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AUSTRALIA

The H_2 Handbook

Legal, Regulatory, Policy, and Commercial Issues Impacting the Future of Hydrogen

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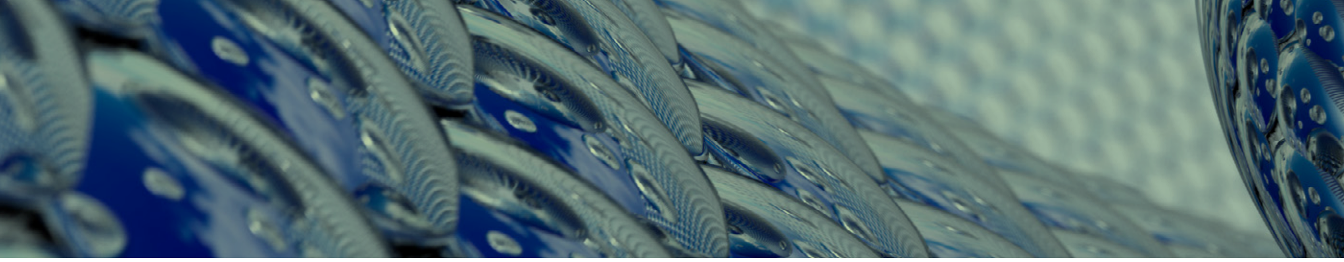

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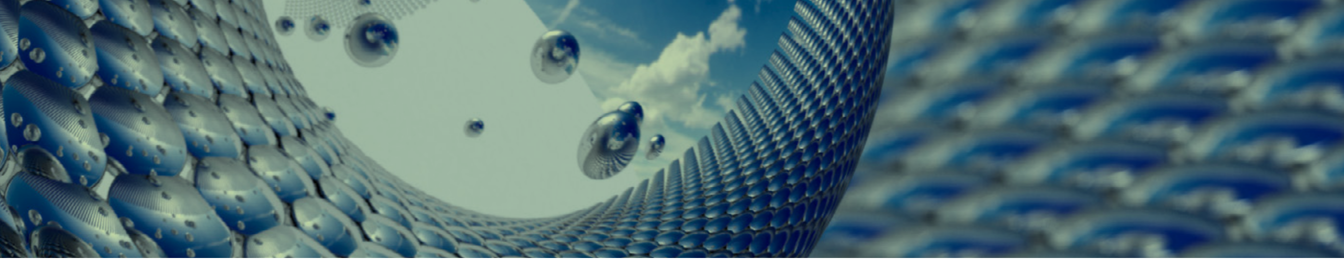

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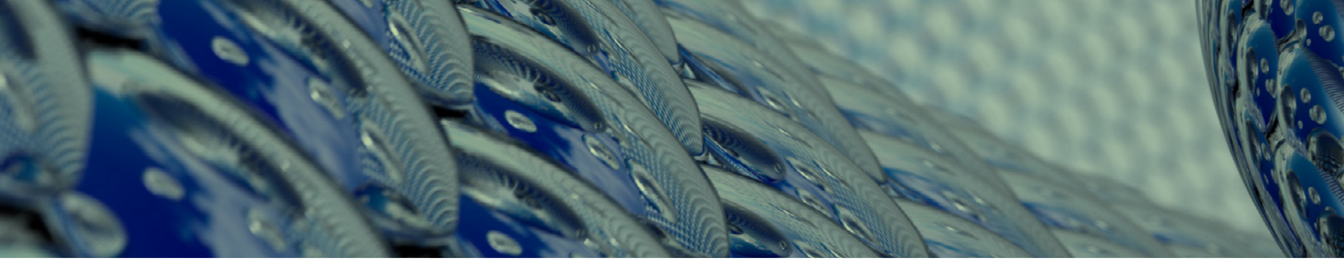

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PART I - INTRODUCTION

I. Background

Like many countries around the world, Australia is transitioning to a low-carbon future to reduce greenhouse gas emissions and combat climate change. Australia ratified the Paris Agreement in 2016, committing to a 26-28 per cent reduction in greenhouse gas emissions below 2005 levels by 2030. In addition, every Australian state and territory has committed to a net-zero emissions target (many of which are legislated).

As Australia undertakes this transition, the need for "clean" fuels that also meet safety, storage, and other commercial requirements is becoming increasingly necessary. Clean hydrogen (either green hydrogen, produced through electrolysis of water using renewable power, or blue hydrogen, made through thermochemical production alongside carbon capture technology) can meet these criteria and is expected to play a key role in the decarbonisation of energy in Australia.

Clean hydrogen can also assist Australia in addressing a number of energy security risks it currently faces.

Australia is in an ideal position to become a global leader in clean hydrogen, and the Australian hydrogen industry could generate an additional A$11 billion in GDP by 2050.[1] Australia's ability to lead the world in clean hydrogen is due to a number of key factors, including:

- **Abundant natural resources**

  These resources include coal and liquefied natural gas (LNG), renewables, and land mass.

- **Proven track record**

  Australia has significant experience in large-scale energy projects and development of energy industries, particularly with respect to LNG export projects.

- **Governmental support**

  The Australian federal government has shown its commitment to hydrogen through policy and funding. It has developed the National Hydrogen Strategy, committed A$146 million to the hydrogen industry since 2015[2], and has committed an additional

[1] Matt Judkins and John O'Brien, *Australian and Global Hydrogen Demand Growth Scenario Analysis*, DELOITTE 8 (Nov. 2019), http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/nhs-australian-and-global-hydrogen-demand-growth-scenario-analysis-report-2019_1.pdf (last visited Sept. 8, 2020).

[2] *Australia's National Hydrogen Strategy*, COAG ENERGY COUNCIL xvi (Nov. 2019), https://www.industry.gov.au/sites/default/files/2019-11/australias-national-hydrogen-strategy.pdf (last visited Sept. 8, 2020) [hereinafter COAG 2019].

A$370 million in funding through various agencies.[3]

- **Skilled workforce**

  Australia has a technically skilled workforce with deep expertise in the energy sector and high-value or advanced manufacturing production processes.

- **Hydrogen expertise**

  Australia leads the world for research in storage, distribution, and use with over 30 pilot projects across Australia.

II. Australia's Competitive Advantage

Australia has a distinct competitive advantage in establishing and expanding its clean hydrogen industry, as well as being well placed for both the domestic use and export of hydrogen. Australia has particular comparative advantages due to the strength of its existing LNG production and export operations, the potential for synergies with its developed renewables industry, demand for hydrogen imports from Australia's largest trading partners in the Asia-Pacific region, and opportunities for domestic use of hydrogen due to Australia's reliance on the importation of liquid fuels and comparatively high price of LNG.

A. LNG and Natural Gas

Australia exports A$50 billion in LNG annually (the second-largest exporter of LNG in the world) and is host to many of the world's largest oil and gas companies, many of whom are looking towards transitioning to a future of hydrogen production for commercial and individual use. Australia has major international ports along its coastline, many with existing LNG and petroleum infrastructure that provide an ideal environment for developing "hydrogen hubs" and to then support the upscaling of hydrogen production for export and domestic use.

Australia also has an extensive network of major natural gas transmission and distribution pipelines, and, in many parts of Australia, a comparatively high price for natural gas. Replacing or blending natural gas with clean hydrogen in these networks has the potential to drive down natural gas prices and stimulate early hydrogen demand-side growth, which has the advantage of being able to be directly influenced by governments. With further R&D into the ability of these networks to transport hydrogen, as well as safety and regulatory matters, Australia can be in a position to capitalise on this infrastructure. The Australian government plans to complete its review in relation to these matters by the end of 2020.

B. Renewables

Australia is home to many high-intensity renewable energy resources. The Australian continent has the highest solar radiation per square metre of any continent, and some of the best wind resources in the world in the southern parts of the Australian continent.

[3] *Australia to be a world leader in Hydrogen*, MINISTERS FOR THE DEP'T OF INDUS., SCIENCE, ENERGY AND RES. (Nov. 23, 2019), https://www.minister.industry.gov.au/ministers/canavan/media-releases/australia-be-world-leader-hydrogen (last visited Sept. 8, 2020).

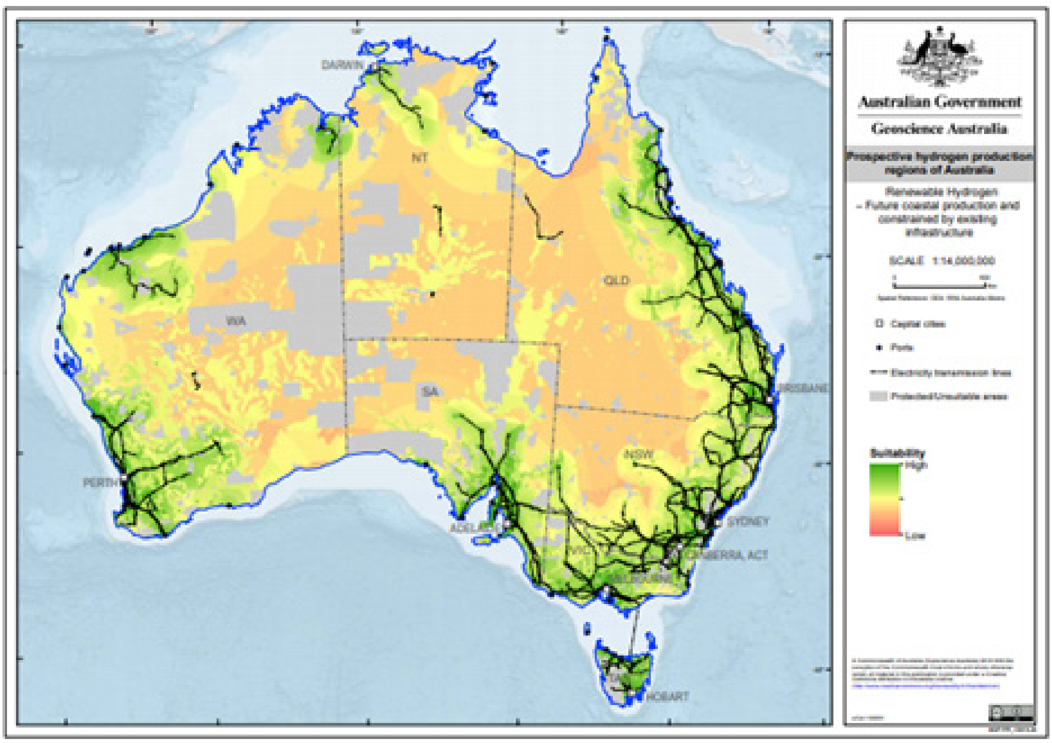
This presents a huge opportunity for Australia in sector-coupling the hydrogen industry with these vast renewables resources, combined with high land availability, given green hydrogen's requirement for access to low-cost, low-emissions electricity.

