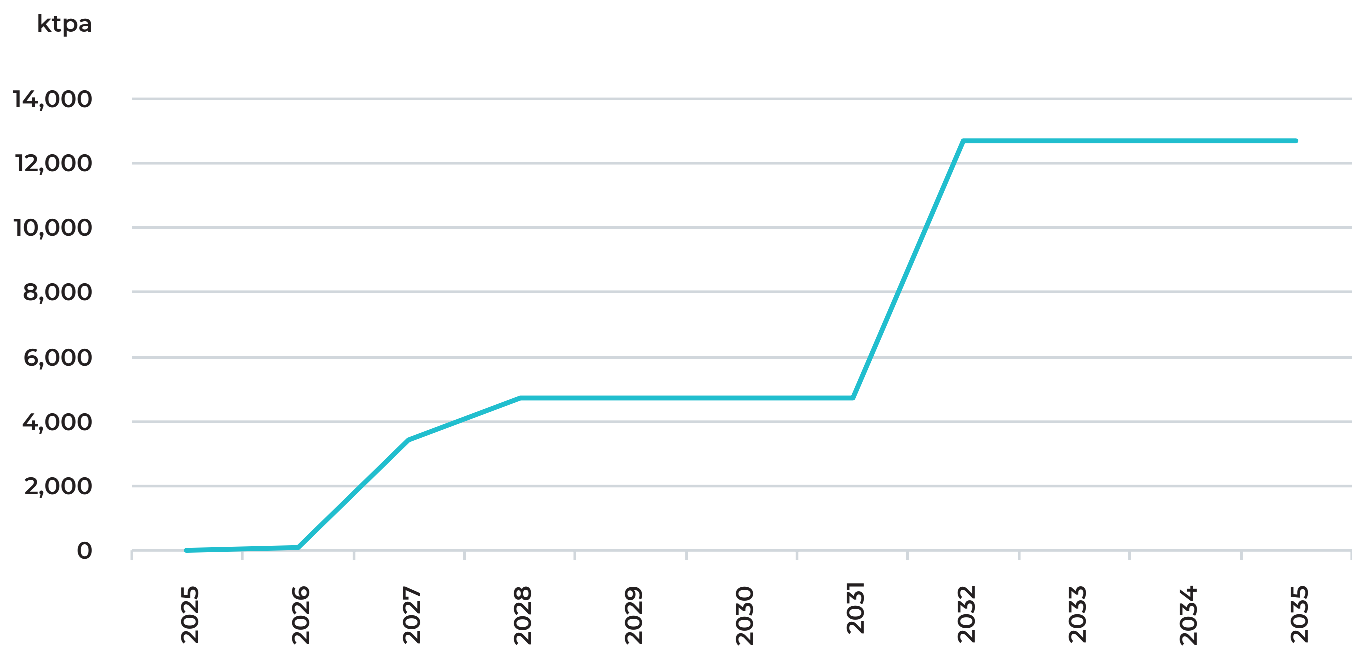


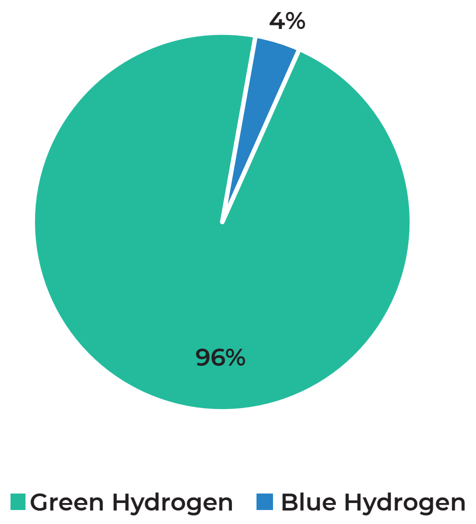
Figure 3-4 Australian hydrogen production development outlook

Size of Blue Hydrogen Production Market

Blue hydrogen consists of a very small portion at 4% of Australia's development pipeline, therefore, supply chain opportunities are limited at present, see Figure 3-5. The opportunity to develop blue hydrogen projects is constrained by the need to decarbonise existing long-term assets that are expected to have a medium to long-term future, to justify the upfront investment, for example Australian LNG operations. Although Australia is currently a leading LNG exporter, very few projects have been announced by their operators, which are mostly large International Oil Companies (IOCs). However, some of Australia's most mature hydrogen projects are planning blue hydrogen production in small quantities. The GEAP Hydrogen Project, based in Queensland is currently in construction and by 2026, the project plans to produce 91 thousand tonnes of blue hydrogen annually to power hard to abate manufacturing.

Size of Green Hydrogen Production Market

Most of Australia's hydrogen opportunity consists of green hydrogen via electrolysis, with Australia's hydrogen development pipeline consisting of over 12 million tonnes of annual production. Based on Xodus' analysis, production is expected to ramp up from 2027 and again in 2032, as illustrated in Figure 3-5. Despite the large industry potential represented by green hydrogen projects in development, over 70% are still in the feasibility or FEED (Front-End Engineering and Design) stage. This reiterates the infancy of Australia's future hydrogen industry and the uncertainty of the industry's potential.



Opportunity for Supply Chain

Most supply chain opportunities exist in green hydrogen. Using Figure 3-6 as a guide, over the next decade a range of supply chain capabilities will be needed at different times to service the green hydrogen industry. In the short to medium-term, concept and detailed engineering along with environment and consenting services will be required to mature concepts through development stage gates as well as obtaining necessary stakeholder and environmental approvals.

Engineering, Procurement and Construction (EPCs) will also be required to service projects nearing production in the first wave of developments. Demand for EPCs is likely to increase towards the end of the decade if the large pipeline of projects in feasibility and FEED stage are to achieve a Final Investment Decision (FID). Similarly, demand for operations and maintenance (O&M) services will ramp up from 2030 onwards once further projects move into operational phases.

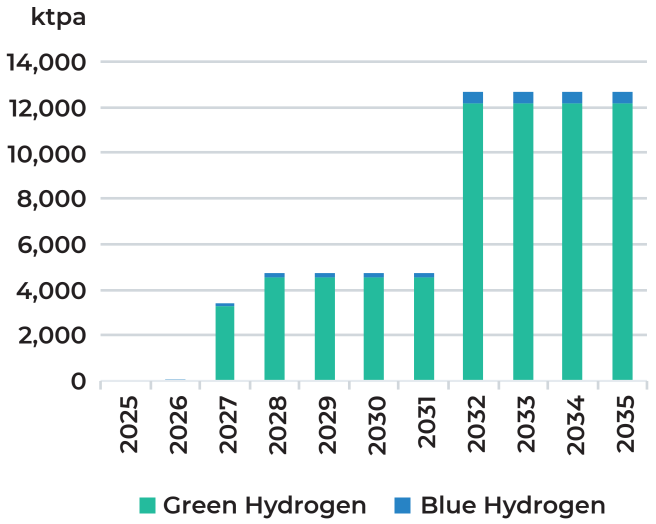


Figure 3-5 Australian development pipeline of blue and green hydrogen projects

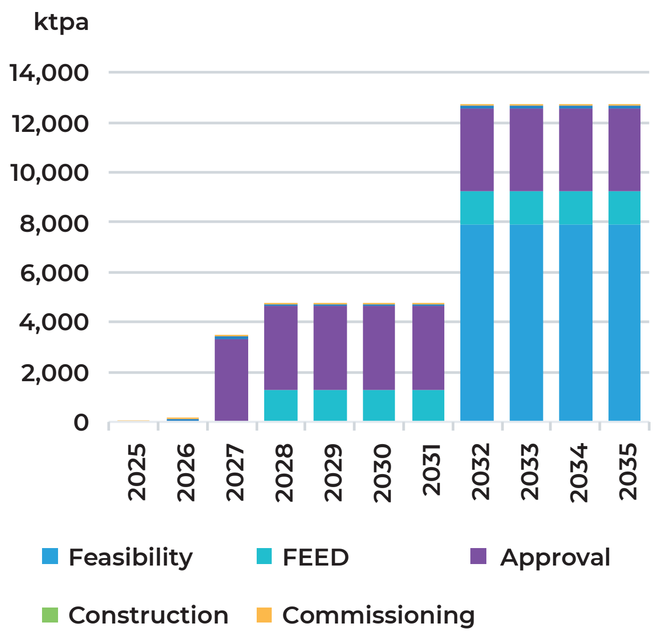


Figure 3-6 Pipeline of Australian hydrogen projects by development stage

3.3 Energy Outlook

Australia's energy system is currently undergoing a rapid transformation to a high concentration of renewable energy, with rapid additions of solar and wind generation over the last decade. The grid in both the east coast and west coast namely the National Electricity Market (NEM) and the South West Interconnector System (SWIS) will be strained by this transition. Significant transmission upgrades are planned, however challenges relating to environmenal and stakeholder approvals are impacting the timing of expansion. In addition to the growth in renewables, coal fired generation which accounts for 57% and 30% of NEM and SWIS capacity respectively, is planned for a fastracked retirement, placing further pressure on grid infrastructure upgrades and the adoption of suitable storage replacements[16].

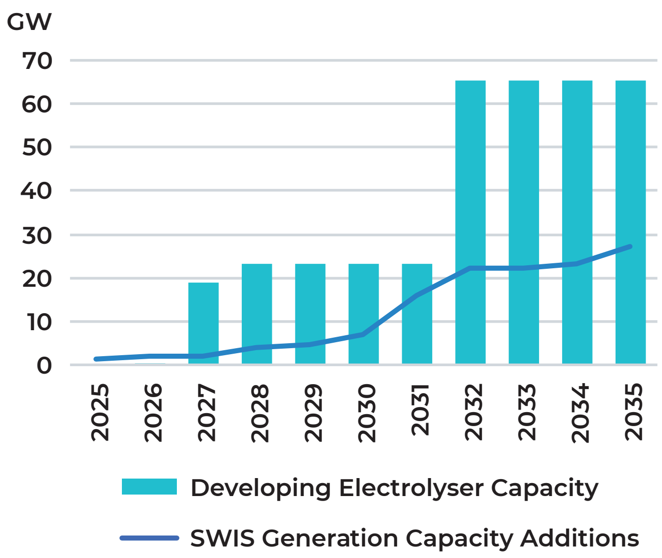


Figure 3-7 Developing green hydrogen electrolyser capacity in Western Australia and forecasted electricity generation additions for the SWIS

Renewable electricity costs are a signficant part of the hydrogen cost stack and in mosts cases over 50% of the delivered production cost for green hydrogen. To add further complexity to the energy system planning, generation required to meet hydrogen electrolyser demand is outpacing regulator forecasts of renewable generation additions. Power generation required for green hydrogen electrolyers is expected to be 35 GW by 2030. In Western Australia, where 70% of all projects are situated, over 23 GW of electrolyser demand is needed by 2030 and only 7 GW of capacity for renewable additions is expected for the SWIS, as illustrated in Figure 3-7. This current situation highlights that potential developers cannot rely solely on grid connections to meet electricity needs and standalone, behind-the-meter electricity solutions should be prioritised.

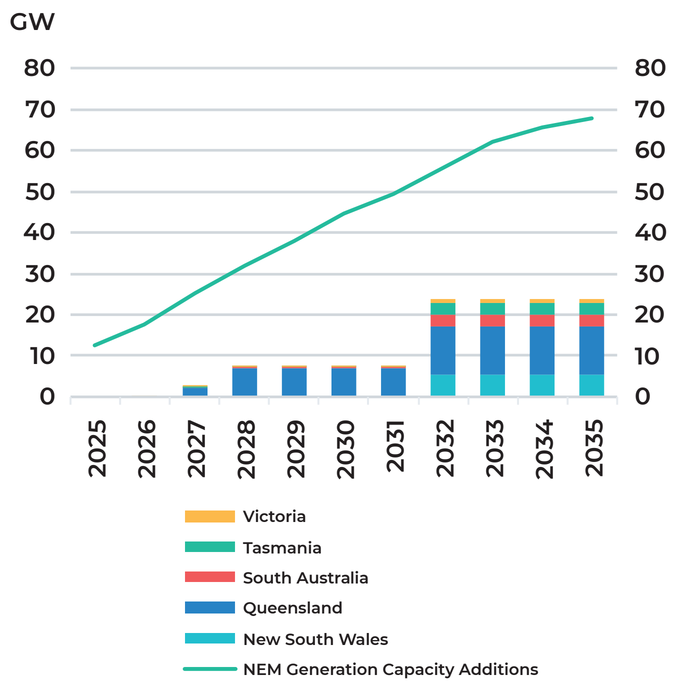


Figure 3-8 Developing green hydrogen electrolyser capacity by state and forecasted electricity generation addition for the NEM

[16] Australian electricity generation statistics', OpenNEM, opennem.org.au

3.4 Australian Hydrogen Hubs

The Australian Government is investing over A$500 million in "Hydrogen Hubs" to accelerate large-scale development of the hydrogen industry through co-location of producers, users, and exporters as well as synergies through sector coupling. Funding for hydrogen hubs for regional areas has been awarded.

The following provides insights into some of the key hubs being developed including several notable developers to highlight. The map in Figure 3-9 provides the location of major hydrogen hubs across Australia and projects in the surrounding area.

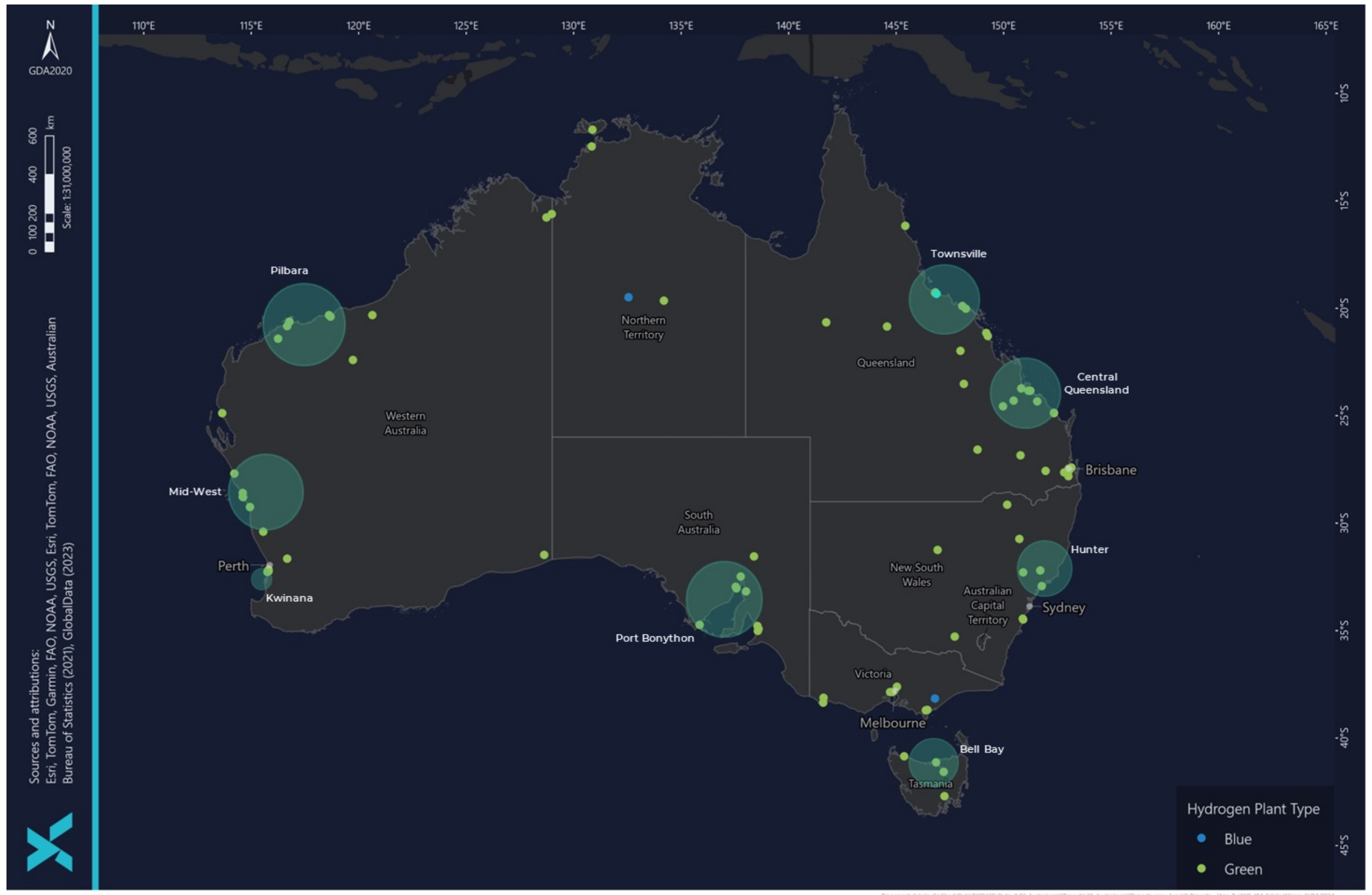


Figure 3-9 Indicative hydrogen hubs and project locations

Kwinana in Western Australia

The Kwinana Hub / Western Trade Coast is an industrial precinct that includes deep-water bulk port facilities, road and rail networks, utilities, and synergies among industrial areas. The Kwinana-Rockingham Industrial Area is a focus area of the region due to its large industrial cluster including mineral refineries, power stations, and supporting industries. The Western Australian Government has announced its commitment to transform the region to a global advanced industries hub, focussing on renewable energy, future minerals processing, and shipbuilding.

HUB PARTICIPANTS	SUMMARY
BP	H_2Kwinana was developed as a conversion of bp's Kwinana refinery facility which was closed. H_2Kwinana has been shortlisted by ARENA for their Hydrogen Headstart Program. The project aims to produce green hydrogen for domestic and export demand as well as produce biofuels.
Woodside Energy	Woodside Energy is proposing to develop a phased, commercial scale hydrogen and ammonia production plant, H_2Perth, to support domestic and international users in the Rockingham Industrial Zone. The facility will produce ammonia through gas reforming with CCS and electrolysis.

Pilbara in Western Australia

The Pilbara region is in northern Western Australia with major settlements such as Port Hedland and Karratha with key port facilities. The Pilbara region is dominated by the mining and energy industries. It has been identified as a Regional Hydrogen Hub location by the Australia Government. Its abundant natural resources and existing industrial infrastructure make it an attractive location for large-scale hydrogen production. The Australian and West Australian Governments have announced a combined agreement of $140 million to support the development of a hydrogen hub in the Pilbara. The hub is expected to become operational in 2028 with a pipeline of projects that could enable the production of 492,000 tonnes of hydrogen per annum.

HUB PARTICIPANTS	SUMMARY
ENGIE Renewables	The Yuri Renewable Hydrogen project aims to produce green hydrogen to replace some of the hydrogen produced through steam methane reforming at its Yara Fertilisers' ammonia site. The project received $3 million in grant funding through the Western Australian Government's Investment Attraction Fund..
BP	The Australian Renewable Energy Hub (AREH) aims to construct a renewable energy facility to provide power to the region and produce green hydrogen for the domestic and international users.
Fortescue	The project will produce hydrogen through the Chichester Solar Gas Hybrid Project. A green hydrogen refuelling station will be constructed within the project facilities. Fortescue aims to replace its fleet of diesel coaches with full-size hydrogen fuel-cell powered coaches.

Mid-West in Western Australia

The Western Australian Government is developing a Strategic Industrial Area (SIA) within the Mid-West. Specifically, the Oakajee SIA is located near Geraldton, a coastal city with port facilities. The SIA is planned to be developed as a heavy industrial area with the potential development of a deepwater port. The SIA will include a "buffer area" which can be used to accommodate renewable energy technologies such as wind and solar. Six proponents have been awarded a land allocation at Oakajee. The Western Australian Government has committed $55 million to the Oakajee Strategic Industrial Area. The Mid-West will also accommodate projects outside of Oakajee, with several other projects announced in the areas around the Mid-West.

HUB PARTICIPANTS	SUMMARY
BP	Located in the Oakajee SIA, project GERI proposes to develop demonstration and commercial-scale ammonia production through renewable hydrogen.
Mitsui & Co	A feasibility study is being undertaken to assess carbon, capture, and storage possibilities in Western Australia. This is being done in support of an ammonia production plant which will produced from blue hydrogen.
Pilot Energy	Pilot proposes the production of hydrogen and ammonia as well as fully integrated CO_2 storage in the Cliff Head offshore oil field.
Kinara Power	Located in the Oakajee SIA, Project Astra proposes to generate green ammonia through 2 GW of solar and wind.
Copenhagen Infrastructure Partners	Located in Kalbarri, Project Murchison aims to generate green hydrogen through solar and wind. The hydrogen will be converted into ammonia and will be exported. This project has been shortlisted by ARENA for their Hydrogen Headstart Program.

Hunter in NSW

The Hunter region has been identified as a major hydrogen hub development opportunity by the New South Wales Hydrogen Strategy. The Hunter region is home to economic activity centres such as mining, agriculture, manufacturing, freight, and logistics which could be potential end use applications. The Port of Newcastle is a deepwater port and major freight and logistics centre in the Hunter region. The News South Wales Government has announced $150 million in grant funding as part of its Hydrogen Hubs Initiative to support commercial-scale green hydrogen projects.

HUB PARTICIPANTS	SUMMARY
Origin Energy	Origin is a leading Australian gen-tailer that will soon retire 2.9 GW of firm coal generation and is investing in new energies such as hydrogen. Origin is developing the Hunter Valley Hydrogen Hub, which is currently in FEED and aims to harness Origin's existing generation portfolio and a 55 MW electrolyser in the initial phase.
AGL, Fortescue	The joint project aims to combine solar thermal storage, grid-scale batteries, wind, and pumped hydro located at the site of retired coal-fired power stations Liddell and Bayswater. The feasibility study is investigating the potential for a hydrogen facility of between 150 MW to 2 GW for both domestic and export use.

Bell Bay in Tasmania

The Tasmanian Green Hydrogen Hub Project at Bell Bay is a catalyst for the state's hydrogen economy. The hub will establish common access infrastructure covering electricity transmission, water, and ports, by utilising its considerable land availability, access to a deep-water port and 100% renewable power supplies from wind and hydroelectric sources. The hub initiative is led by the Tasmanian Government and includes consortium partners comprising of key regional proponents TasNetworks, TasWater, TasIrrigation, TasPorts and the Bell Bay Advanced Manufacturing Zone. Table 3-1 provides a summary of notable hydrogen project developments at the hub.

HUB PARTICIPANTS	SUMMARY
Woodside Energy Group Ltd	H_2TAS focuses on green hydrogen and has completed feasibility studies and secured a long-term land lease.
ABEL Energy	ABEL Energy is developing a 240 MW renewable hydrogen and hybrid e-methanol facility at the Bell Bay Advanced Manufacturing Zone.
LINE Hydrogen	The project, located in George Town, proposes to produce green hydrogen to replace diesel for heavy haulage, light motor vehicles, and mobile power providers.

Gladstone and Townsville in Queensland

The Central Queensland region includes Mackay, Gladstone, and Rockhampton cities. Gladstone is a central area of the region due to its hydrogen industry development and Port. The Gladstone State Development Area is dedicated to industrial development adjacent to the Port of Gladstone. The area is also in proximity to other industrial plants such as an alumina refinery, chemical manufacturing complex, LNG export businesses and a waste oil refining plant. The region will support the Central Queensland Renewable Energy Zone.

The Townsville region is a logistics and processing hub for critical minerals and metals. In addition to mining activities, the region is almost home to defence and agricultural activities. The Port of Townsville is a large port with export potential to Asian markets.

HUB PARTICIPANTS	SUMMARY
Aurizon	Aurizon, a rail freight company, is planning the Hydrogen Mobility Project, which aims to trial up to four hydrogen fuel cell electric trucks and construct a hydrogen refuelling station for heavy vehicles in Townsville.
ABEL Energy	ABEL Energy proposes a green hydrogen plant that will produce e-methanol for the domestic and international market. The project will consist of the renewable power generation assets and the hydrogen production facility.
Ark Energy	The initial phase of the SunHQ Hydrogen Hub will involve a electrolyser co-located at Sun Metals refinery. The electrolyser will be powered by a solar farm and will produce hydrogen for diesel fuel replacement of its fleet. Ark Energy aims to procure hydrogen fuel heavy haulage vehicles for short haul operations between the Port of Townsville and Sun Metals refinery.
Australian Gas Networks (AGN) – Australian Gas Infrastructure Group (AGIG)	The Hydrogen Park Gladstone aims to produce green hydrogen which will be blended with natural gas and supplied to residential homes and businesses on the Gladstone gas network.
Sumitomo	The Sumitomo Gladstone Green Hydrogen Project will produce green hydrogen to deliver to the Rio Tinto alumina refinery and any other domestic parties, with potential for export.
Stanwell Corporation	The Central Queensland Hydrogen Project is proposing the development of a green hydrogen facility near Gladstone and liquefication plant at the Port of Gladstone to export liquid hydrogen to the Japanese market as well as ammonia for domestic and export markets. This project has been shortlisted by ARENA for the Hydrogen Headstart Program.

Port Bonython in South Australia.

Port Bonython has been identified as a hub to support the hydrogen industry in South Australia with wind and solar resources as well as access to a deepwater port. In 2024, the South Australian Government announced that it had signed development agreements with five hydrogen hub partners. These agreements provide a pathway for developers to secure leases on land at Port Bonython through the creation of a multi-user industrial and export facility.

HUB PARTICIPANTS	SUMMARY
Amp Energy	The Cape Hardy Green Hydrogen Project are in support of the development of a hydrogen and ammonia facility to be integrated with a green manufacturing and industrial precinct. The selected concept is an initial 1 GW of electrolyser capacity with plans to expand to 5 GW.
H2U	The Eyre Peninsula Gateway Project aims to produce green ammonia for domestic supply and potentially expand to an export supply. The full-scale development will supply 120 tonnes of ammonia per day.
AGL	AGL Energy is leading a consortium to determine the feasibility of developing a green hydrogen production facility at AGL's Torrens Island site. AGL is planning to develop an integrated industrial hub once its Torrens A and B power generating units are decommissioned. The study explores a range of end uses including co-firing of hydrogen, creation of 100% hydrogen gas networks, and development of low carbon chemicals.
Australian Gas Networks (AGN) – Australian Gas Infrastructure Group (AGIG)	Hydrogen Park South Australia (HyP SA) is an operational plant that blends green hydrogen with natural gas in Adelaide's gas networks, supplying approximately 4,000 properties. It also supplies hydrogen to industry and mobility applications via tube trailers.

4. SUPPLY CHAIN ANALYSIS

4.1 Overview

The hydrogen supply chain represents a network of interconnected industries and services dedicated to the development, construction, operations, and maintenance of hydrogen projects. Irrespective of hydrogen colour, the supply chain encompasses a diverse array of sectors including oil and gas and power generation for manufacturing, transportation, installation, and operation and maintenance. Leveraging expertise and experience across these sectors, Xodus has built a supply chain taxonomy that encompasses primary and secondary capabilities and services necessary for hydrogen project and industry development. This taxonomy is illustrated in Figure 4-1.

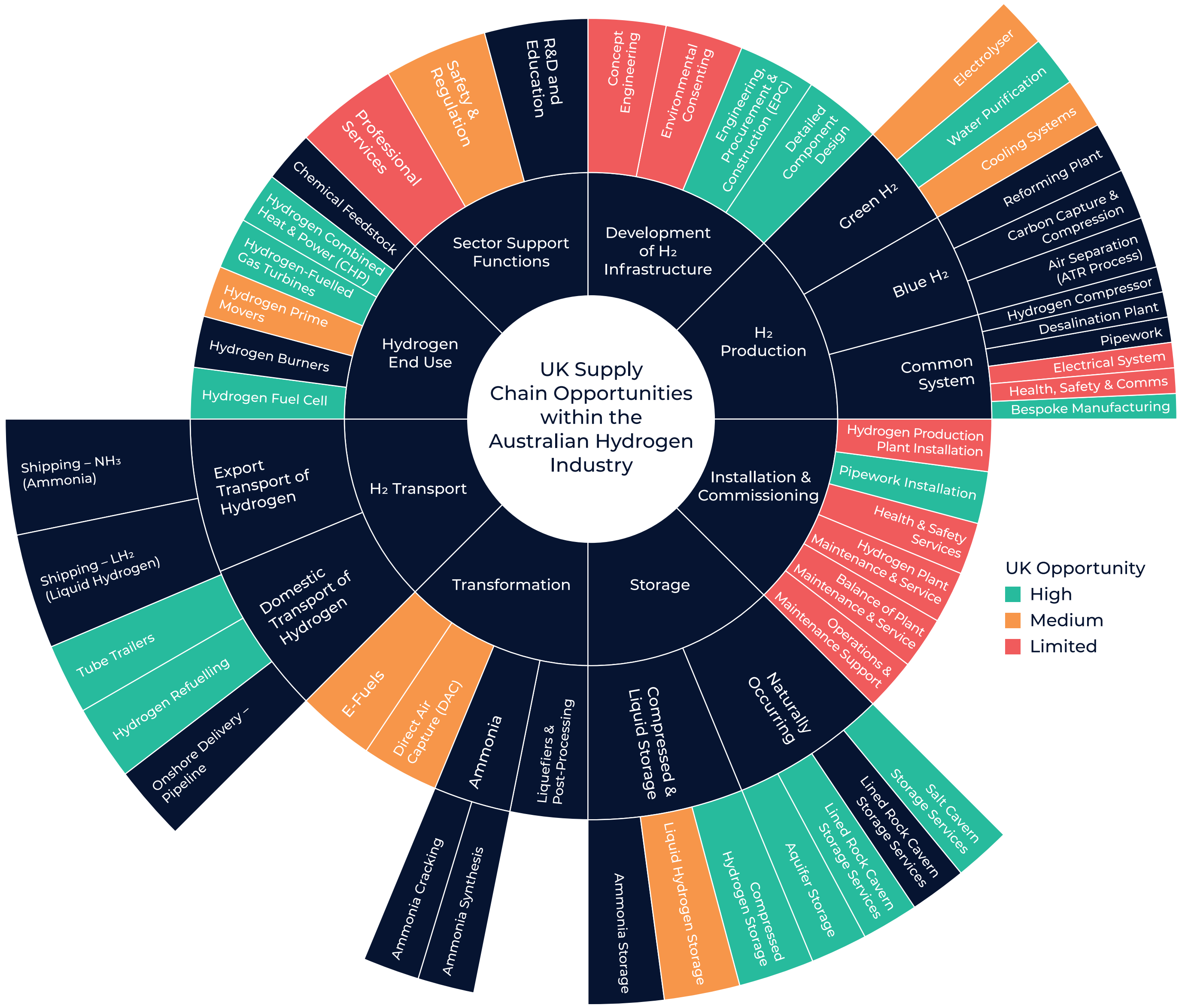


Figure 4-1 Hydrogen taxonomy

4.2 Approach

To analyse the capability of the hydrogen supply chain in the UK and Australia, Xodus used a multi-method research approach which included desk-research and industry engagement through surveys and interviews. This formed the basis for a Red Amber Green (RAG) assessment, in which a critical analysis of both UK and Australian supply chain capabilities was conducted against a supply chain taxonomy developed by Xodus, as illustrated in Figure 4-1. Primary focus and granularity have been applied in areas where there is more potential for UK interests.