It is estimated that about 3 per cent of the Australian continent (about 262,000 square kilometres) would be suitable for green hydrogen production, with proximity to renewable resources, as well as the requirement for water—this amount of land, if utilised, could produce more hydrogen than the global demand predicted by the Hydrogen Council by 2050.[4]

C. Export Opportunities

Australia has a strong reputation as an energy exporter to Asia (with LNG exports to Southeast Asia, China, and Japan accounting for 97 per cent of Australia's total LNG export earnings),[5] and three of Australia's top four trading partners (namely, Japan, the Republic of Korea, and China) have committed to using clean hydrogen to decarbonise their energy systems.

With the global market for hydrogen expected to increase, Australia can capitalise on its proven track record in energy exports, especially to comparatively resource-constrained countries such as Japan, and its knowledge in order to progress the hydrogen industry.



4 *See* COAG 2019, *supra* note 2, at 10.

5 ARUP, *Australian Hydrogen Hubs Study*, 2 COAG ENERGY COUNCIL HYDROGEN WORKING GROUP (Technical Study) (Nov. 2 2019), http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/nhs-australian-hydrogen-hubs-study-report-2019.pdf (last visited Sept. 8, 2020).

Australia has identified four key hydrogen export jurisdictions: Singapore, China, South Korea, and Japan; and assessed its potential market share in each of these markets and the target price of hydrogen required, to be competitive with other potential hydrogen-exporting countries such as Qatar and Norway.[6]

Australia has already entered, or plans to enter, into a number of bilateral agreements with trading partners to promote trade and investment in hydrogen, including with:

- **Japan**—Joint Statement on Cooperation on Hydrogen and Fuel Cells (January 2020)
- **Republic of Korea**—Letter of Intent to develop a Hydrogen Action Plan (2019)
- **Singapore**—Agreement to pursue a Memorandum of Understanding on low-emissions technologies (by end of 2020)
- **Canada**—Memorandum of Understanding to collaborate on the commercial deployment of zero-emission hydrogen and fuel cell technologies (2020)

There is also potential for Australia to blend hydrogen into a number of its existing export commodities (such as methanol and ammonia).

D. Domestic Use

Hydrogen also has a significant potential for use within Australia:

1. Natural Gas

Prices for natural gas remain high in many parts of Australia, particularly across the eastern coast, largely due to local gas supplies being committed to long-term export contracts, coupled with a moratorium on unconventional natural gas exploration in many areas. Hydrogen could replace or supplement natural gas for use in heating and cooking or as feedstock in industrial processes (subject to resolving the technical and regulatory issues as outlined in **II.A** above).[7]

2. Liquid Fuels Security

Australia is currently dependent on imported liquid fuels, and does not meet its domestic fuel reserve targets.[8] Hydrogen production presents an opportunity to localise liquid fuel supplies.

3. Management of Transition to Renewables

As Australia transitions to an electricity grid with a higher penetration of variable renewable energy, hydrogen could play a role in overcoming problems of energy intermittency by acting as a source of storage for renewable electricity.[9]

[6] ACIL Allen Consulting, *Opportunities for Australia from Hydrogen Exports*, AUSTL. RENEWABLE ENERGY AGENCY 29 (Aug. 2018), https://arena.gov.au/assets/2018/08/opportunities-for-australia-from-hydrogen-exports.pdf (last visited Sept. 8, 2020).

[7] *See The Hydrogen Handbook:* United States Part III, Section I.C. for additional details.

[8] *See generally*, Australian Petroleum Statistics, AUSTL. DEP'T OF THE ENV'T & ENERGY (2018) https://www.energy.gov.au/publications/australian-petroleum-statistics-2018 (last visited Sept. 8, 2020).

[9] *See The Hydrogen Handbook:* United States Part III, Section II for additional details.

PART II - GOVERNMENTAL SUPPORT

I. Commonwealth – Australia's National Hydrogen Strategy and Other Policy

Released in 2019, Australia's National Hydrogen Strategy (Strategy) sets out Australia's vision to become, and strategy to establish, a hydrogen industry that is "clean, innovative, safe and competitive," and to position Australia as "a major global player by 2030."[10]

The Strategy identifies 57 strategic actions to achieve this vision, and centres on an adaptive approach to industry development. Some key elements of the Strategy to 2025 are designed to set the foundations for the growth of the industry:

- Advance priority pilots, trials, and demonstration projects
- Assess supply chain infrastructure needs
- Build demonstration-scale hydrogen hubs: being clusters of large-scale demand to promote cost-efficiencies, synergies, and focus innovation as a "springboard to scale"
- Develop supply chains for prospective hydrogen hubs

The key elements of the Strategy beyond 2025 are designed to create large-scale market activation by looking to:

- Identify signals that large-scale hydrogen markets are emerging;
- Scale up projects to support export and domestic needs;
- Build Australian hydrogen supply chains and large-scale export industry infrastructure;
- Build and maintain robust and sustainable export and domestic markets, and supply chains; and
- Enable competitive domestic markets with explicit public benefits.

Separately, in its Technology Investment Roadmap Discussion Paper released in May 2020, the Commonwealth Government identified hydrogen as a "key technology need" as a part of its Long Term Emissions Reduction

10 *See* COAG 2019, *supra* note 2, at 76.

Strategy.[11] This paper also set a goal of "H2 under $2," an economic goal for hydrogen to reach a price of at or under A$2 per kilogram, which is considered to be the point at which hydrogen becomes competitive with alternatives in large-scale deployment.

Alongside the Strategy, the federal government has made the following commitments:

- Between 2015-2019, A$146 million has been committed to hydrogen projects.
- In 2019, a A$70 million "Renewable Hydrogen Deployment Funding Round" was announced for the Australian Renewable Energy Agency (ARENA) to provide grants to demonstrate the technical and commercial viability of hydrogen production at a large-scale using electrolysis.
- In 2020, A$300 million was allocated to the "Advancing Hydrogen Fund" administered by the Clean Energy Finance Corporation (CEFC), to support the growth of a clean, innovative, safe, and competitive Australian hydrogen industry via concessional finance.

Australia's existing regulations will require review to support the development of a world-leading hydrogen industry in Australia (as identified in the Strategy). Currently, technical regulations for the transport of gaseous materials provide broad coverage regarding the use of hydrogen and related technologies, but the legislation will need to develop to provide for hydrogen-specific regulations.

The current regulatory framework for the commercial use of gas in Australia does not specifically reference hydrogen. The existing gas regulations could be expanded to include hydrogen, providing a framework for distribution of hydrogen. Natural gas distribution networks in Australia are largely regulated assets with fixed volumetric pricing. If operated in a similar way, this would mitigate many risks associated with investment, ensuring a steady revenue stream.

Workplace health and safety regulations are governed by each state and territory jurisdiction but are broadly consistent and would cover hydrogen.

[11] *Technology Investment Roadmap Discussion Paper*, AUSTL. DEP'T OF INDUS., SCI., ENERGY & RES. (May 2020), https://consult.industry.gov.au/climate-change/technology-investment-roadmap/supporting_documents/technologyinvestmentroadmapdiscussionpaper.pdf (last visited Sept. 8, 2020).

II. State and Territory – Regulation and Policy

Most Australian jurisdictions have a combination of existing industry incentives that could apply to the hydrogen industry (such as concessional finance, funding for new public infrastructure, favourable zoning and approvals, entry into public private partnerships), as well as hydrogen-specific strategies and funding, including the following:

State	Projects
Victoria	• Victorian Hydrogen Investment Program (2018), Victorian Green Hydrogen Discussion paper (2019) and Zero Emissions Vehicle Roadmap (due for release in 2020) • Hydrogen Energy Supply Chain pilot—the world's largest hydrogen demonstration project, with hydrogen production from brown coal and transportation to Japan
NSW	• Net Zero Plan Stage 1: 2020-2030 (2020)
Queensland	• Queensland Hydrogen Industry Strategy 2019-2024 (2019) • A$15 million Hydrogen Industry Development Fund • Memorandum of Understanding with the Japan Oil, Gas and Metals National Corporation (JOGMEC) to cooperate on hydrogen and a Statement of Intent with the University of Tokyo's Research Center for Advanced Science and Technology • Fuel Cell Electric Vehicle fleet trial
WA	• Western Australian Renewable Hydrogen Strategy (2019) • Renewable Hydrogen Fund
SA	• South Australia's Hydrogen Action Plan (2019)
Tasmania	• Tasmania Renewable Hydrogen Action Plan (2020), including an A$50 million funding round.
ACT	• The ACT is on track to achieve 100 per cent renewable electricity by 2020 and will then look to decarbonise its natural gas, and transport and develop plans in respect of these.

PART III – COMMERCIAL ISSUES

I. Production

The Australian government has demonstrated its commitment to ensuring that Australia can become a major global player in the hydrogen market. It has committed over A$146 million to hydrogen projects.[12] There is great potential for hydrogen production in Australia, with predictions that Australia could produce more than three million tonnes a year, worth up to A$10 billion a year.[13]

The Australian government estimates that approximately 262,000 square kilometres of Australia's coastal areas are suitable for hydrogen production.[14] The Hydrogen Council estimates that utilising such land would prove highly effective and could provide more than the entirety of global demand by 2050. On the basis of the quality of Australia's solar, wind, and hydropower resources, approximately 872,000 square kilometres of overall land in Australia could be suitable for renewable hydrogen production.[15]

Hydrogen hubs are the key to industry success and allow producers to take advantage of infrastructure and innovation. Over 30 ports have been identified as potential hub locations.[16]

Looking specifically at the various means of hydrogen production, following is an exploration of some commercial issues to be addressed:

A. Green Hydrogen—Electrolysis

1. Electricity Requirements

There are additional electricity requirements to produce hydrogen. Unlike thermochemical production of hydrogen, alkaline electrolysis and PEM electrolysis ensure there are no associated operational emissions of CO_2. However, there is an increased demand for electricity with these types of production.

[12] *See* COAG 2019, *supra* note 2, at xvi.

[13] Sam Bruce, et al., *National Hydrogen Roadmap: Pathways to an economically sustainable hydrogen industry in Australia*, CSIRO xix (Austl.) (2018), https://www.csiro.au/en/Do-business/Futures/Reports/Energy-and-Resources/Hydrogen-Roadmap (follow "Main report [pdf • 5mb]" hyperlink) (last visited Sept. 8, 2020) [hereinafter CSIRO].

[14] *See* COAG 2019, *supra* note 2, at 10.

[15] *Id.*

[16] *See* ARUP, *supra* note 5, at 2.

A report calculates that the demand for additional electricity is between 1 TWh by 2025 in a low-demand scenario and 200 TWh by 2040 in a high hydrogen-demand scenario.[17] The Australian Energy Market Operator has predicted that the Australian National Energy Market will grow by 10 TWh into 2036-2037. Thus, additional electricity is needed and will need to be supplied from renewable or traditional energy sources.

2. Power Purchase Agreements

To source this electricity, developers will need to enter into power purchase agreements (PPAs) to secure long-term supply and drive projects further down the cost curve. Sourcing electricity from the grid can still be utilised while ensuring low emission electricity via PPAs.

PPAs also may be used to secure low emission electricity supply from renewable sources. Australia has a strongly developing renewable energy sector that provides hydrogen developers with a unique opportunity to scale up and participate in the future global hydrogen market.

In the last two years, **Corporate Renewable PPAs** (Corporate PPAs) have grown in the Australian energy market. The Business Renewables Centre Australia has estimated in its report that there have been more than 58 Corporate PPAs for 2.3GW of capacity with over 60 per cent being made with new solar and wind farms[18] with strong market interest and activity.

3. Commercial Energy Sourcing

Hydrogen producers should be aware of the potential trade-offs of electricity pricing and capacity of electrolysers when considering their commercial energy sourcing.

Currently, grid-connected electrolysis has the highest average capacity[19] and therefore produces the cheapest levelised cost of hydrogen when utilising PPAs for low carbon electricity supply. As a result, producers should carefully consider the location of the electrolyser in relation to electricity transmission infrastructure.

In addition, the use of otherwise curtailed renewable energy should be considered given such generation capacity would otherwise not be utilised and would allow increased electrolyser utilisation.

A key example is the Port Lincoln green hydrogen plant in South Australia. The A$117.5 million project will utilise a grid-connected alkaline electrolyser, as well as hydrogen turbines and fuel cells. This will balance services to the transmission grid to supply 18,000 tonnes of green

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17 *See* ACIL Allen Consulting, *supra* note 6, at 50.

18 Chris Briggs, Finnian Murphy and Jonathan Prendergast, *Corporate Renewable Power Purchase Agreements: State of the Market*, BUS. RENEWABLES CENTRE-AUSTRL. 1 (Nov. 2019), https://businessrenewables.org.au/wp-content/uploads/2019/11/BRC-A-State-of-the-Market-2019.pdf (last visited Sept. 8, 2020).

19 *See* CSIRO, *supra* note 13, at 15.

ammonia to agriculture and industry sectors.[20]

4. Accessibility to Water

Accessibility to water also will be a key consideration for alkaline and PEM electrolysis. For every 1 kg of hydrogen produced, 9 kg of high-purity water is required,[21] unless a deioniser has been integrated.

Focus groups routinely indicate that water concerns are particularly significant in farming communities and will need to be addressed to gain social acceptance and community support.[22]

The cost of water usually makes up less than 2 per cent of the cost of hydrogen production.[23] Estimates place water needed for Australian exported hydrogen by 2040 in the range of 5.6 gigalitres in a low-demand scenario to 28.6 gigalitres in a high-demand scenario.[24] With total consumption of water in Australia in 2015-2016 being 16,132 gigalitres and industries using a total of 2,014 gigalitres,[25] hydrogen production demands far less water than other industries. Therefore, the amount of water will not likely be prohibitive. Instead, the location of hydrogen hubs will be key in ensuring social acceptance and success of hydrogen production.

B. Steam Methane Reforming (SMR)

1. Emissions

Currently, SMR is the most widely used method for producing hydrogen, representing 48 per cent of global production,[26] and is an established, mature technology.[27] If thermochemical hydrogen production is increased in Australia, emissions domestically will increase. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has estimated that thermochemical production of hydrogen operationally emits 0.76 kilograms of CO_2 per kilogram of hydrogen produced.[28] Therefore, though the use of hydrogen is a means of reducing global greenhouse emissions and air pollution, thermochemically produced hydrogen must consider carbon capture and storage (CCS) strategies, management, and storage.

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20 *Port Lincoln hydrogen and ammonia supply chain demonstrator,* GOV'T OF S. AUSTL.: RENEWABLESSA (July 16, 2020), http://www.renewablessa.sa.gov.au/topic/hydrogen/hydrogen-projects/hydrogen-green-ammonia-production-facility (last visited Sept. 8, 2020).

21 *See* CSIRO, *supra* note 13, at 12.

22 *See* COAG 2019, *supra* note 2, at 60.

23 *See* CSIRO, *supra* note 13, at 17.

24 *See* ACIL Allen Consulting, *supra* note 6, at 37.

25 *Id.*

26 *See* CSIRO, *supra* note 13, at 19.

27 It should be noted that other similar processes, including auto thermal reforming and partial oxidation, are also currently in use and may become more heavily used in the future.

28 *Id.* at 67.

The effect of the cost of CCS on the levelised cost of hydrogen is not significant where production and storage plants are reasonably proximate in "hubs" and therefore CO_2 transporting costs can be absorbed.[29] Location considerations are significant for thermochemical production of hydrogen as proximity to resources and CO_2 storage reservoirs are integral.

2. Pricing Risks

One major consideration for SMR is the risk associated with the pricing of natural gas, which remains high on the east coast of Australia in contrast to some overseas markets. There are concerns about future cost trajectories due to significant reductions in domestic gas supplies.

The North West Shelf of Australia presents opportunities with large natural gas reserves and depleted gas fields that could be utilised as potential CO_2 storage reservoirs. However, there are difficulties with the reserves being committed to long-term LNG export contracts and moratoriums on unconventional gas exploration in the eastern states of Australia.[30]

C. Coal Gasification

Hydrogen production from coal gasification is reliant upon location of coal feedstock.

1. Australian Brown Coal

Although globally thermal black coal is most commonly used for gasification, brown coal is cheaper in the Australian context. It has the disadvantage of slag buildup and some reduced efficiencies. Brown coal presents an early opportunity to develop industry capabilities with modelling demonstrating a levelised cost of hydrogen at approximately A$2.14-$2.74 per kilogram.[31]

The Hydrogen Energy Supply Chain (HESC) project utilises Victorian brown coal in its gasification to produce hydrogen-rich syngas. The proposal is for this to be purified, liquefied, and transported on a tanker to Japan, with the first delivery of hydrogen to be completed in 2021.The hydrogen is to be transported by road, with a view to moving to a pipeline in future commercial phases, and utilises liquefaction and loading resources at the Port of Hastings. If the pilot program is successful, the project aims to begin commercial operations in the 2030s.[32]

2. CO_2 Storage

Hydrogen production through gasification requires a CCS solution to manage emissions. The Victorian and Australian governments have developed a CarbonNet Project,

29 *Id.* at 20.

30 *Id.* at 3.

31 *Id.* at 22.

32 *Id.* at 17.

which has the potential to deliver a CCS solution.[33]

In New South Wales and Queensland, there may be associated issues for coal gasification in relation to CO_2 storage as the storage reservoirs face social licence risks. This may be compounded when considering the social issues associated with continued concerns over fossil fuel use and uncertainty around long-term effectiveness of CO_2 storage.[34] Therefore, it will be key for thermochemical producers of hydrogen to continue to manage and direct resources towards gaining the support of the broader Australian community and local specific communities.

II. Transportation/Delivery

A. Infrastructure

Australia is uniquely positioned in the global market to become a leader in the future clean hydrogen market.[35]

- Australia currently exports LNG and consequently has experience in establishing energy export markets in key markets.
- Australia has already established infrastructure with existing ports, compression facilities, and strong experience with working with supply chains.
- The location and positioning of Australia in the Asia-Pacific region provides a key advantage for supplying Asian markets with hydrogen, as other potential competitors would be disadvantaged by additional transport costs.

It has been asserted that Australia's existing gas infrastructure and distribution network in Australia is capable of being utilised for the transport and storage of volumes of hydrogen through blending up to 10 per cent.[36] Modelling has suggested that utilising hydrogen with existing infrastructure may be up to 40 per cent less expensive than a full electrification of Victoria's gas network.[37] Unfortunately, the use of existing infrastructure and pipelines is somewhat limited, given concerns that higher percentages of hydrogen could significantly impact residential and commercial consumer appliances, industrial user plant and equipment, and degrade the existing distribution network infrastructure due to hydrogen embrittlement (depending on pipe material composition and operation pressure).

For higher hydrogen percentages, or pure hydrogen gas, new pipelines, mains, meters, and appliance replacements would be required. High-density polyethylene (HDPE) pipe has been identified as suitable for transporting higher percentages of hydrogen and has already begun being installed in Australia through replacement programs.[38] In particular, ACT and

33 *Hydrogen Communities: Assessment for suitability of communities for conversion to hydrogen*, KPMG 25 (June 2019), https://arena.gov.au/assets/2019/10/hydrogen-communities.pdf (last visited Sept. 8, 2020).

34 *See CSIRO*, *supra* note 13, at 25.

35 *See* Deloitte, *supra* note 1.

36 *See* ARUP, *supra* note 5, at 73.

37 *See* COAG 2019, *supra* note 2, at 31.

38 *See* ARUP, *supra* note 5, at 74.

Tasmania already have HDPE distribution networks in place. Pending further testing, complete HDPE pipe could be deemed as suitable for 100 per cent hydrogen and presents an opportunity to replace existing distribution networks.

B. Liquefaction

As hydrogen is not dense enough for long-distance transport to be commercially viable, producers need to utilise liquefaction by way of sufficient cooling (to very low temperatures) and compression or conversion to ammonia or combination with a chemical liquid carrier for effective transportation and delivery. The facilities necessary for liquefaction would likely be best located at export hubs. However, conversion to ammonia or combining with liquid chemical carriers could occur further upstream so that subsequent road and rail infrastructure could be utilised.