4.3 Limitations

The following sections of discussion focus on key areas of supply chain for Australia and the UK, including possible providers for each of the below services. This is not exhaustive and is limited by the scope of the work requested as well as being broken down to gain maximum insights from available information. There may be errors and omissions in relation to suppliers and detailed provision of services provided by each supplier.

Attention and detailed analysis has been applied in areas where there is more potential for UK interests. Conversely, less detail has been applied in areas with little to no opportunity for UK involvement. Decommissioning is a crucial phase that warrants consideration throughout all stages, including development and environmental impact assessment. However, this report omits decommissioning due to the potential timeframe of 30 to 40 years from today for Australian hydrogen projects and predicting capabilities and identifying potential export opportunities for decommissioning is challenging this far in advance.

4.4 Key Themes

Based on the approach outlined, key themes were identified in the following three categories:

1. Areas of <u>limited</u> Australian supply chain capability (High Opportunity)

Where the Australian supply chain was ranked Low (Red) and the UK was ranked high (Green) or medium (Orange) in capability, or where it could be identified that there was the most potential opportunity to be gained. This is discussed in Section 4.5

Areas of limited capability within Australia present the strongest opportunity for the UK supply chain. However, these will be competitive areas where other countries with a strong hydrogen supply chain, such as Germany and the US, may also be targeting these Australian weaknesses.

2. Areas of <u>developing</u> Australian supply chain capability (Medium Opportunity)

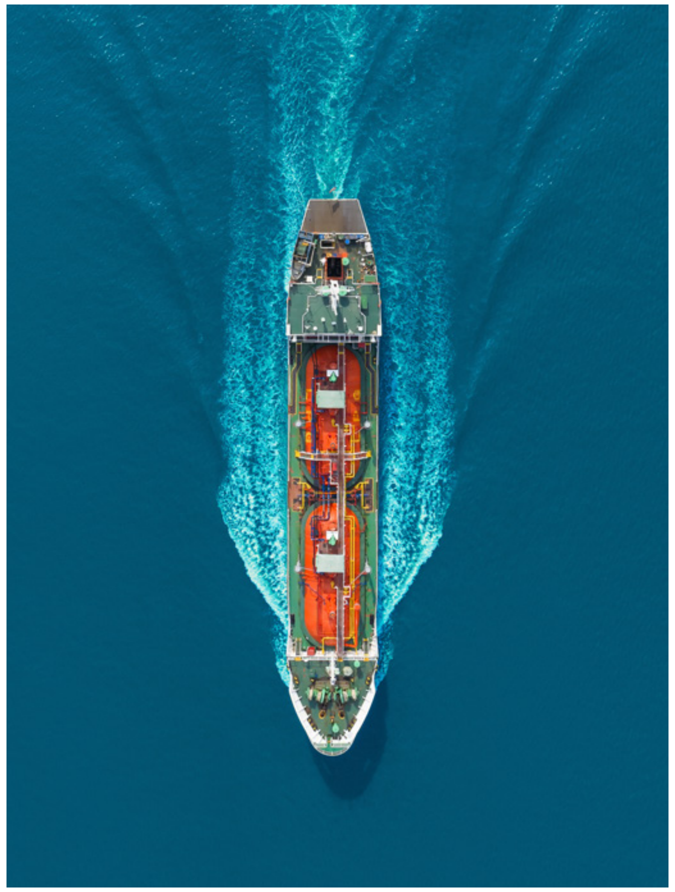
Where the Australian supply chain was ranked Medium (Amber) and the UK was ranked high (Green) in capability. This is discussed in Section 4.6.

Areas of developing Australian supply chain capability represent a reduced window of opportunity for foreign supply chains. It is assumed that the supply chain categories under this theme are being invested in by Australia and/or there are strong synergies with adjacent local industry. As a result, the opportunity for the UK supply chain may be immediate but not sustainable in the long-term, or the opportunity will rely on demand exceeding supply. The discussion in Section 4.6 highlights the circumstances around the developing capability in Australia and where there is opportunity for the UK.

3. Areas of developed Australian supply chain capability (Limited Opportunity)

Xodus have also evaluated areas where both Australian and UK hydrogen supply chain capabilities were ranked as high (green). This is discussed in Section 4.7.

Areas of developed capability in both countries represent an opportunity area for UK businesses due to the unprecedented scale of support needed to deliver Australia's world leading hydrogen development pipeline. The opportunity is however less prospective, due to the increased level of likely competition, hence its ranking behind categories 1 and 2.



4.5 Areas of Limited Australian Supply Chain Capability

Areas of limited capability for the Australian hydrogen supply chain can offer the greatest opportunity for market entry for UK companies that already have a track record within the industry. The elements of the hydrogen taxonomy that have been identified as limited capability within the Australian hydrogen supply chain are presented below.

4.5.1 Hydrogen End-Use

PRIMARY CATEGORY	HYDROGEN END-USE		
SECONDARY CATEGORY	Hydrogen fuel cells	Hydrogen-fuelled gas turbines	Hydrogen Combined Heat and Power (CHP)
TERTIARY CATEGORY AUSTRALIAN CAPABILITY	Medium	Medium	Low
UK CAPABILITY	High	High	Medium

Table 4-1 Hydrogen end-use RAG summary

Hydrogen Fuel Cells

A hydrogen fuel cell uses the chemical energy of hydrogen to produce a clean form of electricity, with only heat and water as the by-products. There are no carbon dioxide emissions or other pollutants, as seen in traditional combustion-based technologies. Fuel cells can be used in a wide range of applications, from personal, public, and long-haul transport to remote power systems.

AUSTRALIAN CAPABILITIES	UK CAPABILITIES
ENERGYS	BRAMBLE ENERGY, ceres, AFC Energy, ECOMAR PROPULSION, MICRO:CAB, ADELAN, Intelligent Energy

Table 4-2 Companies active in hydrogen fuel cells

Potential Opportunities

- Government of New South Wales has set aside $2 billion to transition more than 8,000 buses.
- ACT Government trialling a fuel cell fleet with plans to expand.
- Offsetting heavy fuel consumption through use of hydrogen fuel cells in heavy vehicles for mining and road freight.

Australia's Existing and Future Capabilities

The current use of hydrogen fuel cells in Australia is limited to hydrogen-powered stationary generators, light motor vehicles, and prime movers, with the generators and vehicles mostly being manufactured overseas and imported into the country. Australia is actively developing policies and initiatives to support the development and deployment of hydrogen fuel cells as part of its broader clean energy and decarbonisation efforts.

Several Australian states and private sector entities had launched initiatives to support the development of hydrogen fuel cells. For example, the Australian Capital Territory (ACT) Government has committed to transitioning its bus fleet to hydrogen fuel cells, while the Emerald Coaches Green Hydrogen Mobility Project[17] is proposing a long-term conversion of its entire fleet of 120 diesel coaches to hydrogen fuel cell vehicles. The ACT is also trialling hydrogen fuel cell powered passenger vehicles. In addition, the Western Australian Government has announced funding for hydrogen research and development projects.

As Australia continues to strengthen its policy framework to accelerate the deployment of hydrogen fuel cells across several sectors, the Hazer Group is an early private sector example of hydrogen fuel cells. The Hazer Commercial Demonstration Plant based in Western Australia, will demonstrate Hazer production technology that converts methane feedstocks into hydrogen and synthetic graphite. The project includes a stationary hydrogen fuel cell power generation system, which will enable the plant to produce renewable power by utilising a portion of its hydrogen production.

UK's Existing and Future Capabilities

The UK has strong and growing capability in the development and manufacturing of hydrogen fuel cells. An example is Intelligent Energy, which is focused on the development and manufacturing of zero-emission hydrogen fuel cell products from 800W to 300kW. They have a broad range of use-cases across the automotive industry, materials handling, construction, standby power, and for aviation and UAVs and have deployed their fuel cell technology globally. Intelligent Energy is already working closely with AVID Group to bring their leading-edge hydrogen fuel cell modules to the Australian market.

Another company which demonstrates the UK's strong capability is AFC Energy, who are committed to replacing diesel generation with their hydrogen fuel cells. Similar to Intelligent Energy, the exportability of their products and services has already been demonstrated with case studies in Spain, Saudi Arabia, Senegal, and Greenland. They have also provided their proprietary hydrogen power generation unit to the Northern Oil Advanced Biofuels Refinery in Queensland, Australia.

[17] 'e-Mission Zero Strategy', Emerald Coaches, https://www.emeraldcoaches.com.au/e-mission-zero-strategy

Opportunity

There is currently one PEM fuel cell manufacturing facility in Australia, Nedstack Australia Pty Ltd, a joint venture between Australia-based LAVO Hydrogen Storage Technology Pty Ltd and Nedstack of The Netherlands. Additionally, Energys, an Australian company focusing on the integration of renewable energy systems with hydrogen production and hydrogen use technologies, also develop their own proprietary fuel cell system known as the Fuel Cell Engine. As Australia seeks to reduce dependency on imported fuel cells and diversify supply to meet the growing demands from the power, telecom, mining and transportation industries, opportunities will arise for other fuel cell suppliers to enter the Australian market.

Another potential opportunity is the mining and resources industry in Australia which heavily relies on diesel consumption, accounting for a substantial portion of total energy usage, ranging from 25% to 90% across all key mineable commodities. Annually, the industry consumes over five billion litres of diesel, representing approximately 25% of Australia's total diesel demand. The remote locations of most mining districts amplify the demand for diesel, particularly for mobile power generation and on-site and long-haul transport. By transitioning to green hydrogen, the mining industry can reduce its reliance on imported diesel and mitigate the environmental impact of fossil fuel consumption.

Hydrogen Fuelled Gas Turbines

Gas turbines are flexible and have short ramp-up times, which makes them very effective at balancing intermittent renewable energy production. When running on hydrogen, gas turbines provide a source of renewable electricity. The use of hydrogen as a gas turbine fuel has been demonstrated commercially by companies such as Siemens and GE, with hydrogen content ranging from 5% up to 100% by volume. With the growing momentum towards reducing reliance on coal and diesel, transitioning to cleaner fuels in fuel-flexible gas turbines provides a versatile solution that aligns with sustainability goals and enables a smoother transition to a low-carbon energy future. Fuel-flexible gas turbines can also offer operational benefits by utilising a wide range of fuel sources, including natural gas, hydrogen, biogas, and synthetic fuels.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Not Available.	Rolls-Royce, CENTRAX, PlusZero

Table 4-3 Indicative companies active in the gas turbine market

Potential Opportunities

Potential conversion of ~14.6 GW of gas fired turbines to co-firing with hydrogen to achieve emission reduction.

Australia's Existing and Future Capabilities

Australia will become one of the first countries in the world to power up one of GE's 9F hybrid gas-hydrogen turbines for grid electricity[18]. The 320 MW Tallawarra B power station, situated in the Illawarra region of New South Wales, will function as a dual fuel-capable peaking plant, capable of utilising a combination of natural gas and up to 5% blended renewable-derived hydrogen. GE will also supply gas turbines (GE Vernova's LM2500XPRESS aeroderivative gas turbine generators[19]) to both the Brigalow Peaking Power Plant, Queensland and the world-first hydrogen power station at Port Bonython, near the industrial city of Whyalla on Spencer Gulf, South Australia. Brigalow Peaking Power Plant will have a blend of 35% of hydrogen and is expected to increase to 100% hydrogen by mid-century.

Although GE maintains a significant presence in Australia, GE does not have a gas turbine manufacturing facility within Australia and all turbines used in Australia would have been imported from overseas. The growing number of hydrogen projects presents opportunities for other gas turbine suppliers to engage in the market.

[18] Tallawarra B Dual Fuel Capable Gas/Hydrogen Power Plant, CSIRO, https://research.csiro.au/hyresource/tallawarra-b-dual-fuel-capable-gas-hydrogen-power-plant/

[19] BRIGALOW PEAKING POWER PLANT, CS Energy, https://www.csenergy.com.au/what-we-do/firming-and-storage/brigalow-peaking-power-plant

UK's Existing and Future Capabilities

In the UK, an example of hydrogen-fuelled power plant is the Triton Power Station, which displaces 30% of natural gas with low-carbon hydrogen to provide power and steam to industrial users at Saltend Chemicals Park and electricity to the national grid. Additionally, the Keadby Hydrogen Power Station could be the world's first 100% hydrogen-fuelled power station and is expected to be online by the end of the decade. The UK also has major capability in gas turbines manufacturing. Rolls Royce, with approximately 18% market share of aviation engines, have demonstrated their capability to export their engine technologies and services worldwide. In 2022, it announced a partnership with EasyJet, wherein Rolls Royce will adapt its AE 2100 engine to utilise hydrogen combustion instead of conventional kerosene. EasyJet will commence its short-haul flights with this engine by mid-2030.

This is a competitive market however, with companies such as GE Gas Power in the USA, Siemens Energy in Germany, and the Zero Emission Hydrogen Turbine Centre in Sweden all actively developing hydrogen fuelled gas turbine technologies for various applications beyond aerospace.

Opportunity

While Australia has not announced additional hydrogen power plant projects, there is potential that other gas power plants will follow Tallawarra B, making fuel-flexible gas turbines a versatile and essential technology that can facilitate the nation's energy transition and contribute significantly to achieving its net zero emissions target. Hence, is it expected that turbine manufacturers will see increased market demand and long-term growth opportunities within the Australian market.

The opportunity to replace natural gas in turbines was recognised by the Western Australian Government in 2022, when it announced a hydrogen blending target for all generation of 1% to come from green Hydrogen.

This is particularly interesting in that WA has over 3 GWs of gas fired generation in its main electricity grid as the predominant form of dispatchable electricity. WA is also likely to require dispatchable energy to firm renewables without access to deep storage schemes, as are present within the National Electricity Market. Storage of excess renewable energy and conversion to hydrogen before reconversion to electricity either via a fuel cell or hydrogen turbine, is one such way to firm renewable energy.

Within Australia (excluding the Northern Territory) there is 14.6 GWs of grid connected gas fired generation, with the potential for co-firing with hydrogen to reduce emissions. This represents 19% of total generation on average across all states, however the concentration of gas generation is highest in West and South Australia which have 44% (2.7 GW) and 42% (2.9 GW) respectively of its fleet as gas, with less reliance on coal fired generation. The distribution of capacity by each of the 6 states analysed is provided in Figure 4-6 below.

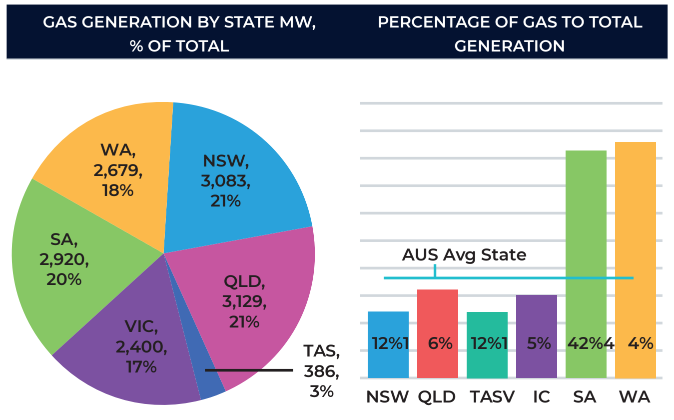


Figure 4-6 NEM state gas fired generation[20]

[20] *AEMO ISP Data Assumptions 2022*

Hydrogen Combined Heat and Power

Combined heat and power from hydrogen (CHP) uses engines to burn hydrogen, before capturing the heat for reuse or to generate power.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Grange	mtu – A Rolls-Royce solution Caterpillar

Table 4-4 Indicative companies active in Hydrogen Combined Heat and Power market

Australia's Existing and Future Capabilities

There is limited activity in Australia exploring the option of CHP beyond blending hydrogen into natural gas networks. Grange Resources has completed a pre-feasibility study to assess the potential of replacing natural gas with hydrogen for process heating at its facility in Tasmania, however the project has not progressed any further studies. There is no real pipeline of any other CHP projects.

UK's Existing and Future Capabilities

Rolls-Royce MTU Power Systems and Caterpillar both have operations in the UK developing engines used in CHP but both are owned by non-UK companies. Exporting engine units to Australia from the UK could incur significant costs for transportation. Establishing domestic production facilities in Australia could be an alternative solution, the up-front capital required to setup may be mitigated by reduced transportation costs in the long-term. However, the limited size of the Australian market and its distance from other markets may not incentivise pursuing this strategy.

Opportunity

There is not a clear pipeline of projects for industrial heating or CHP in Australia, therefore there is a limited pathway for UK companies to enter the market.

4.5.2 Transport of Hydrogen

Summary

PRIMARY CATEGORY	TRANSPORT OF HYDROGEN
SECONDARY CATEGORY	Domestic Transport of hydrogen
TERTIARY CATEGORY	Tube Trailers
AUSTRALIAN CAPABILITY	Medium
UK CAPABILITY	High

Table 4-6 Transport of hydrogen RAG summary

Tube Trailers and Transportation of Dangerous Goods

Tube trailers towed by truck units can transport pressurised hydrogen onshore. In circumstances where hydrogen infrastructure is absent, tube trailers can transport hydrogen from where it is processed to the location end-use. Depending on the size of the trailer and cylinders, more than 1,000kg of hydrogen can be transported.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
H2HAULER, Pioneer Cryogenics	Chesterfield Special Cylinders

Table 4-7 Indicative companies active in the tube trailer market

Potential Opportunities

- Trucking of hydrogen is the priority mode of transport up to 2030.
- Market entry for British companies such as Chesterfield to supply pressurised cylinders for growing Australian market.

Australia's Existing and Future Capabilities

In Australia, hydrogen is typically transported as a compressed gas by tube trailers containing high pressure tubes. H2 Hauler is building Australia's highest capacity tube trailer in Queensland. The 1,000 kg trailer comes with built-in control, automation, monitoring, and communications to facilitate and enhance ease-of-use for the operator, chain-of-custody management and protection and safety layers increased. In 2023, H2 Hauler had signed a memorandum of understanding (MoU) with NanoSUN to deliver hydrogen transport, storage and dispensing for temporary site applications in Australia. Pioneer Cryogenics also has experience in building and refurbishing high pressure tube trailers for hydrogen, supplying to the likes of BOC and Coregas, who are involved in the developing hydrogen industry in Australia.

UK's Existing and Future Capabilities

Hydrogen is typically transported via tube trailers in the UK, but the country does not have local end-to-end capability in the development of tube trailers. Consultation with industry experts identified UK companies such as Chesterfield Special Cylinders, which have experience in the design and manufacture of pressured storage cylinders which can be placed on flat-bed trailers. Additionally, the UK is very experienced in the transportation and haulage of compressed gasses, such as hydrogen. For example, BOC, have an extensive network of hydrogen production facilities and deliver hydrogen to customers across the UK and Ireland using tube trailers. As a result, the UK have a workforce that is very experienced with the operational aspects for carriage of dangerous goods and transportable pressure equipment. In 2023, BOC Linde in partnership with ATCO have been selected by the South Australian Government to construct a world-first hydrogen power station at Port Bonython, near the industrial city of Whyalla on Spencer Gulf.

Opportunity

Tube trailers will be the primary form of transportation for hydrogen in Australia up to 2030, as pipelines are established, and will still be required thereafter between regional towns and major centres according to the National Hydrogen Infrastructure Assessment. With the increasing production and adoption of hydrogen in Australia, there is an opportunity for the country to align with global trends and utilise Type III and Type IV cylinders for long distance transport. Type II, III, and IV cylinders allow pressures of 300 to 500 bar and can support up 1,000 kg per cylinder while Type I cylinders accommodate pressures of 160 to 200 bar and support 250 to 300 kg per cylinder. Type I cylinders may be appropriate for short distances, however, type II, III, and IV cylinder types can increase the cost effectiveness and efficiency of hydrogen distribution by increasing payloads. There is a potential daily total capacity of 27 to 136 tonnes planned for refuelling stations across the country which will require cylinders and tube trailers to transport hydrogen.

4.5.3 Transformation

Summary

PRIMARY CATEGORY	TRANSFORMATION
SECONDARY CATEGORY	Direct Air Capture (DAC)
TERTIARY CATEGORY	
AUSTRALIAN CAPABILITY	Low
UK CAPABILITY	Medium

Table 4-5 Transformation summary RAG

Direct Air Capture (DAC)

DAC is used to extract carbon dioxide directly from the atmosphere to reduce greenhouse gas emissions. It can then be stored in geological formations or used for various applications such as creating e-fuels through the combination of hydrogen and carbon dioxide.

AUSTRALIAN CAPABILITIES	UK CAPABILITIES
CO2CRC (Building a low emissions future)	MissionZero
Southern Green Gas	Rolls Royce

Table 4-6 Indicative companies with direct air capture capabilities

Example Opportunities

- Large emitting industries required to reduce emissions by 4.9% per year until 2030.
- 467 million tonnes of CO_2 emitted in 2023 which needs to reduce by 43% by 2030 compared to 2005 levels, and net zero by 2050.

Australia's Existing and Future Capabilities

Australia will introduce the Guarantee of Origin Scheme, an internationally recognised assurance scheme designed to track and measure emissions across the value chain. The Safeguard Mechanism was also introduced in 2016. This requires the highest greenhouse gas emitting facilities to reduce their emissions to achieve Australia's decarbonisation targets. Oil and gas companies Santos and Tokyo Gas have since announced their intentions to produce e-methane through Direct Air Capture to reduce their emissions.

UK's Existing and Future Capabilities

In 2020, as part of its Plan for Jobs, the UK Government provided £100 million of funding to the research and development of direct air capture technology. The UK's first direct air capture plant began operations in 2023. The plant aims to capture 50 tonnes of carbon dioxide per year to turn into Sustainable Aviation Fuel (SAF). The DAC unit was developed by Mission Zero Technologies. Rolls Royce has also secured £3 million from the UK to build a demonstrator DAC system. A full-scale version could remove 1 million tonnes per year. The UK aims to remove 25 million tonnes of CO_2 per year by 2030.

Opportunity

Due to Australia's impressive resources which tie into the production of hydrogen, there is a real opportunity for growth in the e-fuels sector, incorporating direct air capture technology. In addition to the production of e-fuels, major emitters may select Carbon Capture and Storage (CCS) through which direct air capture technology can also be used. The Safeguard Mechanism's default baseline of allowable emissions is 100,000 tonnes of carbon dioxide equivalent emissions per year for all facilities under the Safeguard Mechanism. The baseline will decline at a rate of 4.9% per annum until 2030. Australia's CO_2 emissions, year ending June 2023, were 467 million tonnes, an increase of 4 million tonnes from the previous year. The number of emissions emitting industries in Australia and the restrictions set by the Safeguard Mechanism indicates there is a significant market for carbon capture technology.

4.6 Areas of Developing Australian Capability

Areas of developing capability in the Australian supply chain present limited opportunity for the UK due to the capability eventually becoming mature in the region. The opportunity for the UK supply chain will be dictated by Australia having capability but not the capacity to deliver. The following areas of the hydrogen taxonomy have been identified as under development compared to the UK where the capability is mature.

4.6.1 Development of Hydrogen Infrastructure

Summary

PRIMARY CATEGORY	DEVELOPMENT OF HYDROGEN INFRASTRUCTURE	
SECONDARY CATEGORY	Engineering, Procurement & Construction (EPC))	Detailed component design
TERTIARY CATEGORY		
AUSTRALIAN CAPABILITY	Medium	Medium
UK CAPABILITY	High	High

Table 4-7 Development of hydrogen infrastructure RAG summary

Development of hydrogen infrastructure is an area of relative strength for the UK supply chain, with hydrogen projects such as HyNet, HyDeploy and H_2Teesside established for several years. UK companies supported the development of these projects, drawing upon their experience of other industries to build their experience in the sector. Xodus Group and Arup are examples of UK companies that gained hydrogen project experience across several infrastructure development categories through participation in projects such as the Bacton Energy Hub.

Engineering, Procurement and Construction (EPC)

An Engineering, Procurement, and Construction (EPC) company for a project will handle all aspects of a project's infrastructure design, delivery and construction. The development of the hydrogen network will heavily rely on supporting hydrogen transportation and storage infrastructure. Hydrogen infrastructure will be required to supply both a country's domestic hydrogen and international export demand.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
GPA, worley, enGv, MONFORD, aurecon, LINE HYDROGEN	wood., PENSPEN, COSTAIN, RWE, equilibrion., Bohr

Table 4-8 Indicative companies active in the EPC/integrator market

Example Opportunities

Many hydrogen projects are at developmental stages, allowing time for EPCs to enter the market as projects move toward FID in the late 2030s.

Australia's Existing and Future Capabilities

While Australia has significant expertise in engineering and construction across sectors, including energy and resources, the specific capabilities and experience required to integrate large-scale hydrogen facilities is limited. This is noticeable in the absence of domestic integrators that can package delivery across the entire supply chain. As the Australian Government actively invests in hydrogen hubs, producers, users, and exporters will share infrastructure and expertise to enable and accelerate the industry. These present opportunities for local EPC companies to participate, potentially eliminating the need for a single company to facilitate the entirety of a large-scale hydrogen project.

UK's Existing and Future Capabilities

Large engineering and consulting firms such as Wood, Worley, and WSP, have substantial presence in both the UK and Australia. They offer services across diverse sectors including energy, infrastructure, and environment and are often engaged in EPC aspects of projects; however, they are not always the main contractor. Leveraging their extensive experience in hydrogen projects in the UK and other key hydrogen developing countries, these companies will be able share and or transfer resources, knowledge, and best practices to their Australian offices.

Opportunity

There are approximately 150 hydrogen projects across Australia which will either require EPCs or integrators for the overall project or for defined scopes within the project, providing opportunities for UK companies to become involved. Most hydrogen hub projects are aiming for commissioning between 2027 and 2032, providing UK companies time to seize opportunities to participate as developments advance through to Final Investment Decision (FID) towards the end of the decade.

Detailed Component Design

Detailed component design is a critical stage in the development of hydrogen infrastructure. This stage ensures the required specifications, subsystems, technical calculations, and compliance with the standards of a component or system are in place and accurate. Another key outcome of this stage is detailed plans, scheduling and costings.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
AXIOM, Downer, GPA, LINE HYDROGEN	Balfour Beatty, bpa, MOTT MACDONALD

Table 4-9 Indicative companies active in the detailed design market

Example Opportunities

- Many hydrogen projects are at developmental stages, allowing time for detailed design companies to enter the market as projects move toward FID in late 2030s.
- UK companies have an existing presence in Australia through which they can partner.

Australia's Existing and Future Capabilities

Australia has current capabilities for detailed designs which are highlighted by various energy projects established around the country including oil gas, large-scale onshore wind and solar, as well as mining facilities. There is also a developing capability for hydrogen through small-scale and pilot hydrogen projects, and as flagship projects such as the Western Green Energy Hub (WGEH) and Australian Renewable Energy Hub (AREH) advance, Australia stands to gain valuable experience in large-scale hydrogen developments.

UK's Existing and Future Capabilities

The UK has capability to deliver detailed component design with companies such as Xodus Group, Mott MacDonald, Frazer Nash, and ARUP all providing detailed component design services. All the aforementioned organisations, although headquartered in the UK, already have offices in Australia and can share capability and knowledge across borders.

Opportunity

The opportunity for UK companies entering the market may require tendering for projects through their Australian offices and providing inter-regional support and partnering with local companies who are specialists and can leverage local experience.

4.6.2 Hydrogen Production

Summary

PRIMARY CATEGORY	HYDROGEN PRODUCTION	
SECONDARY CATEGORY	Green hydrogen	
TERTIARY CATEGORY	Electrolysers	Cooling systems
AUSTRALIAN CAPABILITY	Medium	Low
UK CAPABILITY	High	Medium

Table 4-10 Hydrogen production RAG summary

Electrolysers

Electrolysers are the key technology for production of green hydrogen. Alkaline and Proton Exchange Membrane (PEM) electrolysers are the two most technologically mature and commercial scale electrolysers in the market. Other promising, emerging electrolyser technologies expected to achieve technical maturity by 2030 include Solid Oxide electrolysers (SOE), Anion Exchange Membrane (AEM) electrolysers and Capillary-Fed electrolysers (CFE). Although not all of these are currently available for industrial use, each technology claims to be fully commercialised and offer multi-MW production capacity by 2030.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Hysata	ITM POWER, INEOS
ENERGYS	BRAMBLE ENERGY, ceres
FORTESCUE FUTURE INDUSTRIES	AFC Energy, HOPE
ENDUA	pure ENERGY CENTRE
	ELECTROGENOS
	Engas Global an electrolyser and H₂ compressor company
	SUPERCRITICAL

Table 4-11 Indicative companies active in the electrolyser market

Example Opportunities

- Australia is forecast to account for 20% of global electrolyser capacity, representing a A$66 billion market by 2030 and A$137 billion by 2032[21].
- The Western Australian Government highlighted interest in developing local electrolyser manufacturing plant.
- New South Wales Government is making strategic co-investment with private sector to establish and expand local supply chains for renewable energy, including hydrogen electrolysers.
- Through the $22.7bn "Future Made in Australia Act"[22], which aims to attract investment to build domestic capacity, renewable hydrogen production is identified as a priority sector.

Australia's Existing and Future Capabilities

Currently, Australia has a limited electrolyser production capacity with companies such as Hysata, Energys, Endua and Fortescue Future Industries actively developing their electrolyser manufacturing capabilities. Hysata has been awarded $21 million by the Australian Renewable Energy Agency to enhance their electrolyser technology. The company aims to swiftly escalate its production capacity to 100 MW per annum and subsequently transition to gigawatt-scale production. The company has received conditional orders from potential green hydrogen consumers, amounting to over 9.4 GW of capacity, bringing the company's pipeline to almost 40 GW.

UK's Existing and Future Capabilities

Several UK-based companies are actively involved in electrolyser manufacturing and deployment. Companies like ITM Power, Ceres, and Johnson Matthey are leading players in the UK's electrolyser market. ITM Power has developed large-scale electrolyser systems for industrial applications and renewable energy integration and had been involved in several Australian projects such as the Christmas Creek Renewable Hydrogen Mobility Project and the Renewable Hydrogen Production and Refuelling Project at Bulwer Island. ITM Power's Australian subsidiary, ITM Power Pty Ltd, was set up in 2017 and the business case study undertaken by ITM Power and Linde Engineering recommended that an electrolyser stack manufacturing facility, capable of producing 2 GW of electrolyser capacity annually, be established at the Latitude 32 industrial zone near Fremantle Port, WA.

[21] Xodus market analysis using CSIRO GenCost 2024, and GlobalData November 2023.

[22] Investing in a Future Made in Australia | Budget 2024–25.

Opportunity

Over 90% of all announced Australian hydrogen projects will generate green hydrogen, utilising electrolysis. By 2030, it is expected that the Australia's electrolyser capacity, based on announced projects, will be 20% of the global capacity. This represents a A$66 billion market by 2030 and A$137 billion by 2032 as electrolyser capacity is build out across Australia's hydrogen development pipeline. as discussed in Section 3.2.[23]

This puts Australia in second place for global capacity in development, behind Europe at 30%. The Western Australian Government have investigated a potential electrolyser manufacturing facility and, in partnership with ITM Power and Linde Engineering, have released a business case for electrolyser manufacture in WA.

[23] Xodus market analysis using CSIRO GenCost 2023, and GlobalData November 2023.

Cooling Systems

A cooling system for green hydrogen aims to reduce the electrolyser's energy loss, which is lost as heat. The efficiency of the electrolyser can be increased by cooling it.