There is particular interest in ammonia as an early pathway, as it allows for easy handling in shipping due to the high energy density compared to liquid hydrogen. For greater distances of transport required for hydrogen exports, liquefaction or ammonia storage is typically used to allow for shipping. Though shipping costs are varied due to the extent of compression and carrier used, they are estimated to be in the range of A$0.03 and $0.61 t/km.[39]

However, this will need to be balanced against the associated energy output for the initial conversion of hydrogen to ammonia and the subsequent reconversion for end-use. This process may see cost reductions as technological developments are introduced to the market, with the CSIRO having developed technology for the conversion of ammonia into high purity hydrogen at point of use through the use of vanadium membranes.[40]

There would also need to be additional consideration of the end-user of the exported hydrogen, as they may not have the facilities necessary at ports to convert the ammonia to hydrogen or remove the liquid chemical carrier. Pilot studies are currently being carried out in Australia with an aim to develop the shipping of liquid hydrogen (LH2) on tankers.[41] If successful, LH2 tankers could be facilitated through the use of existing, expanded, or additional infrastructure at existing ports in Australia that have capabilities in handling gas- and liquid-petroleum products.

Even where shipping is utilised for exported hydrogen, rail and road transport will likely be necessary for hydrogen delivery. A consideration of distances for input or output product carriage is a significant driver for producers to consider. In the United States and Europe, it is relatively common for LH2 to be transported by road, utilising liquid tankers. However, this has not yet occurred in Australia. There are challenges to transporting liquefied hydrogen by road, but larger masses of hydrogen are able to be transported

39 *See* ACIL Allen Consulting, *supra* note 6, at 38.

40 *See* COAG 2019, *supra* note 2, at 40.

41 *See* ARUP, *supra* note 5, at 60 n. 5.

than in its gaseous form. While there are some considerations regarding boil-off during transport, use of chemical liquid carriers enables less complex storage engineering.[42]

C. Hydrogen Hubs

One of the biggest cost implications for hydrogen producers is the cost of processing, storage, and transport pathways. Hydrogen hubs are a cornerstone of Australia's National Hydrogen Strategy, as scale has been identified as the key to Australia becoming a globally competitive supplier. Over 30 potential ports have been identified in Australia as being potential hub locations, with analysis delivered according to key criteria such as gas transmission pipelines, electrical transmission lines, transport access, and port infrastructure.

D. Shipping, Road, and Rail

Refuelling stations are a specific focus for states and territories, particularly for freight and public transport. The increase in private hydrogen-powered vehicles will be limited by the number and availability of refuelling stations. The Council of Australian Governments identified that the greatest opportunity for fuel cell electric vehicles (FCEVs) is in the heavy vehicle market due to the competitive weight advantage in comparison to a battery electric vehicle (BEV) truck, as well as shorter refuelling times.[43] Preliminary work has begun to identify the requirements for refuelling stations as governments seek to support developments on major freight and passenger road corridors.[44]

42 *Hydrogen for Australia's Future*, HYDROGEN STRATEGY GROUP FOR THE COAG ENERGY COUNCIL 21 (Briefing Paper) (Aug. 17 2018), http://www.coagenergycouncil.gov.au/publications/hydrogen-australias-future (last visited Sept. 8, 2020).

43 *Id.* at 31-33.

44 *Hydrogen as a Transport Fuel: Location options for a freight-based limited initial deployment of hydrogen refuelling stations*, BUREAU OF INFRASTRUCTURE, TRANSP. & REG'L ECON. (Information Paper) (Oct. 2019) [hereinafter BITRE].

III. Use

Hydrogen is a clean, versatile, and safe energy carrier that can be used for multiple purposes. It can be used to generate electricity; power vehicles; generate heat; produce chemicals such as ammonia, methanol, and alkenes/olefins; as well as for export. Figure 1 illustrates these potential uses.

Figure 1: Potential uses of Hydrogen[45]

A. Transport and Fuel Cells

Instead of combustion, fuel cells produce electricity via an electrochemical reaction that combines hydrogen and oxygen to generate an electric current with water as a by-product. This is the reverse of an electrolysis procedure. Fuel cells are preferable as they are quiet, have very low emissions, and are two to three times more efficient than traditional combustion technologies.[46]

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45 *See* COAG 2019, *supra* note 2, at 4.

46 *Fuel Cells for Stationary Power Applications*, U.S. DEP'T OF ENERGY 1 (Oct. 2017).

1. Emerging Fuel Cells

Reversible fuel cell systems combine the electrolysis and fuel cell process into a single system. This will result in a system that operates similarly to a battery, allowing for reductions in capital cost.[47] Subsequently, reversible fuel cells may potentially disrupt the broader hydrogen value chain.

Hydrogen can also power FCEVs. The advantages of hydrogen-powered transport compared to BEVs are faster refuelling times and the ability to travel longer distances carrying larger loads before refuelling. Refuelling hydrogen vehicles requires a network of refuelling stations, similar to what exists for petrol and diesel.

2. Vehicles

Passenger FCEVs consist of an electric drive train powered by a proton exchange membrane (PEM) fuel cell stack and hydrogen storage tank pressurised to 700 bar. They may be more suitable for consumers who travel longer distances (i.e., 400-600km without refuelling), expect shorter refuelling times, and are without easy access to BEV recharging infrastructure.

3. Hydrogen Refuelling Stations (HRS)

HRSs consist of a standard overall system (Figure 2), with key differences regarding the hydrogen delivery method, dispenser pressure, and capacity. This can impact the configuration and consequently the cost. Hydrogen is delivered in gaseous form, which is compressed for intermediate storage with pressures of up to 500 bar.

Due to the high operating pressures of hydrogen delivery, refuelling requires additional equipment considerations. An increase in electricity is required to meet the precise temperature requirements that are needed for a fast fill.[48] Furthermore, additional control systems are necessary to monitor volume, temperature, flow rate, and pressure. Current dispenser nozzles also cost up to 100 times more than the petrol equivalent.[49]

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47 *Id.* at 3.

48 K. Reddi, et al., *Impact of hydrogen SAE J2601 fuelling methods on fuelling time of light-duty fuel cell electric vehicles*, 42 INT'L J. OF HYDROGEN ENERGY 26, 16675 (June 29, 2017) https://www.sciencedirect.com/science/article/abs/pii/S0360319917316853 (last visited Sept. 8, 2020).

49 *US DRIVE Hydrogen Delivery Technical Team Roadmap*, U.S. DEP'T OF ENERGY 27 (Jul. 2017), https://www.energy.gov/eere/vehicles/downloads/us-drive-hydrogen-delivery-technical-team-roadmap (last visited Sept. 8, 2020).

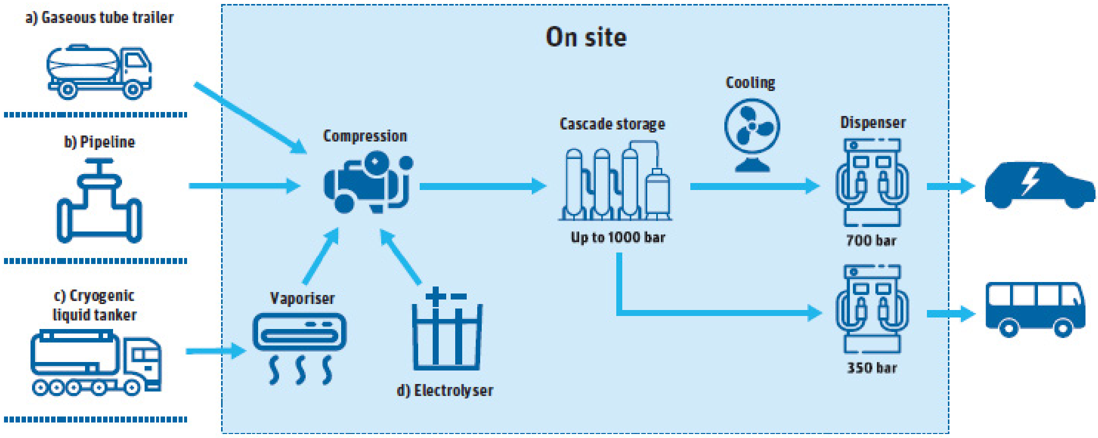

Figure 2: Standard refuelling station configuration[50]

4. Materials Handling

Hydrogen fuel cell powered materials handling is becoming a favourable technology option over battery and diesel equivalents for a number of operations. Currently, large warehouses with 24/7 operating requirements that rely on battery-driven equipment require additional batteries to be purchased. This creates a hazard, increases in capital costs, and storage space issues as well as the release of odours when charging the batteries, which may damage warehouse inventory. Consequently, the rate of hydrogen refuelling and absence of odours make FCEVs more attractive in these types of operations.

5. Other Emerging Technologies

Fuel cell trains are comparable in cost with electrification, given the capital requirements for overhead rail as compared with being able to use existing infrastructure.[51] With only 10 per cent of Australia's railway tracks electrified, hydrogen-powered rail could have a place in future rail infrastructure considerations.[52]

Pure hydrogen-powered marine passenger ships are gradually emerging to combat air and water quality issues. Similarly, fuel cells are beginning to be adopted by Unmanned Aerial Vehicles (UAV) or drones to power propulsion mechanisms. Fuel cells can provide 8-10 times more flight time in some UAV models and have shorter refuelling times than batteries.[53]

50 *See* CSIRO, *supra* note 13, at 40.

51 *Id.*

52 Jeremy Dornan, Peter Kain and John Ryan, *Trainline 2: Statistical Report*, Canberra ACT, BUREAU OF INFRASTRUCTURE, TRANSP. & REG'L ECON. v (Nov. 2, 2014) https://www.bitre.gov.au/publications/2014/train_002 (last visited Sept. 8, 2020).

53 *Horizon launches Hycopter fuel cell multirotor UAV*, 2015 Fuel Cells Bulletin 6, (June 2015), https://www.sciencedirect.com/science/article/pii/S1464285915301450?via%3Dihub (last visited Sept. 8, 2020).

Although fuel cells have been used to power small manned aircraft, their application to large-scale passenger transport appears to be distant.

6. Opportunities

Australia currently lacks sufficient FCEV refuelling infrastructure to incentivise domestic adoption of FCEVs. While the commercial benefits to operators are yet to be proven and the likely potential uptake remains uncertain, there is likely to be little commercial incentive to provide the necessary infrastructure to support a nascent FCEV market. Some assistance may be required to support the necessary refuelling infrastructure while the technology is maturing.[54]

Furthermore, a current lack of education and awareness appears to be an impediment to the potential adoption of FCEV technologies. There is general consensus that electric vehicles are needed to decarbonise the transport sector. However, the public is largely unaware that FCEVs fall within this category and incentive and educational schemes will be needed to create public awareness and normalisation of FCEVs.