AUSTRALIAN SUPPLIERS	UK CAPABILITIES
Energys	Transtherm Hydrogen; Alfa Laval

Table 4-12 Indicative companies active in the hydrogen fuel cell market

Example Opportunities

Australia is forecast to account for 20% of global electrolyser capacity, representing a A$66 billion market by 2030 and A$137 billion by 2032, requiring cooling systems.

Australia's Existing and Future Capabilities

- Australia is forecast to account for 20% of global electrolyser capacity, representing a A$66 billion market by 2030 and A$137 billion by 2032, all likely to require cooling systems.

Australia's Existing and Future Capabilities

Australian electrolyser manufacturer, Energys, includes balance of plant equipment required for the electrolyser, including cooling systems, however these integrated applications are not suited for large scale hydrogen production. Overall, the market for these systems in Australia is limited. Cooling systems used in other major industries may be leveraged to support electrolyser cooling.

UK's Existing and Future Capabilities

The UK does not have large-scale hydrogen plants operating, however there are more operating projects in the UK compared to Australia. All the operating projects in the UK utilise green hydrogen. These will require cooling systems for the electrolyser. While most electrolysers and support equipment come from the USA or Europe, there are UK companies such as Transtherm and Alfa Laval that offer electrolyser cooling equipment. It can be expected that these companies will increase their production to meet the growing demand as projects move toward FID and commissioning.

Opportunity

Both countries do not have expertise in large scale hydrogen or cooling system requirements, however this can be due to the immaturity of the market in both regions and can be developed as the industry matures. The scale of hydrogen projects expected in Australia provides opportunity for UK entrants to support the supply of cooling systems in some capacity. The majority of the projects will be green hydrogen, utilising electrolysers and will require cooling systems.

4.6.3 Installation and Commissioning

PRIMARY CATEGORY	INSTALLATION AND COMMISSIONING OF HYDROGEN INFRASTRUCTURE
SECONDARY CATEGORY	Pipework installation
TERTIARY CATEGORY	
AUSTRALIAN CAPABILITY	Medium
UK CAPABILITY	High

Table 4-13 Installation and commissioning of hydrogen infrastructure RAG summary

UK company experience in the installation and commissioning of hydrogen infrastructure projects, such as HyNet and the Bacton Energy Hub, means that there is high level of capability within the UK supply chain. Genesis, ERM, Apollo, Voar and Atkins are examples of companies with significant experience across the installation and commissioning elements of the hydrogen supply chain.

Gas Pipelines

Networks are required to connect hydrogen producers with consumers, to deliver hydrogen reliably and safely. Pipelines allow large volumes of hydrogen to be transported over significant distances for a relatively low cost. Installation and commissioning of hydrogen pipelines considers installation of new 100% hydrogen pipes, injection of hydrogen to blend with natural gas or repurposing existing gas networks for hydrogen use.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Australian Gas Networks; apa	Cadent; national gas; Northern Gas Networks; ENOFLEX; SGN; LIBERTY

Table 4-14 Indicative companies active in the gas pipeline market

Examples Opportunities

- Pipeline infrastructure to begin to enter the market in 2030, starting at 300 km and increasing further to potentially overtake trucking by 2040 as the volume of transported hydrogen increases.

Australia's Existing and Future Capabilities

Australia has no established hydrogen pipelines, but has a large, existing distribution network of gas pipelines where experience can be leveraged. Some of these gas pipelines are currently being used for two hydrogen blending projects in Western Australia and South Australia. Australia Gas Infrastructure Group (AGIG) is set to build, commission, and operate the Hydrogen Park Murray Valley project comprising a 10 MW electrolyser, aimed at supplying approximately 10% renewable hydrogen by volume to approximately 40,000 current residential, commercial and industrial customers connected to the Albury-Wodonga gas network. In 2022, ATCO successfully blended 2-10% of renewable hydrogen into the existing natural gas distribution network as part of a two-year Hydrogen Blending Project in the City of Cockburn.

The Parmelia Gas Pipeline conversion project will be Australia's first conversion of gas transmission pipeline to pure hydrogen. A 43 km section of pipeline in Western Australia is proposed to be converted after it was tested and has shown that the steel transmission pipeline can transport both pure and blended hydrogen without reducing operating pressure. APA Group and Wesfarmers Chemicals, Energy and Fertilisers (WesCEF) have also agreed to undertake a study to assess the viability of transporting green hydrogen via the Parmelia Pipeline to facilities in Kwinana. This section of steel pipeline under consideration for conversion is made of X52 grade ERW 350 NB line pipes, with a standard wall thickness of 5.56 mm, with some heavy walls with a nominal 7.92 mm wall thickness. This pilot project will support decision making for other APA assets[24].

UK's Existing and Future Capabilities

In the UK, Cadent, National Gas and Northern Gas Networks are collaborating in the East Coast Hydrogen (ECH_2) project covering hydrogen production, storage, transmission and distribution. The project would repurpose existing and build new gas infrastructure to transport hydrogen at bulk centres of production, to large commercial and industrial facilities as well as population centres.

While the core business activities of these companies involves managing and operating gas distribution networks, ensuring the safe and reliable supply of gas to their local customers, partnerships, or joint ventures with overseas companies in related sectors could provide avenues for diversification or expansion beyond their traditional business activities.

Opportunity

Successful hydrogen blending projects and short-distance pipeline projects have laid the groundwork to further integrate hydrogen into existing pipelines at low volumes. Australia has indicated plans to increase hydrogen pipelines volumes in the future, which will require dedicated hydrogen pipelines. The National Hydrogen Infrastructure Assessment highlights that pipelines will first appear in 2030, with the initial main pipelines equating to approximately 300 km in Queensland and Tasmania[25]. Australia currently has 88,000 km of gas distribution pipeline[26] that may be replaced to support high percentage volume blends of hydrogen. The European Union (EU) Agency for the Cooperation of Energy Regulators approximates that the cost of new hydrogen pipelines is 110-150% of new natural gas pipelines with similar diameters[27].

[24] Parmelia Gas Pipeline Conversion Project, APA, https://www.apa.com.au/news/asx-releases/2023/the-parmelia-gas-pipeline/

[25] National Hydrogen Infrastructure Assessment, https://h2council.com.au/wp-content/uploads/2023/04/national-hydrogen-infrastructure-assessment-final-report.pdf

[26] Gas supply chain, AEMC, https://www.aemc.gov.au/energy-system/gas/gas-supply-chain

[27] Transporting Pure Hydrogen by Repurposing Existing Gas Infrastructure: Overview of existing studies and reflections on the conditions for repurposing, ACER, https://acer.europa.eu/sites/default/files/documents/Publications/Transporting%20Pure%20Hydrogen%20by%20Repurposing%20Existing%20Gas%20Infrastructure_Overview%20of%20studies.pdf

4.6.4 Storage

Summary

PRIMARY CATEGORY	HYDROGEN STORAGE			
SECONDARY CATEGORY	Naturally occurring		Compressed and liquid storage	
TERTIARY CATEGORY	Salt cavern storage services	Aquifer storage services	Depleted gas reservoir storage services	Compressed hydrogen storage
AUSTRALIAN CAPABILITY	Medium	Medium	Medium	Medium
UK CAPABILITY	High	High	High	High

Table 4-18 Storage RAG summary

Salt Cavern Storage Services and Aquifer Storage Services

Underground hydrogen storage (UHS) and metal hydride storage hold promise for storing significant amounts of hydrogen, bolstering renewable energy storage, and reducing the overall carbon footprint of the energy system. Salt caverns, saline aquifers, and depleted reservoirs are all potential options for storing hydrogen underground. Salt caverns are artificially created cavities in geological salt deposits, while saline aquifers are geological features made up of water-porous rocks and act as saltwater reservoirs. The use of subsurface storage for storing gas is an established industry in North America and Europe but not in Australia, where exploration for suitable storage locations is still in the initial frontier stages.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
entX	sse EDF ENERGY UKEn

Table 4-15 Indicative companies active in the salt cavern/aquifer storage services

Potential Opportunities
Untapped industry with huge potential (310 million tonnes of hydrogen storage capacity). The expertise of UK service providers can be instrumental in supporting Australia's efforts to develop a robust UHS service.

Australia's Existing and Future Capabilities
Australia's Future Fuels Cooperative Research Centre reported that Australia has the potential to store approximately 310 million tonnes of hydrogen underground. However, most of these possible UHSs are located away from potential sources of hydrogen production, ports, or infrastructure. Despite the large distance, the low hydrogen storage cost justifies the use of these locations when the hydrogen demand is sufficiently high. Currently there are no examples of salt caverns/aquifers for hydrogen storage in Australia. However, Geoscience Australia has identified potential sites for the development of numerous underground caverns within salt deposits located across the Canning Basin in Western Australia, the Adavale Basin in Queensland, and the offshore Polda Basin in South Australia. The suitability of each of these locations will depend on their proximity to nearby hydrogen production sites. Under the Western Eyre Green Hydrogen and Ammonia project, EntX has been granted a Gas Storage Exploration License to begin early exploration on the Polda Basin salt deposits.

UK's Existing and Future Capabilities
Gas storage within salt caverns is considered a highly mature technology in the UK, with proven experience of storing natural gas, nitrogen, and hydrogen. Salt caverns are a robust method of hydrogen storage, can store hydrogen up to 200 bar, are relatively leak-proof and have less contaminants than other forms of geological storage. However, salt caverns are restricted by geographical location, and their capacity to store hydrogen varies.

As of November 2022, there are six salt cavern storage sites in the UK. Owners of these sites include UK-based SSE and EDF Energy, as well as European companies Storengy and Uniper. EDF Energy has an established Australian operation since 2017, with a portfolio of wind and solar projects. The company's expertise in underground gas storage could play a valuable role in supporting Australia's salt cavern storage strategy. Additionally, UKEn will build the UK's largest hydrogen storage site in Portland Port, between the South Wales and Southampton industrial hubs. The initial construction of 19 new salt caverns will provide around 1 billion cubic meters of storage, increasing the current UK onshore underground storage capacity by around 70%. A planned second phase, both in the adjacent offshore and onshore would add a further 1 billion cubic meters of storage[28].

Opportunity
The skills and experience in the operation and maintenance of these storage solutions should offer an opportunity for UK companies seeking to enter the Australian market, especially as there are few barriers and costs to the export of knowledge-based services.

[28] Salt Caverns, UKEn, https://ukenergystorage.co.uk/salt-caverns/

Depleted Gas Reservoir Storage Services

Depleted gas reservoirs are among the most promising storage solutions for hydrogen, having already proven their capability to store natural gas. Despite this, hydrogen is a highly reactive gas and can penetrate materials that are used in the storage of commonly used gases, so the suitability of gas reservoirs is dependent on the geology of individual sites.

AUSTRALIAN SUPPLIERS	UK OPERATORS
Australian Gas Infrastructure Group	Centrica Humbly Grove Energy

Table 4-16 Indicative companies active in the depleted gas reservoir storage services

Example Opportunities
- Australia has good potential for the development of depleted gas reservoirs into gas storage, with some already in use as natural gas storage.

Australia's Existing and Future Capabilities
Australia has significant capability in storing gas in depleted reservoirs, leveraging its vast geological formations and existing infrastructure. Depleted gas fields around Port Campbell in South-West Victoria have been used for gas storage for more than two decades. While no such fields have been utilised to store hydrogen, Australia's expertise in drilling, reservoir engineering, and subsurface characterisation indicates its potential to extend its capability to effectively utilise depleted reservoirs for hydrogen storage.

UK's Existing and Future Capabilities
The UK has significant experience in storing natural gas in depleted reservoirs, primarily for purposes of energy security and supply flexibility. This expertise in gas storage infrastructure, including reservoir characterisation, drilling techniques, and operational management, provides a strong foundation for exploring hydrogen storage possibilities. While hydrogen storage in depleted reservoirs is still in the early stages of development globally, the UK has been investing in research and pilot projects to assess the feasibility and viability of this technology. These initiatives aim to leverage existing gas storage infrastructure and repurpose it for hydrogen storage, capitalising on the UK's extensive network of depleted gas fields and storage facilities.

In 2005, Humbly Grove Energy, developed one of the largest gas storage facilities in the UK, which they still own and operate. Humbly Grove Energy owns and operates the Humbly Oil Field, near Alton, Hampshire. Other demonstrations of UK capability include Xodus and RPS, who are experienced in supporting the engineering, environmental, and commercial aspects of depleted gas reservoir storage projects.

Opportunity
While the UK's experience in storing hydrogen in depleted reservoirs may be limited compared to its expertise in natural gas storage, ongoing research and development efforts are positioning the country as a leader in exploring and advancing hydrogen storage technologies. Hence, its experienced academics and industrial workforce can play a pivotal role in unlocking the potential of Australia's depleted gas fields for hydrogen storage.

Compressed Hydrogen Storage

As with any gas, small to medium volumes of hydrogen can be compressed and stored in pressurised steel tanks. Compressed hydrogen storage is the most established method of hydrogen storage, with vessels widely used in industry operating up to 700 bar. Hydrogen storage vessels are categorised into four types based on its construction material. Type 4 vessels are constructed with a fully wrapped composite cylinder with plastic liner, allowing them to be the lightest, strongest, and most durable pressure vessels making them particularly suited to the energy industry.

AUSTRALIAN SUPPLIERS	UK OPERATORS
PROVARIS	STORELECTRIC WESSINGTON CRYOGENICS FLEXERGY

Table 4-17 Indicative companies active in the compressed gas storage services

Example Opportunities

Technology to compress hydrogen is required for hydrogen transportation and refuelling stations. The lack of local suppliers for hydrogen compression presents an opportunity for UK companies to enter the market.

Australia's Existing and Future Capabilities

Compressed hydrogen storage is essential for unlocking the full potential of hydrogen as a clean and sustainable energy carrier. By enabling efficient storage, transportation, and utilisation of hydrogen, compression technologies play a pivotal role in advancing the transition towards a low-carbon energy future. Australia's Provaris Energy has a compressor, H_2Leo, with a design capacity range of 300 to 600 tonnes of hydrogen, expandable to up to 2,000 tonnes. It is suitable for various hydrogen applications, including bunkering for the maritime sector, intermittent/buffer storage for green hydrogen production, and long-duration storage for excess renewable energy. Other hydrogen storage suppliers in Australia such as LAVO, Hydrexia and Green LOHC employ metal hydrides and organic carriers as their primary storage technologies.

UK s Existing and Future Capabilities

The UK National Composites Centre (NCC) is currently supporting research, design and development of the pressure vessels, pipes and cryogenic tanks used to compress and store hydrogen. Manufacturing capability in this area is likely to be low because of the recency of the research, but companies that can support the work of the NCC may be able to develop their own products and services using this experience and would be well positioned to exploit the relative lack of experience in the Australian supply chain. Additionally, global engineering and manufacturing companies such a Siemens, Sulzer and Atlas Copco which provide a wide range of gas compression solutions, have a presence in both the UK and Australia. Hence, by drawing upon their extensive expertise gained from hydrogen projects undertaken in the UK and Europe, they are well-positioned to impart and or transfer resources, insights, and best practices to their Australian branches.

Opportunity

Most hydrogen transport in Australia will be in the form of compressed hydrogen, outlined in the National Hydrogen Infrastructure Assessment, and will be transported either through pipelines or by truck. As trucking will be the preferred mode of hydrogen transport up to 2030, there will be a demand for compressed hydrogen storage vessels. Compressed hydrogen storage will primarily be used in the domestic hydrogen market as it is not a suitable storage method for export. Compressed storage is commonly used for refuelling stations and Australia has 20 projects in the pipeline that have a potential total daily capacity of 27 to 137 tonnes which will require compressed storage vessels.