7. Policy and Regulation

Given the lower-cost and more readily available infrastructure for internal combustion engines and BEVs, various policy and regulatory provisions are required to assist in the creation of a market for FCEVs in Australia. Emission or "clean air" standards on vehicles are an important policy consideration, as they represent a long-term commitment to decarbonise the transport sector by limiting the types of vehicles available. Specific incentives, however, are also likely to be needed to stimulate uptake of FCEVs. These could be in the form of direct subsidies, taxation (e.g., fuel excise), and registration discounts (or a combination of all options) that can increase the rate of uptake (see Parts V and VI for further commentary on Australian tax issues that may affect hydrogen project developments and investments).

B. Chemical Feedstock

Hydrogen can be used in industrial applications as a chemical feedstock, which includes refining petrochemicals, ammonia production, as well as the manufacture of chemicals.

1. Petrochemical

The demand for hydrogen is increasing in the petrochemical and the bio-crude industry due to the increased importance of air quality and emission requirements, as well as a need to decarbonise both sectors.[55] Hydrogen is used for hydrotreating to refine petrochemicals and hydrocracking to produce jet fuel, kerosene, and diesel.

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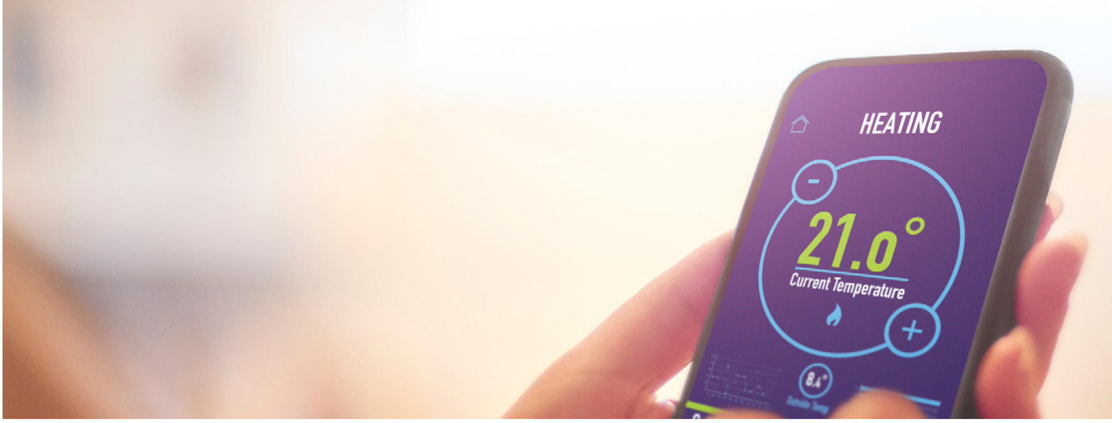
54 *See* BITRE, *supra* note 43, at 9.

55 Tom Campey, et al., *Low Emissions Technology Roadmap*, INT'L ENERGY AGENCY 214-25 (Austl. June 2017), https://www.csiro.au/en/Do-business/Futures/Reports/Energy-and-Resources/Low-Emissions-Technology-Roadmap (last visited Sept. 8, 2020).



2. Ammonia

Ammonia derived from clean hydrogen can be used in fertilisers and as a potential energy carrier. Research will be required to develop the synthesis of ammonia using electrolysis, instead of from the Haber-Bosch Process.

3. Methanol

Synthesis gas, which consists of hydrogen, carbon monoxide, and carbon dioxide, can be converted to produce methanol and its derivatives. Renewable methanol also may be synthesised via the hydrogenation of CO_2. Although its synthesis will be undertaken at half the efficiency of the previous process, there is an increasing global interest in the technology.[56]

4. Alkenes/Olefins

Alkenes are usually produced via the steam cracking process to produce various products such as plastics, fibres, and other chemicals. Alternatively, the hydrogenation of CO_2 in the presence of specific catalysts may be used instead to reduce the dependence on hydrocarbons and create a greater demand for hydrogen.[57]

C. Grid Electricity

Hydrogen produced from renewables via electrolysis can be blended with natural gas and injected into the gas grid. This will reduce emissions related to natural gas usage.

Gas grid injection is a low-value, low-investment stepping stone to support the early-stage scaling-up of hydrogen.[58] In the long run, injecting hydrogen into the gas grid will allow large amounts of renewable energy to be stored. Furthermore, the system will be able to cope with large swings in demand and

[56] Sukhvidner P.S. Badwal, et al., *Emerging technologies, markets and commercialization of solid-electrolytic hydrogen production*, 7 WIRES ENERGY AND ENV'T 3 (Mar. 2, 2020), https://onlinelibrary.wiley.com/doi/abs/10.1002/wene.286 (last visited Sept. 8, 2020).

[57] Lisheng Guo, et al, *Directly converting carbon dioxide to linear a-olefins on bio-promoted catalysts*, 1 COMMC'N CHEMISTRY 11, 4-7 (Mar. 22, 2018), https://www.nature.com/articles/s42004-018-0012-4 (last visited Sept. 8, 2020).

[58] C. Chardonnet, et al., *Study on early business cases for H_2 in energy storage and more broadly power to H_2 applications*, HINICIO AND TRACTEBEL ENGIE (June 16, 2017), www.fch.europa.eu/sites/default/files/P2H_Full_Study_FCHJU.pdf (last visited Sept. 8, 2020); Emanuele Taibi, et al., Hydrogen from renewable power: Technology outlook for the energy transition, INT'L RENEWABLE ENERGY AGENCY 39 (Sept. 2018), https://www.irena.org/publications/2018/Sep/Hydrogen-from-renewable-power (last visited Sept. 9, 2020).

be an option for inter-seasonal storage to meet varying demand peaks.

Using low hydrogen concentrations of up to 10-20 per cent in volume may not require major investment or modifications to the current infrastructure.[59] In contrast, blending concentrations greater than 20 per cent would require significant changes to existing infrastructure and end-use applications. Accordingly, it may be more practical to convert the entire infrastructure and applications to be compatible with pure hydrogen.[60]

More research is required to better understand the technical impact of different levels of hydrogen blending and injection into existing gas infrastructure and the required modifications and investment.[61] Following this, Australian regulations will need to be amended to adapt to hydrogen blending and set new limits on the hydrogen content of natural gas.

D. Heat

Hydrogen may be combusted to generate heat in residential homes, as well as for commercial and industrial uses. A concentration of hydrogen of up to 20 per cent by volume can be tolerated by household appliances,[62] and a 10-15 per cent by volume hydrogen blend in industrial cases,[63] without the need for significant infrastructure upgrades. Regardless, existing appliances will need to be upgraded or replaced to accommodate for the complete substitution of natural gas with 100 per cent hydrogen.

1. Residential

Changes to domestic appliances are set out in the table below.

Table 1: Domestic Residential Heating Appliances[64]

TYPE	HARDWARE	DESCRIPTION
Boiler	Water heater	Natural gas is burned to heat water either through continuous flow or a storage mechanism
Cooker	Cooktop	Natural gas is supplied through the cooktop for cooking
Cooker	Grill/oven	Natural gas is supplied through burners for cooking
Heater	Gas heating	Can be centralised with ducted heating or wall mounted. May be flued (vented outside) or non-flued (by-products released into room).

[59] Alexander Körner, et al., *Technology Roadmap: Hydrogen and Fuel Cells*, INT'L ENERGY AGENCY (June 2015), https://www.iea.org/reports/technology-roadmap-hydrogen-and-fuel-cells (last visited Sept. 8, 2020).

[60] Emanuele Taibi, et al., *Hydrogen from renewable power: Technology outlook for the energy transition*, INT'L RENEWABLE ENERGY AGENCY 39 (Sept. 2018), https://www.irena.org/publications/2018/Sep/Hydrogen-from-renewable-power (last visited Sept. 9, 2020).

[61] *Id.* at 40.

[62] *First Project Progress Report*, HYDEPLOY PROJECT 2 (Dec. 2017), https://hydeploy.co.uk/app/uploads/2018/02/13894_HYDEPLOY_PROJECT_REPORT_LR-1.pdf (last visited Sept. 8, 2020); COAG Energy Council, 'Hydrogen in the Gas Network' Kickstart Project (2019), https://consult.industry.gov.au/national-hydrogen-strategy-taskforce/national-hydrogen-strategy-issues-papers/supporting_documents/NationalHydrogenStrategyIssue6HydrogeninGasNetwork.docx (last visited 5 September 2020).

[63] Progressive Energy Ltd., *The Liverpool-Manchester Hydrogen Cluster: A Low Cost Deliverable Project*, CADET (Aug. 2017).

[64] *See* CSIRO, *supra* note 13, at 46.

2. Commercial and Industrial Use

The industrial heat appliances that may require an upgrade are set out in Table 2. This poses a greater challenge,[65] as it may consist of the reconfiguration of an entire plant.

APPLIANCE	DESCRIPTION	USE
Furnace/kilns	May be low temperature (<650°C) or high temperature (650°C-1500°C). At higher temperatures, care needs to be taken with furnace degradation and higher NOx emissions.	Low temperature: industrial ovens/ dryers High temperature: glass and ceramics industries
Boilers	Includes both fire-tube (3-5MWth) and water-tube (>5MWth). Can burn different fuels but would likely require a plant redesign for 100% hydrogen.	Steam production, space heating, pulp and paper industry
Combined heat and power	Includes reciprocating engines and gas turbines. For the former, preliminary research shows safe operation up to 80% H2 but requires NOx treatment. For the latter, there are already examples of IGCC running at 60-100% H_2 with permissible NOx levels. When running at high concentrations, a diluent (usually nitrogen or steam) is added to bring hydrogen concentration down to 65%, thereby lowering the temperature.	Various heat and electrical applications

Table 2: Industrial Heat Appliances Upgrade[66]

3. Opportunities

An alternative to the displacement of natural gas with hydrogen is electrification. This may be undertaken through electrification technologies such as heat pumps or electrical heating. Heat pumps require constant connection to the electrical grid and could be used for low-grade heating operations such as in households. Electrical heating requires connection to an electrical power source and has a temperature range of 3000°C. Although electrification may prove to be economically favourable, the complete substitution of energy from the gas network will be subject to space constraints and may be unfeasible due to the cost of upgrading and facilitating a hydrogen gas network.[67]

4. Policy and Regulation

There is a need to upgrade industrial appliances with the changeover in gas supply. Such an upgrade is associated with technical complexities where any transitions are likely to be ad hoc and site specific. Subsequently, clear policy directions and legislation will be required to assist with the coordinated roll out of hydrogen combustion systems on industrial sites. Following this, manufacturers in Australia will gain confidence to begin producing relevant appliances at scale. Therefore, legislation regarding the manufacture and installation of standardised appliances

65 Dan Sadler, et al., H21, LEEDS CITY GATE (2016) https://www.h21.green/wp-content/uploads/2019/01/H21-Leeds-City-Gate-Report.pdf (last visited Sept. 8, 2020).