4.6.5 Transport of Hydrogen

Summary

PRIMARY CATEGORY	TRANSPORT OF HYDROGEN
SECONDARY CATEGORY	Domestic Transport of hydrogen
TERTIARY CATEGORY (IF APPLICABLE)	Hydrogen Refuelling
AUSTRALIAN CAPABILITY	Medium
UK CAPABILITY	High

Table 4-15 Transport of hydrogen RAG summary

Hydrogen Refuelling

Hydrogen-powered vehicles are expected to play a significant role in meeting Net Zero targets, particularly with long-haul, heavy vehicles and freight transport. For these transport methods, hydrogen-powered vehicles have an advantage over battery electrical vehicles in shorter refuelling times, greater range between refuelling and avoiding negative impact of carrying large, heavy batteries.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
AMPOL ActewAGL coregas ITM POWER FORTESCUE FUTURE INDUSTRIES	ELEMENT 2 NanoSUN Commercial Fuel Solutions Howden LOGAN bp

Table 4-16 Indicative companies active in the hydrogen refuelling services.

Example Opportunities

- More refuelling stations planned as the federal and state governments launched initiatives to accelerate the uptake of FCEVs.
- Hydrogen Highway plans announced along key road freight routes.
- Potential to offset heavy fuel vehicles through conversion of ICE engines to offset emissions.

Australia's Existing and Future Capabilities

As of November 2023, there are 12 hydrogen refuelling stations either operating or under construction in Australia with the refuelling infrastructure sourced from overseas manufacturers. There are 20 additional projects in the pipeline, including the development of a refuelling network along key freight corridors such as the Queensland Hydrogen Super Highway and Hume Hydrogen Highway between Melbourne and Sydney. An MoU has been signed by Queensland, New South Wales, and Victoria for a tri-state collaboration for a hydrogen refuelling network that will run along the east coast of Australia, across all three states.

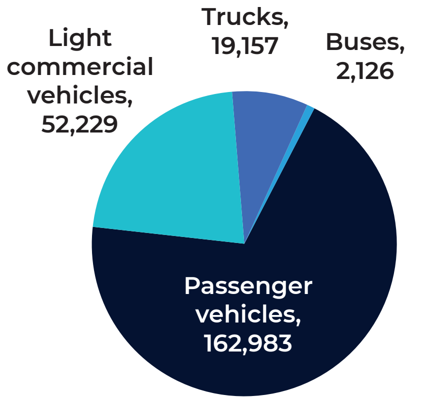
UK's Existing and Future Capabilities

The UK has a growing network of refuelling stations for hydrogen-powered vehicles and some of the demand for these stations are being met by UK companies. Element 2 has been building the national network of hydrogen refuelling stations across the UK and Ireland and expects to cover the entire country by 2027. Additionally, Lancaster-based NanoSUN is a world leading company with a range of proprietary mobile hydrogen refuelling solutions. NanoSUN already has an active collaboration with H_2 Hauler which will see its Pioneer refuelling stations being distributed across Australia. Howden, a subsidiary of Chart Industries, has also signed a cooperation agreement with Hydrexia to bring its hydrogen refuelling technology offering to the Australian market, with a focus on modularisation[29 30].

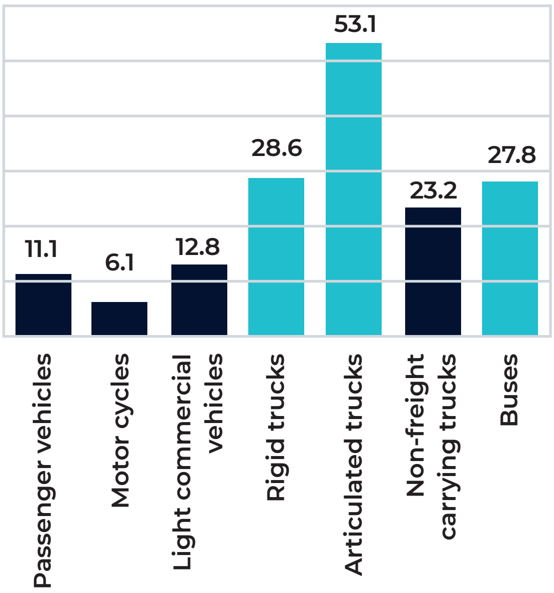
Opportunity

The current refuelling station plans will potentially accommodate heavy transport across 3,000 km of road, providing a clear market opportunity for UK companies. The total kilometres travelled by vehicle type over a 12-month period, as well as the fuel consumption by vehicle type, highlights the opportunity in Australia for hydrogen refuelling to offset fuel consumption of heavy vehicles such as busses and trucks. State governments in Australia are implementing plans to convert their bus fleets to hydrogen fuelled vehicles and politicians are trialling hydrogen fuel passenger cars for the ACT Government fleet. If this trend continues, there is an opportunity to introduce refuelling stations across the country to support the distances driven by all vehicle types. The Driving the Nation Fund will provide up to $10 million to all jurisdictions on a matched basis (up to $80 million total) to help industry fleets acquire heavy hydrogen fuel cell vehicles and construct renewable hydrogen refuelling stations on major freight routes across Australia.

TOTAL KILOMETRES (MILLIONS) TRAVELLED BY VEHICLE TYPE[31]



FUEL CONSUMPTION (L/100 KM) BY VEHICLE TYPE



[29] GlobeNewswire by notified, https://www.globenewswire.com/en/news-release/2023/04/24/2652731/9318/en/Hydrexia-Expands-its-Partnership-withHowden-to-Include-all-Chart-Industries-Inc-Solution-Offerings-for-Hydrogen-Fueling-Stations.html

[30] Yahoo!Finance, https://finance.yahoo.com/news/chart-industries-inc-expands-partnership-201000888.html

[31] Australian Bureau of Statistics

4.6.6 Sector Support Functions

Summary

PRIMARY CATEGORY	SECTOR SUPPORT FUNCTIONS
SECONDARY CATEGORY	Safety and Regulation
TERTIARY CATEGORY (IF APPLICABLE)	n/a
AUSTRALIAN CAPABILITY	Medium
UK CAPABILITY	High

Table 4-17 Sector support functions RAG summary

Safety and Regulation

Safety and regulation services ensure that hydrogen projects run safely and in accordance with local regulations.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Hydrogen Society of Australia (HSA)	national gas
Five Engineering	DNV
sherpa consulting	SGN
	Cadent

Table 4-18 Indicative companies active in the safety and regulation market

Example Opportunities

- Technical risk and safety consultancies offering hydrogen specific services.
- Developing best safety practices and training.

Australia's Existing and Future Capabilities

Australia's hydrogen facility regulations will be dependent on the type of technology used and a combination of federal and state specific regulations. Basic hydrogen safety training courses are being offered in Queensland, and New South Wales are developing gas blending frameworks. Hydrogen safety and regulations have been developed as the market continues to mature and leverages knowledge from similar industries such as oil and gas and LNG. It is likely that production facilities will be classified as Major Hazard Facilities (MHF) and will require dangerous goods licences to perform some of the work.

UK's Existing and Future Capabilities

The UK hydrogen safety and regulation supply chain has developed alongside the growth of hydrogen projects in the country. Companies have used their experience in gas safety and regulation to develop their capability in the hydrogen sector, particularly gas transmission network operators who are researching the possibility of repurposing gas infrastructure for hydrogen use. Northern England is home to DNV's Spadeadam Research and Testing facility, which focuses on developing understanding of fire and explosion events, as well as on testing for rapid crack propagation in non-metallic pipes. A possible export strategy for UK suppliers in this area could centre around sharing learning through consultancy work on Australian projects.

Opportunity

Hydrogen safety and regulation will depend on both federal and state frameworks. There are few pathways to enter the Australian market based on regulations. The opportunity for entry of UK companies will lie in offerings of hydrogen training, through developing safety practices, or technical risk and safety consultancies.

4.7 Areas of Developed Supply Chain Capability

Areas of developed capability in the Australian supply chain are a limited opportunity for the UK supply chain, due to the well-developed capability or local expertise that exist in Australia. The following areas of the hydrogen taxonomy have been identified as high capability in both regions, indicating that there are limited pathways for UK companies to enter the market unless existing relationships or partnerships have been formed with Australian companies. However, the volume of projects in the pipeline could indicate a possibility for UK support if these projects are realised.

4.7.1 Development of Hydrogen Infrastructure

Summary

PRIMARY CATEGORY	DEVELOPMENT OF HYDROGEN INFRASTRUCTURE	
SECONDARY CATEGORY	Concept engineering and consultancy	Environmental consenting
TERTIARY CATEGORY (IF APPLICABLE)		
AUSTRALIAN CAPABILITY	High	High
UK CAPABILITY	High	High

Table 4-19 Development of hydrogen infrastructure RAG summary

Concept engineering and consultancy

Concept engineering and consultancy forms part of the early development of a project. It involves the pre-concept designs, initial conceptual design, feasibility studies, and any other early project development works.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
GPA	Mott MacDonald
Momentum	kent
GHD	ARUP
aurecon	XODUS
CNF & Associates	

Table 4-20 Indicative companies active in the engineering and consultancy market

Australia's Existing and Future Capabilities

Australia has a strong track record of building new large-scale industries as a global leader in the export of LNG, coal and oil. It is also on track to become a renewable energy superpower due to its impressive natural wind and solar resources. Australia has over one hundred hydrogen projects at varying stages of development, of which 70% are at early-stage.

Over 90% of all hydrogen projects announced are green hydrogen, which will utilise renewable energy sources either from a behind-the-meter connection or through the grid. Australia has a well-established track record of installation for onshore wind and solar generation assets, as well as having developed small-scale hydrogen projects across the country.

UK's Existing and Future Capabilities

The relative maturity of UK hydrogen projects means that there is also existing capability in concept engineering and consultancy of hydrogen projects in the UK. Firms such as Xodus, Arup and Genesis have experience supporting in this area in the UK and would likely be capable of providing this capability to the Australian market due to the low barriers facing the export of knowledge-based services.

Opportunity

Approximately 70% of hydrogen projects are at feasibility or FEED stages of development which indicates an opportunity for businesses established in these services to enter the market. Australia has experience in renewable power generation; however, the hydrogen production industry is developing and there is an opportunity for established UK consultancies with expertise in hydrogen to supply concept engineering and FEED services to these projects.

Environmental Consenting

Proponents will need to investigate the likely impacts of a development on the natural habitat and built environments, as well as social and economic impacts on the project area. This is done through impact assessments that look into water management, biodiversity, noise and air quality, contamination and community and stakeholder engagement.

AUSTRALIAN SUPPLIERS	UK SERVICES
RPS (A Tetra Tech Company)	ARUP
ARUP	SWECO
WSP	Mott MacDonald
RISC	XODUS

Table 4-21 Indicative companies active in environmental consenting

Australia's Existing and Future Capabilities

The Environment Protection and Biodiversity Conservation (EPBC) Act 1999 (EPBC) outlines the Australian Government's environment assessment processes. The EPBC Act states that a proponent needs approval from the Australian Government for any proposed project, development, or activity that is likely to have significant impact on a matter protected by the EPBC Act. In addition to the EPBC Act, there may be state or territory authorisations that need to be followed. For example, South Australia has established a Hydrogen and Renewable Energy Act which outlines requirements for environmental assessments.

Australia requires environmental consenting for any major activity or project, and businesses have developed the local expertise of the consenting process and potentially affected matters. Therefore, Australian businesses have completed extensive environment impact assessments and relevant environmental consenting processes for industries such as oil and gas and renewable energy projects that have been established.

UK's Existing and Future Capabilities

Environmental consulting is a strength for the UK hydrogen supply chain, with several years of projects providing these services to UK projects. Companies such as Arup and Xodus are already present in both markets and able to transfer learnings from their UK experiences to add value to their Australian offering.

Opportunity

Due to the local environmental knowledge required for this project scope, the opportunity for UK businesses to enter the Australian market will likely lie in establishing local office bases or partnering with local firms.

Summary

PRIMARY CATEGORY	HYDROGEN PRODUCTION	
SECONDARY CATEGORY	Common Systems	
TERTIARY CATEGORY (IF APPLICABLE)	Electrical Systems	Health and Safety Communication Networks
AUSTRALIAN CAPABILITY	High	High
UK CAPABILITY	High	High

Table 4-22 Hydrogen production RAG summary

Electrical system

The electrical systems involved in hydrogen production include the primary electrical infrastructure that is required to connect the facilities to one another and to the electricity supply. It also includes major systems required for the functioning of the plant such as Heating, Ventilation, and Air Conditioning (HVAC) systems, communication systems, and control and monitoring systems.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Schneider Electric (Life Is On)	Petrofac
GENUS	Dron & Dickson
AMPCONTROL	Hitachi Energy

Table 4-23 Indicative companies active in the electrical systems market

Australia's Existing and Future Capabilities
The Australian electricity grid is separated into two major markets. The east coast is home to the National Electricity Market (NEM) network while the west coast is serviced by the Wholesale Electricity Market (WEM). There are additional, independent grids in the Northern Territory. There are now several transmission upgrade projects under construction by the Australian Government to enable the connection of new renewable energy and reduce constraints on existing grids.

Most of Australia's proposed hydrogen projects are green hydrogen projects that will use either a grid connection or a behind-the-meter connection to renewable power generation assets. Australia has a well-established renewables industry, primarily of solar and wind which requires the construction of substations and electrical infrastructure supply and installation. In general, most hydrogen projects are located near designated Renewable Energy Zones or demand centres, allowing short connection distances to electricity infrastructure.

UK's Existing and Future Capabilities
Petrofac and Dron and Dickson are examples of UK companies with significant experience in electrical system engineering and represent the strong capability across the UK hydrogen supply chain in this area. Existing capabilities have been built upon work on existing hydrogen projects but also in adjacent energy sectors, such as renewables energy and oil and gas.

There are few barriers to the export of knowledge-based services, and UK electrical systems companies such as Petrofac have successfully established themselves in Australia.

Opportunity
Australia has a developed supply chain for electrical systems and infrastructure, however there may be an opportunity for additional entrants to the market that can offer specialised systems or equipment that may be required for a hydrogen project.

Health and safety and communications networks
Healthy, safety, and communication networks for hydrogen facilities will be required in Australia, as these facilities will be listed as Major Hazard Facilities (MHF). The systems required include fire and gas, emergency shutdown (ESD) and control systems, as well as IT networks and potentially offshore communications. Hydrogen is highly flammable, and the gas and flame are colourless and odourless, making it impossible for human detection.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Life Is On Schneider Electric	Life Is On Schneider Electric
Wormald Technology	ESC Engineering Safety Consultants
powertec	Firstclass Safety & Control Ltd
MSA The Safety Company	Dräger

Table 4-24 Indicative companies active in the health and safety and communications networks market

Australia's Existing and Future Capabilities
Australia has a well-established mining and oil and gas industry from which fire, gas, ESD, and general health and safety systems experience can be leveraged for the hydrogen industry. The remote location of some hydrogen projects will also require additional systems to prevent bush fires from occurring/spreading, in the event of any accident at the facility. There are several existing suppliers that service the oil and gas, and mining industry in Australia and could expand their services to the hydrogen industry.

UK's Existing and Future Capabilities
The developed nature of the UK oil and gas industry and its associated infrastructure has ensured that ancillary services, such as health and safety and communications networks, are well established within the country. The parallels between the skills and experience required for natural gas and hydrogen means that there is strong UK supply chain capability in this area. First Class Safety and Control and Engineering Safety Consultants are examples of UK companies operating in this area. Schneider Electric is a French-headquartered company that has successfully entered both the UK and Australian markets and could act as a model for market entry for other suppliers.

Opportunity
Both countries have well developed healthy and safety communications networks due to experience in oil and gas industries. The opportunity for UK entrants to the Australian market is limited unless existing relationships or partnerships exist, however the scale of services required may provide a pathway for entry.