66 *See* CSIRO, *supra* note 13, at 47.

67 2050 Energy Scenarios, KPMG (July 2016), https://www.energynetworks.org/gas/futures/the-uk-gas-networks-role-in-a-2050-whole-energy-system.html (last visited Sept. 8, 2020).

prior to the transition will reduce changeover times and labour costs.

E. Exports

Finally, hydrogen can be exported, either as an energy carrier or for use as a chemical feedstock. As noted, the four key hydrogen export jurisdictions include Singapore, Japan, the Republic of Korea, and China.[68] Furthermore, Australia already has established trading relationships and free trade agreements with these countries, including significant trade in energy and resources products. Consequently, this may provide Australia with a competitive advantage in comparison with other potential suppliers of hydrogen.

Further agreements between Australia and the above four countries will be required in relation to the export and receipt of hydrogen. This will attract investment, which is important because a significant injection of capital is required to meet the export and hydrogen production demands. Such resources are best pooled from various companies in a joint venture.

IV. Pricing Models

The hydrogen industry will need to go through a number of stages for industry development and market activation. Australia will be able to realise its hydrogen opportunity if producers are able to produce at scale, in order to capitalise upon cost efficiencies and lower the unit cost of delivered hydrogen.

While this presents some barriers, Australia has a strong track record at rising to the challenge in similar industries. For example, after the first exports of LNG in the late 1980s, Australia has recently overtaken Qatar as the world's largest LNG exporter,[69] with increasing export values growing from A$31 billion in 2017-2018 to A$50 billion in 2018.[70]

Currently, there are relatively mature production, transport, and storage technologies for hydrogen. However, these technologies have not yet been tested at scale, as part of a viable global supply change. There will need to be further technological commercialisation to bring down the current cost of production, transport, and storage.

Cost estimates vary significantly depending upon the method of transportation, distance transported, and end-user requirements. Cost modelling has predicted that for distances up to 1,500km gas by pipeline will be the cheapest method for large volumes of hydrogen. Over this distance, cost modelling has predicted shipping hydrogen as ammonia or as a liquid

68 *See* ACIL Allen Consulting, *supra* note 6, at C-5, 31.

69 Jessica Jaganathan, *Australia grabs world's biggest LNG export crown from Qatar in Nov.*, Reuters (Dec. 10, 2018), https://www.reuters.com/article/us-australia-qatar-lng/australia-grabs-worlds-biggest-lng-exporter-crown-from-qatar-in-nov-idUSKBN1O907N.

70 Cole Latimer, *Coal is Australia's most valuable export in 2018*, THE SYDNEY MORNING HEAD (Dec. 21, 2018), https://www.smh.com.au/business/the-economy/coal-is-australia-s-most-valuable-export-in-2018-20181220-p50nd4.html.

organic hydrogen carrier will be more cost effective.[71]

The Japanese government has stated through its Basic Hydrogen Strategy that it is targeting a delivered cost of hydrogen to be US$3/kg by 2030. By comparison, the International Energy Agency predicts that by 2030 exporting hydrogen from Australia to Japan as ammonia will cost around US$5.50/kg with transport and handling US$1.50/kg. This pricing discrepancy demonstrates the need for a focus on innovation and efficient supply chain development in order to bring the cost of Australia's exported hydrogen down.

There are a number of national funding mechanisms that could be utilised to provide support to the hydrogen industry to increase technology research, lower barriers to market entry, and reduce investment risks. These include ARENA, CEFC, NAIF, and EFIC.[72] Further, the Australian government has demonstrated a willingness to share knowledge and lessons learned from research and demonstration projects to encourage industry development.[73]

The Australian government is focused on the development of hydrogen hubs to provide co-utilisation of infrastructure to minimise losses and allow for a ramp up in production when demand increases. Further, using existing port and rail infrastructure that currently serves oil and gas industries would allow hydrogen to be more readily used in populated areas, leveraging existing coastal industrial clusters. Australia's substantial road, rail, storage, and port infrastructure already supports a globally competitive extractive export industry, valued at A$278 billion in 2018/2019.[74]

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71 *The Future of Hydrogen, seizing today's opportunities*, INT'L ENERGY AGENCY at 67 (June 2019).

72 *Hydrogen at Scale*, COAG ENERGY COUNCIL at 4 (July 2019), https://consult.industry.gov.au/national-hydrogen-strategy-taskforce/national-hydrogen-strategy-issues-papers/supporting_documents/NationalHydrogenStrategyIssue1HydrogenatScale.pdf (last visited Sept. 8, 2020).

73 *Id.* at 5.

74 *Resources and Energy Quarterly – March 2019*, DEP'T OF INDUS., INNOVATION & SCI. 8 (Mar. 2019) https://publications.industry.gov.au/publications/resourcesandenergyquarterlymarch2019/index.html (last visited Sept. 8, 2020).

PART IV - ENVIRONMENT AND PLANNING

I. Australian Elements

Australian laws require planning and environmental approvals to authorise most new developments and uses of land, including for the purpose of hydrogen projects. While each state and territory has its own land-use planning and environmental laws, it is possible to identify the following common themes across all Australian jurisdictions.

As approval requirements vary between jurisdictions and can be complex, we recommend seeking specific advice on the approval pathway and timelines that will apply to your hydrogen project.

II. Planning Approval

A. General

Planning approval will almost always be required to authorise the construction and operation of a hydrogen project.

B. Application Process

An application for planning approval must be made to the relevant consent authority (typically either the local council or the state government minister or department, depending on the state and territory and the specifics of the project).

An application for planning approval will need to be accompanied by a detailed environmental assessment prepared by suitably qualified consultants, which describes the hydrogen project in detail and assesses the impacts of the project and the measures proposed to mitigate any such impacts. The environmental assessment will provide a justification for the hydrogen project and will consider matters such as:

- Potential alternatives to the project
- Social and economic impacts, including the energy benefits of the project and the impacts on the local community
- Potential hazards and risks associated with the project, including, for example, the safety implications of transporting hydrogen
- Impacts on biodiversity, for example, through the clearing of native vegetation
- Impacts on water, including water supply and use, impacts on water quality and quantity, considerations of the use of waste water or recycled water, stormwater management, erosion, and sedimentation

- Heritage impacts, including impacts on Aboriginal cultural heritage
- Waste generation and disposal
- Noise impacts during construction and in operation
- Impacts of the project on air quality
- Visual impacts
- The traffic impacts likely to be generated by the construction and operation of the project, including any upgrades required to the road networks

Applications for planning approvals are usually, though not always, placed on public exhibition, during which time submissions may be made by interested stakeholders, including neighbouring landholders and the community.

In addition, the regime in all states and territories requires some level of consultation with stakeholders in the project as part of the environmental assessment of the project. Stakeholders are likely to include relevant government authorities, local councils, community groups, and affected landholders and Aboriginal land councils or corporations.

Applicants are typically provided with an opportunity to amend the project or provide further information in response to the issues raised in public consultation or submissions.

The application will then be assessed by the consent authority, who will determine whether to grant approval and, if so, on what conditions.

C. Conditions

Planning approvals are typically issued subject to detailed conditions regulating all aspects of the construction and operation of the project, including requiring offsets for any native vegetation cleared for the project.

A failure to comply with a condition imposed on a planning approval is a criminal offence.

D. Appeal Rights

Most jurisdictions allow the proponent of a project to commence legal proceedings to appeal a decision to either refuse planning approval for a project or to approve the project subject to unfavourable conditions.

In some jurisdictions there are statutory rights given to some third parties, such as people who have made submissions objecting to the project, to appeal a decision to approve a project on its merits where they are dissatisfied with the approval. Where third-party merit appeals are not available, there will usually be rights for a third party to challenge the validity of the planning approval if they believe a reviewable error of law was made by the consent authority in approving the project.

III. Secondary Approvals

In addition to planning approval, a range of additional environmental-related approvals may also be required for hydrogen projects. These vary depending on the specifics of the project and the state and territory, but may include:

- Environment licences from the Environment Protection Authority or equivalent regulator to carry out the project and authorise discharges to land, air, or water
- A major hazard facility licence from safety regulators if the amount of hydrogen generated or stored exceeds certain thresholds
- Pipeline licences to authorise construction and operation of a pipeline for transporting hydrogen
- Heritage permits for activities that will impact on historic or cultural heritage artefacts
- Approvals to authorise the upgrade of roads
- Approvals to clear native vegetation
- Water licences and approvals to authorise the taking and use of water from natural water sources
- Approvals to permit the construction and occupation of buildings or any subdivision of land required for the project

IV. Commonwealth Approvals

If a hydrogen project is likely to have a significant impact on matters of national environmental significance, it will also require referral to the commonwealth minister for environment under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). Matters of national environmental significance are, relevantly:

- Listed threatened species and ecological communities
- Listed migratory species
- Wetlands of international importance
- The commonwealth marine environment
- World Heritage properties
- National heritage places
- The Great Barrier Reef Marine Park

Once a project is referred, the commonwealth minister for environment will release the referral to the public, as well as to relevant state, territory, and commonwealth ministers, for comment on whether the project is likely to have a significant impact on matters of national environmental significance.

The minister or the minister's delegate will then decide whether the likely environmental impacts of the project are such that it should be assessed and approved under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

There are agreements in place between the commonwealth government and each state and territory, whereby the commonwealth minister for the environment may rely on the planning approval assessment processes of the state or territory to assess the impacts of a referred project under the Environment Protection and Biodiversity Conservation Act 1999 (Cth) and determine whether to approve the carrying out of the project.

V. Consequence of Breach

In general, if all required planning and environmental approvals have not been obtained or are not being complied with for a hydrogen project, there is a risk that:

- The relevant governmental authority may prosecute the proponent of the project;
- The relevant governmental authority may issue an order requiring that the project be stopped; and
- In some jurisdictions, a third party may commence civil enforcement proceedings to restrain any breach of environmental or planning legislation.

PART V - FEDERAL TAX

I. Overview

This section provides a high-level overview of common tax considerations for non-resident businesses considering undertaking a new venture in Australia, including hydrogen energy production. The comments that follow are focused on tax issues for corporate and trust entities, not individuals.