4.7.2 Installation & Commissioning

Summary

PRIMARY CATEGORY	INSTALLATION AND COMMISSIONING			
SECONDARY CATEGORY	Production Plant Install	Health and safety services	Production Plant servicing	BoP Plant servicing
TERTIARY CATEGORY (IF APPLICABLE)				
AUSTRALIAN CAPABILITY	High	High	High	High
UK CAPABILITY	High	High	High	High

Table 4-25 Installation and commissioning RAG summary

Hydrogen production plant installation
The hydrogen production plant installation includes the installation and commissioning of hydrogen systems.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Valmec	Vertex Hydrogen
	Logan Energy
	Linde

Table 4-26 Indicative companies active in the hydrogen production plant installation market

Australia's Existing and Future Capabilities

There has been no development of large-scale hydrogen facilities in Australia yet. Currently, there are 13 operating hydrogen projects across Australia. Of these, five are refuelling station projects, five involve hydrogen blending projects, and other projects may include demonstration or pilot hydrogen projects. Therefore, there are no Australian businesses that have established capabilities in large production plant installation and are limited to small-scale, domestic applications.

While Australian businesses have no experience implementing large-scale hydrogen projects, the skills required for the construction of facilities can be leveraged from other industries. Core skills will include trades that can be leveraged from other large-scale industries such as oil and gas, mining, and LNG, while more specialised skills such as instrumentation and pipeline work can be leveraged from LNG industries.

UK's Existing and Future Capabilities

The UK hydrogen supply chain can draw upon skills and experience from adjacent industries, such as oil and gas, to successfully install hydrogen production plants. Vertex Hydrogen and Logan Energy are examples of UK companies that have direct experience in this area, and are involved in the development of the hydrogen production for the HyNet and Levenmouth Community Energy projects respectively. Despite distance between the UK and Australia potentially disincentivising UK supply chain companies attempting market entry based on physical work scopes, knowledge services, in the form of consultancy informed by lessons learned from these projects, could be an alternative market entry strategy.

Opportunity

Australia and the UK have experience in installation of small-scale hydrogen facilities, but do not have large-scale installation experience in hydrogen. Both countries do however have experience installing and commissioning large-scale projects in other industries, such as oil and gas, mining and LNG in Australia. These experiences present a limited opportunity for UK entrants, however the scale of construction and installation services required may provide a pathway for entry.

Health and safety services

Health and safety services required for the installation and commissioning of a hydrogen project include health and safety inspections and equipment. Safety inspections should be regularly undertaken by technicians, while equipment may include Personal Protection Equipment (PPE) for workers, fire retardant materials and extinguishers, and any other relevant safety equipment.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
GEXCON	Dräger
BUNZL safety & lifting	BOC A Linde company

Table 4-27 Indicative companies active in Health and safety services

Australia's Existing and Future Capabilities

The Australian Government is reviewing legal frameworks that are relevant to the hydrogen industry safety and development, and determining what amendments need to be made to develop the hydrogen industry and ensure safety. The National Gas Law is currently being reviewed to include hydrogen blending in gas networks, for example. Specific requirements and laws may also vary state by state and will also differ dependent on the hydrogen technology utilised.

Australia has an established capability in health and safety services through other high-risk industries such as mining, LNG, oil and gas and coal. The knowledge and equipment from these industries can be leveraged to service the hydrogen industry, however specific hydrogen knowledge or training may be required to carry out inspections.

UK's Existing and Future Capabilities

UK capability in this area is well established due to transferable skills and experience from adjacent industries, such as oil and gas. Dräger and BOC are examples of companies that are active in the health and safety space for hydrogen projects in the installation and commissioning phase of the project lifecycle. Both companies are non-UK owned and are examples of successful foreign market entry for UK suppliers with Australian expansion as part of their strategy.

Opportunity

Both Australia and the UK have experience in health and safety services for large-scale projects in other industries such as oil and gas, or mining and LNG in Australia which can be leveraged to support hydrogen facilities. These experiences present a limited opportunity for UK entrants.

Hydrogen plant maintenance and service

The maintenance and service of the hydrogen plant includes the inspection, repair, refurbishment and or replacement of the electrolyser, reformer, CO_2 processing, post-production processing plants and storage and delivery components, if used.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
VALMEC	Linde
coregas	cngservices
	AIR PRODUCTS

Table 4-28 Indicative companies active in the hydrogen plant maintenance and service market

Australia's Existing and Future Capabilities

Australia does not have any operating large-scale hydrogen production plants, so any experience of maintenance and service of hydrogen production plants is limited to the small-scale production, refuelling, and gas blending projects that are in operation. The hydrogen industry is immature in Australia and projects that have been established are relatively new, therefore there is no long-term experience in the maintenance of hydrogen production plants. Skills and knowledge from adjacent industries such as oil and gas, LNG, and mining can be leveraged to support the maintenance of hydrogen plant equipment.

UK's Existing and Future Capabilities

The UK is home to multiple companies active in hydrogen plant maintenance and services. Companies, such as Linde and Air Products, are example of global players active in the UK market. CNG Services are a UK-owned company in this space and have capability in hydrogen plant maintenance and service.

Opportunity

Australia and the UK have experience in installation of small-scale hydrogen facilities, but do not have large-scale installation experience in hydrogen. Both have experience providing maintenance and services to large-scale projects in other industries such as oil and gas, or mining and LNG in Australia. These experiences present a limited opportunity for UK entrants unless specialised skills can be offered.

The market size for electrolyser maintenance services could be worth over A$5 billion annually, based on the installation of electrolysers for green hydrogen projects by 2032. This assumes the maintenance costs equate to 4% of electrolyser costs.

Balance of plant maintenance and service

The balance of plant maintenance and service scope includes the inspection, repair, refurbishment, and or replacement of the desalination plant, pipelines, electrical equipment, valves, air separation, offshore structures, and tooling and consumables.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Metal Maintenance, Ampcontrol, Horizon, Aquasure, Vertech Group	ABB

Table 4-29 Indicative companies active in the balance of plant maintenance and service market

<u>Australia's Existing and Future Capabilities</u>

The hydrogen industry is immature in Australia and any projects that have been established are relatively new, therefore there is no established experience in the maintenance of hydrogen systems. There is, however, well established experience in the maintenance and services of offshore structures, desalination plants, and electrical equipment due to the nature of other industries in Australia. These skills will be leveraged from the mining, oil and gas, LNG, and other renewable generation assets.

<u>UK's Existing and Future Capabilities</u>

The presence of extensive oil and gas and chemical industries in the UK means that there is a good level of capability in balance of plant maintenance and service for plants in those adjacent industries. Due to the similarities between aspects of these industries and the hydrogen industry, there is logic in assuming that current capability could also extend to hydrogen projects.

<u>Opportunity</u>

The balance of plant maintenance includes maintenance to the desalination plant, which is an area that Australia has long-term experience in. For other components, Australia, and the UK both have experience providing maintenance and service to large-scale projects in other industries such as oil and gas, or mining and LNG in Australia. There is a limited opportunity for UK entrants into the Australian market, however specialised skills for maintenance services may provide an entry point.

Operations and maintenance support

The operations and maintenance support scope includes additional maintenance services that are required to keep the hydrogen facility running. These support services may include monitoring software, IT support, cybersecurity tools, and specialised hydrogen value chain software.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Schneider Electric (Life Is On), Yokogawa, computing australia	ABB

Table 4-30 Indicative companies active in operations and maintenance support

<u>Australia's Existing and Future Capabilities</u>

Australia has experience in large-scale production and export industries through established oil and gas, mining, and LNG industries. These industries also require production management software, including management software, IT support, and cyber security tools. These tools have been developed for these specific industries and can likely be adjusted to suit the requirements of the hydrogen industry.

<u>UK's Existing and Future Capabilities</u>

The presence of extensive oil and gas and chemical industries in the UK means that there is a good level of capability in operations and maintenance support for plants in those adjacent industries. Due to the similarities between aspects of these industries and the hydrogen industry, it is reasonable to assume that current capability could also extend to hydrogen projects.

<u>Opportunity</u>

Australia and the UK both have experience providing maintenance and service to large-scale projects in other industries such as oil and gas, or mining and LNG in Australia, which also require complex production management software and IT support. Skills for other industries will likely be leveraged to provide the skills needed for operations and maintenance, leaving limited opportunity for UK entrants. However, these services can be delivered without a physical base, which provides potential entry options for UK companies with existing hydrogen offerings.

4.7.3 Sector Support Functions

Summary

PRIMARY CATEGORY	SECTOR SUPPORT FUNCTIONS
SECONDARY CATEGORY	Professional Services
TERTIARY CATEGORY (IF APPLICABLE)	
AUSTRALIAN CAPABILITY	High
UK CAPABILITY	High

Table 4-31 Sector support functions RAG summary

Professional Services

Professional services are not specifically linked to the hydrogen industry but are required to ensure the hydrogen facility's continued operation. Professional services could include insurers, legal firms, training, consultancies, and financial institutions.

AUSTRALIAN SUPPLIERS	UK SUPPLIERS
Gilbert + Tobin, MinterEllison, ANZ, Marsh, Liberty Specialty Markets	Lloyd's, LGIM, Barclays, Norton Rose Fulbright, Clifford Chance

Table 4-32 Representative companies active in the professional services market

Australia's Existing and Future Capabilities
The professional services sector is well developed in Australia and is a large share of the workforce in major cities. Australia has the potential to become a global leader in hydrogen and many of its financial institutions and law firms have launched hydrogen offerings to support the development of the industry and achieve decarbonisation goals.

UK's Existing and Future Capabilities
Professional services are a core strength for the UK economy due to London's position as a global hub for insurance, legal, and financial services. This reputation has led to UK companies successfully projecting this strength into other markets and this could be similarly replicated in Australia for professional services for hydrogen projects.

Opportunity
Both countries have well established professional services sectors that play a large part of the economy. Professional services offerings can largely be delivered without the need for a physical base or presence within the country, therefore, the opportunity for UK entrants to the Australian market for these services may lie in business partnerships. There is a strong opportunity for global businesses with hydrogen experience in other regions to enter the Australian market.

5. BARRIERS TO ENTRY

5.1 UK Supply Companies

5.1.1 Overview

Several issues exist for international suppliers and service businesses looking to establish themselves within Australia. While the UK and Australia have a free trade agreement, exempting a wide range of physical products from importation duty, UK businesses also need to factor the cost of performing business within Australia as well as the added burden of regulation.

This is particularly true for businesses looking to establish a physical manufacturing footprint within Australia, as these factors will influence the competitiveness of UK business products when compared to imported hydrogen products from low-cost manufacturing countries such as China and India. A selection of the primary issues facing UK products and services businesses entering Australia are presented below.

5.1.2 Regulation

In Australia, regulatory frameworks struggle to keep up with the rapid evolution of the hydrogen industry. Nevertheless, efforts are underway to develop a comprehensive national hydrogen strategy and regulatory framework to guide the growth of the industry within the country. Notably, Standards Australia is actively engaged in formulating comprehensive documentation tailored for Australian usage, covering all aspects of the hydrogen industry. For example, it had adopted relevant ISO standards on the design of fuel cells and the Australian Standards for the Fuel Cell is now officially gazetted.

Additionally, existing Australia's industry standards are known to be unique and international companies navigating the Australian market may find that compliance with local regulations, standards, and certification processes may require significant time and resources. For example, during the SunHQ Hydrogen Hub project execution, Ark Energy noted that international vendors had to undergo multiple design revisions to meet compliance requirements, despite the owner's engineers having already furnished them with all necessary specifications and guidance on addressing them effectively.

5.1.3 Fiscal Regime

Despite holding a AAA investment grade credit rating according to Standards and Poor's, Australia faces challenges with its headline corporate tax rate of 30%, which compares unfavourably to competitors in the hydrogen export market, including the UK. For instance, Singapore, renowned for its commercial port and manufacturing and distribution hub status, boasts a significantly more favourable corporate tax rate of 15%, half that of Australia's. This tax discrepancy could potentially impact Australia's competitiveness in the global hydrogen market, particularly as countries like Singapore offer more attractive tax incentives for businesses operating in the sector.

CORPORATE TAX RATE (VS NET EXPORTERS)

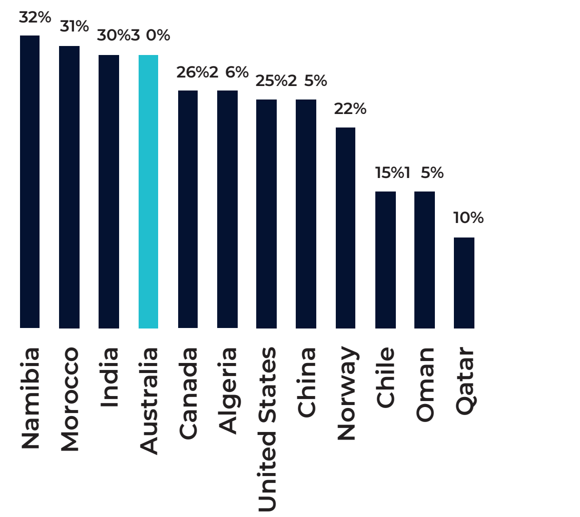


Figure 5-1 Corporate tax rankings

Consideration should be given to the application of Special Economic Zones for foreign businesses establishing themselves in Australia to help establish the hydrogen supply chain boosting economic expansion, lifting barriers to the export of skills, increase competitiveness and improving commercial exchange.

PATENT BOX RATE (TOP 10 MOST EXPENSIVE)

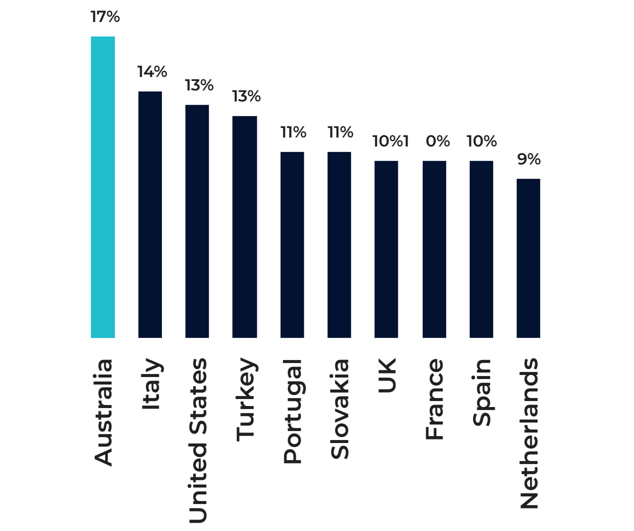


Figure 5-2 Patent box rankings

Tax provisions known as "Thin Capitalisation" can also reduce the ability to offset tax liabilities in Australia through the injection of debt capital beyond the "Safe Harbour" provisions of 60%, with interest rate payments more than the safe harbour limits being ineligible for deduction from taxable profits.

Despite previously generous tax incentives encouraging the investment in research and development activities through the deduction of qualifying R&D expenditure, Australia's tax regime has not been geared towards incentivising the scale up of industry or manufacturing.

In recent years, the Australian Government have adopted a patent box which aims to encourage the development and registration of patents in Australia by lowering the headline corporate tax rate to 17% on profits associated with these activities. However, Australia's patent box ranks as the highest concessional tax rate of the 24 countries with the same scheme and application is limited to patents for biomedicine only. As of the date of this report, a decision to expand the patent box to clean energy technologies is being considered subject to industry consultation.

5.1.4 Labour Costs

Australia's cost of labour, as reported by Trading Economics, is relatively high compared to other manufacturing regions globally. This is attributed to the country's high levels of education and a predominantly skilled labour force. While this may not be fully representative of the entire labour force, it remains a significant factor for businesses operating in the manufacturing sector. For companies heavily reliant on automation, the impact of labour costs may be less pronounced. However, for service-based businesses venturing into the Australian market, this presents a notable consideration when aligning pay structures and local service delivery.

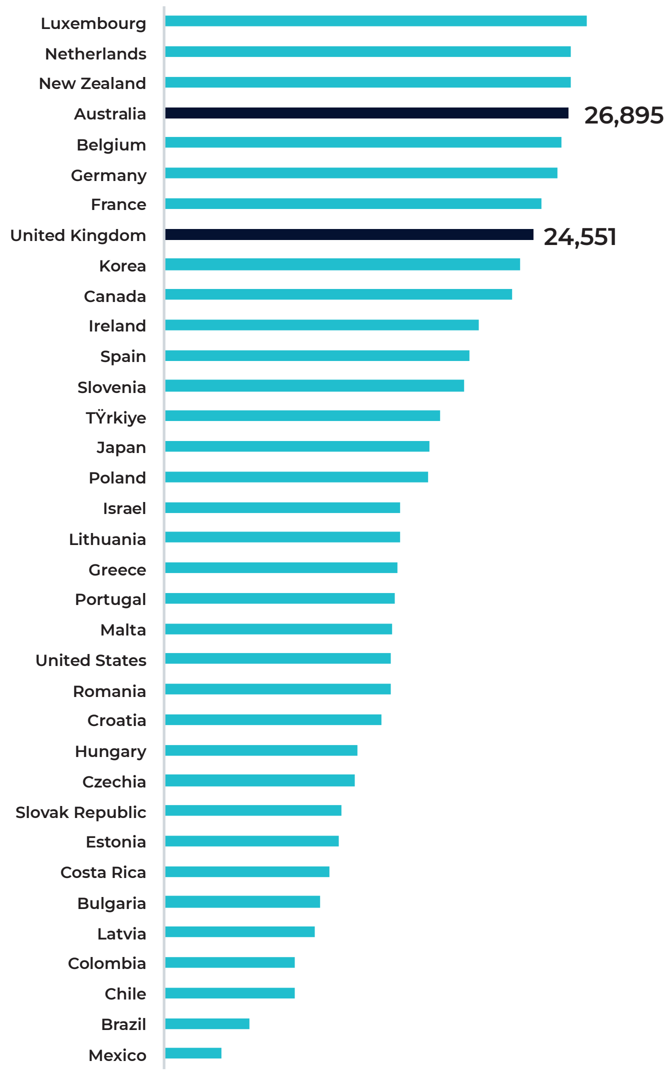


Figure 5-3 Real annual minimum wage (2022) (chart adapted from OECD data)

5.1.5 Physical Barriers

Geographical Distance:
Australia's location, particularly for companies based in the UK, poses logistical challenges in terms of transportation, shipping, and supply chain management, which inevitably result in higher costs and longer lead times.

Infrastructure:
Australia lacks existing hydrogen infrastructure, including production facilities, distribution networks, and refuelling stations. Overseas companies looking to establish operations or deploy hydrogen technologies will need to factor in the additional costs and time required to establish the necessary infrastructure.

Environment:
Australia's diverse and sometimes harsh environmental conditions, such as extreme temperatures, may require specialised equipment or adaptation of technologies to ensure reliability and performance (e.g., appropriately cyclone rated). This is particularly true in Northwest Australia which is in some parts rated as a category D cyclonic region and the location of green hydrogen projects within Australia.

5.2 UK Developer Challengers

As green and blue hydrogen projects are in their relative infancy, the most pressing issues facing developers include approvals, land access, carbon policy, certification and revenue certainty to advance projects towards a financial investment decision. In addition to this, as Australia's policy positions on these matters are not fully developed, as compared with other regions such as in the US and Europe, there is an inherent level of uncertainty facing investors and developers involved with Australian projects.

Furthermore, Australia's federated system requires careful consideration of the differences in approach between the States to things such as environmental approvals as well as the interaction between State and Federal Government authorities.

The most prominent challenges facing inbound developers in Australia are summarised in the sections below.

5.2.1 Land Access

As with any major infrastructure project, securing tenure over land is a critical first step in establishing a development. In recognition of this, the Western Australian Government passed the Land Public Works Amendment Act in 2023. This was significant, given most hydrogen projects are within Western Australia, allowing for the granting of diversification leases for crown or government owned land. The impact of the legislation is that it allows for leases to be granted to renewable energy and hydrogen projects from existing use.

However, the legislation states that leases would be provided on a non-exclusive basis and would require the approval of the ministers for mines, native title parties and minister for lands. Furthermore. where applicants for land require surrender of a pastoral lease this could lead to costly and potential lengthy negotiations for land.

An additional challenge for foreign developers entering Australia is the requirement to apply to the Foreign Investment Review Board (FIRB) in parallel with acquiring Australian assets. This applies for any entity with ultimate ownership outside of Australia securing interests in land (via lease or direct ownership), assets or securities and presents an additional hurdle for UK developers. The broad intent of FIRB is to ensure that foreign investments are in the national interest, hence investments in line with Australia's emission targets could be viewed favourably.

5.2.2 Environmental Approvals

Critical to any major infrastructure project within Australia is successfully gaining environmental approvals. Australia's biodiversity has led to it being one of 17 megadiverse countries, with more than 80% of its mammals and plants occurring nowhere else globally[32]. According to Australian Wildlife Conservancy, almost 50% of Australia's GDP has a high or moderate dependency on ecosystem services, hence its heightened importance by The Federal, State and Territory Authorities.

The key issues relating to environmental approvals are summarised below, with further detail provided in Appendix C.

[32] *Australian Wildlife Conservancy*

Regional Nuances

The environmental approvals process in Australia differs both between the individual states and territories and the Federal Government, but also between each state and territory within Australia.

The Federal environmental approvals process arises from the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The EPBC Act protects certain nationally significant (protected) animals, plants, habitats, or places, which collectively are known as Matters of National Environmental Significance (MNES). Any action that may have a significant impact on any MNES must be referred to the Federal Environment minister for assessment and an approval decision.

The environmental approvals processes implemented by the states and territories however are often more complex and far reaching than the Federal environmental approval process. For instance, while the Federal environmental approvals process is tied to potential impacts on MNES, the State and Territory approvals processes often take into consideration a much broader view of potential environmental impacts from projects, with assessments organised using environmental factors.

In practice this can lead to instances where a MNES is not triggered by the Federal process, but state and territory processes are likely to lead to referral of these matters. In most instances however, referral under Federal legislation will be required in addition to State and Territory based processes.

Another example of regional differences are the roles of various environmental bodies within the states and territories. Within the Northern Territory and Western Australia for example, environmental assessment is completed by the Environmental Protection Authority (EPA) with final approval being determined by the Minister. Whereas in New South Wales, South Australia and Victoria, the EPA will undertake environmental assessments for a project with state planning authorities providing the final approval.

Approval Times

Another key challenge for all renewable energy developers including hydrogen, is the length of time to receive environmental approval for projects. According to analysis conducted by Herbert Smith Freehills and the Clean Energy Investor Group, the average approval time frame for large scale renewable energy projects in NSW was 746 days over the last 5 years. This is further compounded when considering additional review time required under Federal Environmental laws. In recognition of this problem, the Western Australian Government announced funding support for the creation of a green approvals body in 2022 to help streamline renewable energy project environmental applications and decisions, a move that could be adopted in other states to assist with the scale of projects required to meet emissions targets.

Assessment timelines are often a product of the quality of information provided by the proponent in support of the project, with projects often requiring additional environmental studies after referral to provide the Regulators with sufficient information to support their assessment.

Transparency and Public Consultation

Environmental approvals processes within Australia at the State, Territory and Federal level are designed to promote transparency between the Government and the public. This means proponents must expect their referral reports and supporting studies to be made public by Regulators to facilitate public comment on the project. Regulators are also often required to take public comments into consideration during the assessment process and projects with a high level of public interest can expect longer assessment timeframes.

5.2.3 Low Carbon Hydrogen Certification

Australia's Guarantee of Origin scheme to track and verify emissions associated with hydrogen aims to provide assurance to international buyers and align it with globally recognised standards. Consultation regarding the scheme has now closed and on the 12th of September a bill containing the provisions of the scheme were introduced to parliament. This legislation will be key for developers in unlocking funding schemes requiring certification, as well as alignment with international standards.

The Hydrogen Headstart Program is Australia's $2bn funding initiative to bridge the commercial gap between the price off-takers are willing to pay for green hydrogen and the cost to produce. The scheme has signalled only the requirement for electricity associated with green hydrogen to either be directly from a renewable energy co-located with hydrogen production, or from the grid with an accompanying renewable energy certificate.

Whilst The Guarantee of Origin Scheme will provide further clarity on the renewable energy requirements for green hydrogen, the US, Europe and the UK have put in place stringent requirements that require green hydrogen production to be matched to renewable energy input on an hourly basis to qualify as renewable. The USA's Inflation Reduction Act links the maximum incentive for low carbon hydrogen of US$3.0/kg to this requirement also. This all creates a degree of uncertainty as to the likely direction of certification within Australia and the impact this will have on developments in terms international compliance and project viability.

5.2.4 Carbon Policy

Key to the success of low carbon hydrogen is the adoption of a robust carbon policy, such that the environmental cost of carbon is appropriately attached to fossil fuels to provide a fair comparison with clean energy. By way of example, Figure 5-3 shows the current commercial gap between publicly announced green hydrogen projects[33] and unabated diesel and gas fuel in hydrogen equivalents. Using an equivalent carbon intensity for each fuel type, the commercial gaps represent carbon equivalent prices of ~$150 and $900/t CO_2e for diesel and gas respectively. This is as compared with the maximum price of $75/t CO_2e applied to emissions above allowances under Australia's Safeguard Mechanism.

While improvements in the cost of green hydrogen could be expected to close the current commercial gap in the future, a strong carbon pricing mechanism is essential to industry adoption.

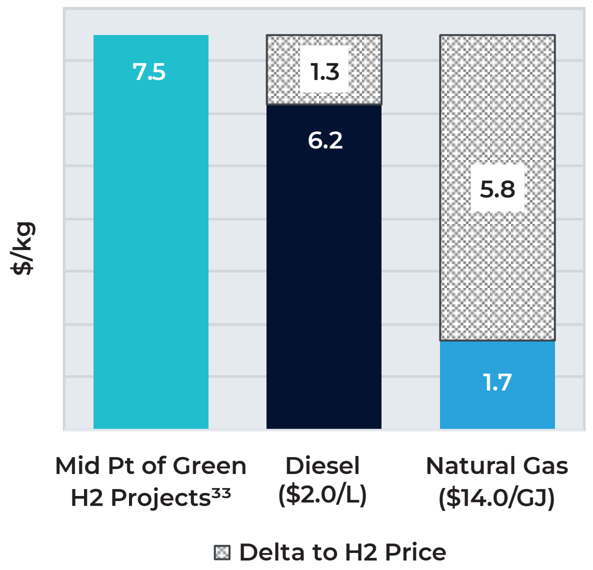


Figure 5-4 Green hydrogen commercial gap

[33] Darren Miller ARENA CEO $6-9/kg for green hydrogen. https://arena.gov.au/ The Future of Hydrogen

Australia's current target for reducing emissions includes a legislated reduction of 43% below 2005 levels by 2030 and net zero by 2050. However, Australia's only carbon policy currently is the Safeguard Mechanism, which requires emitters producing over 100,000 tonnes of carbon per annum to reduce emissions from baseline levels by 4.9% per annum by 2030. The penalty for breaching these commitments is to purchase and surrender Australian Carbon Credit Units (ACCUs) which trade at ~$30/t of CO_2e (£17). This is significantly below the traded price of carbon in Europe of c.€90/t CO_2 (£75), and arguably provides limited incentive to take up low carbon hydrogen. While the price of ACCUs is likely to increase as demand increases relative to supply, under The Safeguard Mechanism there is also no limit as to the amount of emissions that can be offset financially (with ACCUs), rather than physically through renewable energy, clean hydrogen or carbon capture. Furthermore, emitters captured under The Safeguard Mechanism only account for 28% of emissions within Australia, reducing the direct incentive to use hydrogen within Australia to reduce carbon intensity.

5.2.5 Revenue Certainty

Perhaps the most critical step in taking a final investment decision in hydrogen projects, is the security of revenue to underwrite the large capital investments required. Australia announced the Initial Hydrogen Headstart Program along with an expansion of the program in 2024 aiming to provide revenue support to hydrogen producers where commercial off-take does not support the price of hydrogen required. However, the scheme only has committed funds of $2bn for 10-year contracts, which is likely to support only ~1 GW of Australia's projects. A further issue presented by this (and schemes in the US and Europe H_2 Global) is that they do not provide certainty over revenues for the entirety of project, which would likely aim to operate over a 20-year period or more. During the Federal Budget announcements in 2024, a further $6.7bn was pledged for a $2/kg production tax credit for 10 years post-production. Whilst this provides added incentive to producers, this more accessible form of support would only cover a fraction of the total capacity currently in development, leaving other measures such as mandates requiring fuel switching or more comprehensive carbon policies, to help ensure hydrogen production becomes attractive longer term, beyond the end of subsidies.

These challenges aside, Australia's underlying fundamentals for green and low carbon hydrogen production are incredibly strong for reasons mentioned throughout this report and as the world leading number of projects in the clean hydrogen pipeline suggests.

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6.1 List of Acronyms

ACRONYM	DESCRIPTION
AAA	AAA Credit Rating
ACT	Australian Capital Territory
AEMO	Australian Energy Market Operator
AGIG	Australia Gas Infrastructure Group
APAC	Asia and Pacific
AREH	Australian Renewable Energy Hub
ARENA	Australian Renewable Energy Agency
ATR	Autothermal reforming
AU	Australia
AUD	Australian Dollars
BP	British Petroleum
BoP	Balance of Plant
CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage
CFE	Capillary-Fed electrolysers
CHP	Hydrogen Combined Heat and Power
CO_2	Carbon Dioxide
COP	Conference of the Parties
DAC	Direct Air Capture
DCCEEW	Department of Climate Change, Energy, Environment and Water
EAC	East Australian Current
ECH_2	East Coast Hydrogen
EPBC	Environment Protection and Biodiversity Conservation Act 1999
ESD	Emergency Shutdown
EPC	Engineering Procurement Construction
ERW	Electric Resistance Welded
EU	European Union
FC	Financial Close
FCDO	Foreign, Commonwealth Development Office
FEED	Front-End Engineering and Design
FID	Final Investment Decision
GE	General Electric
GEAP	Gladstone Energy and Ammonia Project
GHG	Greenhouse Gases
GO	Guarantee of Origin
GW	Gigawatts
ISO	International Organization for Standardisation

ACRONYM	DESCRIPTION
JV	Joint Venture
KTPA	Thousand Tonnes Per Annum
kW	Kilowatt
LH2	Liquid Hydrogen
LNG	Liquefied Natural Gas
MHF	Major Hazard Facilities
MJ	Mega Joule
MJLHV	Lower Heating Value
MoU	Memorandum of Understanding
MW	Megawatts
NB	Nominal Bore
NCC	National Composites Centre
NEM	National Energy Market (connecting QLD, SA, NSW, VIC and ACT)
NGER	National Greenhouse Gas and Energy Reporting
NH_3	Ammonia
O&M	Operations and Maintenance
OPGGS	Offshore Petroleum and Greenhouse Gas Storage (Act 2006)
PDC	Pilbara Development Commission
PEM	Proton Exchange Membrane
R&D	Research and Development
RAG	Red-Amber-Green
SA	South Australia
SIA	Strategic Industrial Area
SOE	Solid Oxide electrolysers
SWIS	South West Interconnected System
TJ	Tera Joule
UK	United Kingdom
US	United States
UAV	Unmanned Aerial Vehicle
USA	United States of America
USD	American dollars
WA	Western Australia
WEM	Wholesale Electricity Market (Western Australia)
WHS	Work Health and Safety
EPBC	Environment Protection and Biodiversity Conservation
HVAC	Heating, Ventilation and Air Conditioning
MHF	Major Hazard Facility

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