Tax is imposed in Australia at both a federal and state (or territory) level. The Australian Taxation Office (ATO) is charged with addressing the tax laws that are imposed at the federal level—primarily income tax and goods and services tax (GST). The states and territories each have their own administrative body for the laws imposed in their jurisdiction.

II. Income Tax

Companies, including non-resident companies, carrying on business in Australia or deriving Australian-sourced income that is not subject to withholding tax or otherwise exempt, are taxed at 30 per cent (although a 27.5 per cent rate applies to some companies with an annual turnover of less than A$50 million).

Australia has a self-assessment income tax system where taxpayers are required to lodge annual income tax returns for the 12 months to 30 June each year and to pay tax in accordance with those returns.

Returns may be subject to a subsequent audit by the ATO, generally for a period of four years subsequent to lodgement of the returns. Subsidiaries of non-resident companies often obtain permission from the Commissioner of Taxation to lodge tax returns with a year-end other than 30 June (a "substituted accounting period") corresponding with the accounting and tax year end of their parent.

A distinction is drawn between residents and non-residents, with residents being liable to pay tax on their worldwide income and non-residents generally only on their Australian-sourced income. Rather than impose a separate tax on capital gains, Australia's Capital Gains Tax (CGT) legislation is incorporated in the income tax legislation and net capital gains are included in a taxpayer's assessable income.

Entity	Residence Test
Company	A company is a resident of Australia if it: • Is incorporated in Australia, or • Carries on business in Australia and either: » its central management and control is in Australia; or » voting power is controlled by Australian resident shareholders.
Trust	A trust is a resident of Australia if: • The trustee is an Australian resident; or • Central management and control of the trust is in Australia.
Trust for CGT purposes	For non-unit trusts, the test is the same as the normal trust residence test. For unit trusts, residence for CGT purposes will exist where: • Trust property is located in Australia; or • The trust carries on business in Australia; and either: » central management and control of the trust is in Australia, or » Australian resident beneficiaries hold more than 50 per cent of the income or property of the trust.

III. Capital Gains Tax (CGT)

Capital gains are taxed as part of the income tax regime. For residents, the CGT rules bring into the tax net gains from the disposal of assets acquired (or deemed to have been acquired) on or after 20 September 1985. Net capital gains are included in a taxpayer's overall assessable income.

For non-residents, CGT applies only in respect of gains arising from a disposal of an asset that is taxable Australian property. This includes:

- Direct interests in Australian land
- Shares, units, or other interests in entities whose principal assets are interests in Australian land
- An asset used in carrying on a business in Australia at or through a permanent establishment
- Options to acquire any of the above-mentioned assets

Capital losses can only be offset against capital gains. To the extent that capital losses exceed capital gains, the excess can be carried forward to offset capital gains made in future years. They cannot be offset against revenue gains.

Net capital gains, on the other hand, can be set off against revenue losses.

When a non-resident becomes a resident for tax purposes, the law deems the former non-resident to have acquired those assets that were not already subject to CGT and that were actually acquired on or after 20

September 1985 to have been acquired at the time of the change of residence for their then market value.

When a resident taxpayer becomes a non-resident for tax purposes, the taxpayer is deemed to have disposed of all assets that are not taxable Australian property and that were acquired on or after 20 September 1985, for their current market value, unless certain elections are made.

IV. Foreign Source Income

There are special rules for the taxation of foreign source income of residents. In addition to a system of foreign income tax offsets (in essence, foreign tax credits), Australia operates a controlled foreign companies (CFC) system and a controlled foreign trust/transferor trust (CFT) system. The aim of the CFC and CFT systems is to tax foreign source income accumulated offshore at low rates of tax in the hands of Australian controllers of the offshore entity. These systems allow Australia to tax certain income and gains that have not been repatriated to Australia.

V. Tax Consolidation

Wholly owned groups of companies (and certain other entities) may elect to form a tax consolidation group. This means that the group is treated as a single entity for tax purposes.

VI. Imputation

Australian tax paid by resident companies gives rise to franking credits that attach to dividends paid from those taxed profits to shareholders.[75] Such dividends are "franked dividends." Resident shareholders include both the cash dividend and the franking credit in their income, and can then apply the franking credit against their tax liability. Individuals and superannuation funds are eligible to claim refunds of franking credits where their franking credits exceed the tax otherwise payable on their income. Non-resident shareholders receive franked dividends free of withholding tax (discussed below).

VII. Withholding Tax

Unfranked dividends, interest, and royalties paid to non-residents are subject to withholding tax. If withholding tax is paid, then no further tax is payable in Australia on that income.

The general rates of withholding tax are set out below:

- Interest – 10 per cent
- Unfranked dividends – 30 per cent
- Royalties – 30 per cent

Note that lower rates (especially for dividends and royalties) usually are prescribed in applicable tax treaties, and certain domestic exemptions may also apply (for example, interest paid on

[75] If dividends are paid from an Australian company's profits that have already borne Australian company tax, the dividends are "franked" by the company when paid to shareholders. This means the dividends carry a tax credit reflecting underlying Australian corporate tax paid. If the dividends are not franked, or only partly franked (and this can happen to the extent that corporate profits are not taxed in Australia, because of a tax concession, or because they are from foreign sources), the unfranked portion carries no tax credit.

certain types of offshore debt is exempt from withholding tax).

Withholding tax also may apply to distributions from managed investment trusts (MITs). Those distributions may be subject to withholding at either 10 per cent, 15 per cent, or 30 per cent, depending upon the classifications of the relevant MIT and the nature of the income being distributed.

Additionally, where a non-resident disposes of certain types of taxable Australian property, the purchaser will be required to withhold a non-final withholding tax at a rate of 12.5 per cent of the purchase price, and remit the amount withheld to the ATO.

VIII. Conduit Foreign Income Rules

Special rules allow "conduit foreign income" to flow through Australian resident companies to foreign shareholders without being taxed in Australia. "Conduit foreign income" is foreign income that is ultimately received by foreign residents, through one or more interposed Australian resident companies.

Australian resident companies that receive an unfranked distribution that is declared to be conduit foreign income will not pay Australian tax on that income if the conduit foreign income is on-paid to shareholders within a certain period. In such cases, the conduit foreign income will not be assessable to the Australian resident company. Conduit foreign income is also exempt from dividend withholding tax when it is on-paid to a foreign resident as an unfranked distribution.

Foreign sourced income generally flows through a trust to foreign beneficiaries without Australian tax, as do foreign sourced capital gains, provided a fixed trust (such as a plain unit trust) is involved.

IX. Losses

Losses can be carried forward indefinitely by corporate taxpayers, subject to the taxpayer satisfying one of two tests. The first is the continuity of ownership test, which requires that a majority underlying ownership of the company is maintained in the same hands in the loss recoupment year as was the case in the year the losses were incurred. The alternative test is the same business test, which requires that the same or a similar business is conducted in the loss recoupment year as was conducted immediately prior to the failure of the continuity of ownership test.

Different and more complex tests apply for the recoupment of losses by trusts.

Revenue losses can be offset against assessable income, which may include both income and capital gains. Capital losses can only be utilised against capital gains.

X. Thin Capitalisation

Broadly, Australia's thin capitalisation rules operate to disallow deductions for interest paid on loans from related parties, where the amount of related offshore debt exceeds a permitted level, having regard to the amount of related offshore equity capital. The rules apply to both foreign controlled Australian entities and to Australian entities with offshore operations.

XI. Transfer Pricing

Australia's transfer pricing rules are broadly in accordance with the Organisation for Economic Co-operation and Development (OECD) model. These rules require that related party cross-border transactions are conducted on arm's length terms. Taxpayers undertaking related party cross-border transactions are required to disclose details of these transactions with their annual income tax return.

The ATO has undertaken a number of audits and other reviews that have resulted in substantial adjustment to the taxable income of taxpayers where it has been found that the rules have not been complied with.

Companies are required to maintain contemporaneous documentation in relation to related party cross-border transactions, and a transfer pricing policy.

XII. Double Tax Treaties

Australia is a party to many bilateral double tax treaties dealing with income and, in most cases, capital gains. These treaties set out to regulate the taxing rights between the countries involved. Most of the treaties follow the OECD model agreement and provide for reduced rates of withholding tax as well as relief from double taxation by either foreign tax credit or exemption. Business profits earned by a resident of one country from sources in the other country are generally exempt from tax in the source country, unless the profits have been earned through a permanent establishment in the source country.

XIII. Goods and Services Tax (GST)

GST is a form of valued added tax. It applies at a rate of 10 per cent to most supplies connected with Australia, at each step along the production chain. It also applies to most importations. Registered suppliers are obliged to remit GST on supplies they make. For the most part, registered recipients of supplies will be entitled to a credit for any GST included in the price of acquisitions they make. Non-residents may be entitled to register, thereby enabling input tax credits to be claimed in relation to expenses incurred in Australia.

GST does not apply to limited categories of goods and services, including (among others) exports and financial supplies. From an administrative perspective, the GST system relies on registration of businesses and the issuance of tax invoices by the suppliers of taxable goods and services.

XIV. Fringe Benefits Tax (FBT)

FBT is imposed on employers at 47 per cent on the grossed up value of benefits provided to employees in respect of employment. The effect of taxing fringe benefits in this way is that employers pay FBT equivalent to the income tax that an employee in the top marginal rate of tax receiving the benefit would have paid had they purchased the benefit themselves from their after-tax income. FBT is deductible to the employer for income tax purposes. Certain benefits, such as superannuation, are exempt from FBT, while other benefits, such as motor vehicles, are concessionally taxed.

XV. Research and Development Incentive

A tax incentive is available for eligible entities that undertake qualifying research and development (R&D) activities in Australia, which could include participants in the hydrogen sector.

The two core components of the incentive are:

- A refundable tax offset for certain eligible entities with an aggregated annual turnover of less than A$20 million; and
- A non-refundable tax offset for all other eligible entities.

To claim an R&D tax offset, an entity must first register its R&D activities with Innovation and Science Australia, via AusIndustry.

Generally speaking, an eligible entity must be a company that is:

- Incorporated in Australia; or
- Incorporated under a foreign law, but resident in Australia for tax purposes; or
- Incorporated under a foreign law and both:
  - » Resident in a country that has a double tax agreement with Australia that includes a definition of "permanent establishment"; and
  - » Carrying on business in Australia through such a permanent establishment.

Generally, trusts will not qualify, with an exception for public trading trusts with a corporate trustee.

Corporate limited partnerships and exempt entities do not qualify. There are special rules for tax consolidated groups and R&D partnerships.

PART VI - STATE TAXES

The states and territories also impose taxes. These include stamp duty, payroll tax, and land tax.

I. Stamp Duty

Stamp duty, or "duty," is generally a tax payable on transactions, including the transfer or conveyance of property or assets situated in, or attributable to, that state or territory.

The amount of duty payable is calculated on the higher of the consideration or the unencumbered value of the property transferred. Duty is usually payable by the purchaser or transferee. The duty rates vary between each state and territory. Duty is an important factor in any purchase of land, or purchase of an interest in a company or trust that has interests in land.

Duty must also be considered in the context of the purchase of a business. However, the rules on which assets are dutiable vary from state to state, and can operate differently if a different mix of assets is acquired (for example, an asset may be exempt from duty if acquired in isolation, but brought into the duty net if acquired along with land).

II. Payroll Tax

Payroll tax is a tax levied in each state and territory on the gross salaries and wages paid by an employer for services rendered by employees in the state or territory. Certain payments to contractors may also be deemed to be wages. The tax is payable on a monthly basis, with a final reckoning at the end of the year. The rates vary across the states and territories, as do the thresholds from which point the tax becomes payable.

III. Land Tax

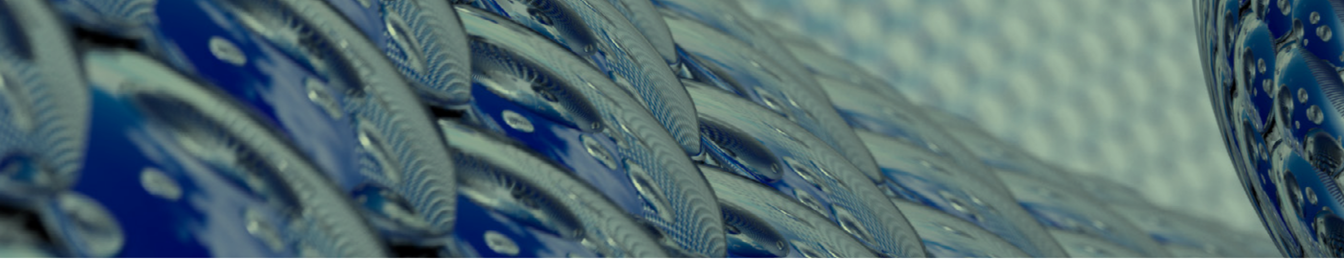
Land tax is a tax levied annually on the unimproved value of freehold land held within a state. Some lessees may be deemed to own the freehold land for tax purposes. The rate of land tax varies from state to state. Generally, land tax is calculated using a progressive tax scale; however, the threshold level for the imposition of the tax also varies from state to state.

Foreign investors can be liable for land tax surcharges (including in respect of commercial property) in some jurisdictions, such as Queensland and Victoria. There are some surcharge exemptions available for projects that significantly benefit a state's economy.

ANNEXURE AUSTRALIA

LIST OF AUSTRALIAN PROJECTS FROM THE IEA HYDROGEN PROJECT DATABASE

Project Name	State/ Territory	Proponents	Announced Start Date	Currently Operational (Y/N)	Technology	Product
Arrowsmith Hydrogen Project	WA	Infinite Blue Energy	2022		Unknown PtX	H_2
Asian Renewable Energy Hub	WA	ICE, CWP Energy Asia, Vestas, and Macquarie	2027	N	Unknown PtX	H_2
ATCO Clean Energy Innovation Hub	WA	ATCO	2019	Y	PEM	H_2
Australian Hydrogen Centre, Vic	Vic, SA	AGN, Neoen, AusNet Services, ENGIE		N	Unknown PtX	H_2
BP Ammonia WA	WA	BP Australia		N	Unknown PtX	NH_3
Collie Synfuel West Australia Project	WA	Collie Synfuels Pty Ltd		N	Coal gasification + CCS	H_2 Synthetic hydrocarbons
Crystal Brook Energy Park, SA	SA	Neoen Australia		N	Unknown PtX	H_2
Engie-Yara Pilbara test	WA	Yara and ENGIE	2021	N	Unknown PtX	NH_3
Fenosa Canberra Hydrogen Demo Project	ACT	Neoen, Megawatt Capital, Union Fenosa		N	Unknown PtX	
Hazer Group CH4 Pyrolysis	NSW	Hazer Group Ltd	2020	N	Biogas pyrolysis	H_2
HESC (Liquefied hydrogen energy supply chain)	Vic	HEA	2030	N	Coal gasification + CCS	H_2
Hydrogen Park Gladstone	Qld	AGIG	2021	N	PEM	H_2
HyPSA	SA	AGIG	2020	N	PEM	H_2
Jemena Gas Network – H2GO project	NSW	Jemena	2020	N	PEM	H_2
Kidman Park in Adelaide depot	SA	AGN	2018	N	Unknown PtX	H_2



Project Name	State/ Territory	Proponents	Announced Start Date	Currently Operational (Y/N)	Technology	Product
Moranbah	Qld	Dyno Nobel Moranbah Pty Ltd		N	Unknown PtX	NH_3
Moreland garbage truck filling station	Vic	Moreland Council	2018	N	Unknown PtX	H_2
Moura	Qld	QNP, Neoen, Worley		N	Unknown PtX	NH_3
Murchison Renewable Hydrogen Project	WA	Hydrogen Renewables Australia		N	PEM	H_2
Port Lincoln Project, Eyre Peninsula	SA	H2U	2021	N	PEM	H_2 NH_3
Sir Samuel Building Griffith Center, Brisbane	Qld	Griffith University	2013	Y	ALK	
Toyota Australia, Altona, Victoria	Vic	Toyota Australia	2020	N	Unknown PtX	H_2
UniSA, Mawson Lakes Campus	SA	UniSA	2020	N	Unknown PtX	H_2

GLOSSARY AUSTRALIA

AGIG	Australian Gas Infrastructure Group
AGN	Australian Gas Network Limited
ALK	Alkaline Electrolysis
Coal gasification + CCS	Hydrogen production from coal gasification (all types of coals and derivatives) coupled with CO_2 capture
H_2	Hydrogen in molecular form
H2U	Hydrogen Utility
HEA	Hydrogen Engineering Australia (a consortium comprising Karasaki Heavy Industries, J-Power, Iwatani Corporation, Marubeni Corporation, Sumitomo Corporation, and AGL)
ICE	InterContinental Energy
NH_3	Ammonia
PEM	Proton exchange membrane electrolysis
QNP	Queensland Nitrates Pty Ltd
Synthetic hydrocarbons	Synthetic liquid fuels (e.g., gasoline, diesel, jet-fuel equivalent)
UniSA	University of South Australia
Unknown PtX	Undisclosed electrolysis type

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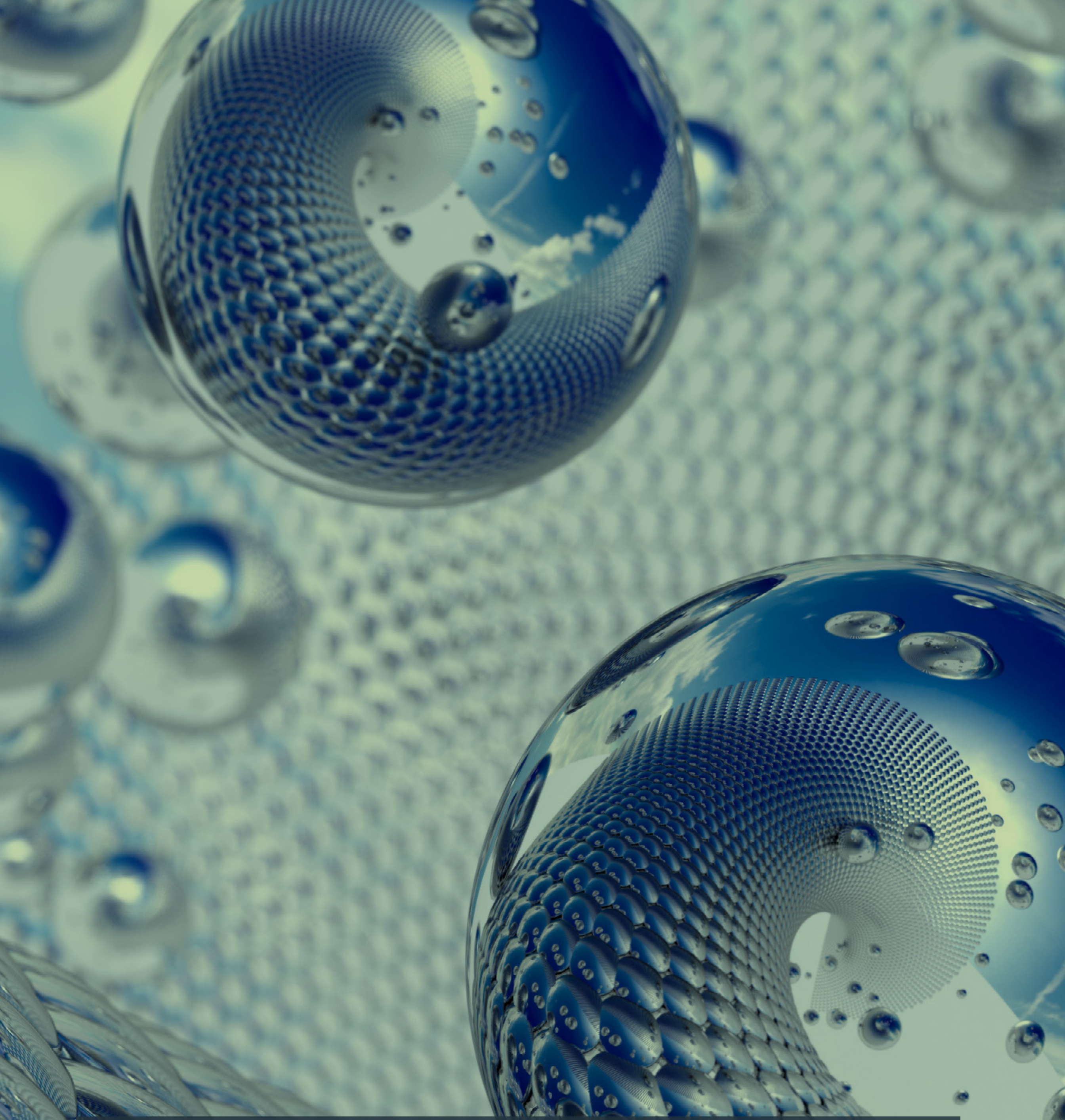

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