



# QUEENSLAND HYDROGEN INDUSTRY STRATEGY

2019–2024

May 2019



The Department of State Development, Manufacturing, Infrastructure and Planning

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# Foreword from the Premier

Hydrogen provides the opportunity to export Queensland's sunshine to the world and support more jobs in regional Queensland.

My Government's record of attracting investment in renewables combined with our existing gas pipeline infrastructure and export facilities make us the ideal state to lead the future production and export of hydrogen.

We backed the \$60 billion LNG industry providing thousands of jobs for our regions.

Now the world is looking to hydrogen and we want them to get it from Queensland so we can create even more jobs in our regions.

This emerging industry will have enormous economic benefits for Australia, worth an estimated \$1.7 billion in exports annually by 2030.

Now is the time for Queensland to position itself as a significant hydrogen trading partner with our international neighbours.

I have met with Government officials and major companies in Japan and South Korea to discuss the potential for Queensland to export 'green hydrogen' produced using renewable energy sources. Both countries have ambitious plans for renewable hydrogen to meet their domestic energy needs, and Queensland is well-placed to support the energy goals of these long-standing trading partners.

Earlier this year, we celebrated our State's first delivery of green hydrogen to Japan, exported by the Japanese petroleum conglomerate JXTG. This was produced at the Queensland University of Technology's solar cell facility at the Queensland Government's Redlands Research Facility.

Queensland's and Australia's growing populations and economies also require increasing supplies of reliable, affordable and preferably renewable power. Manufacturing sectors that use hydrogen in their processes will also benefit from a reliable domestic supply.

My government's priorities are creating jobs in a strong economy and supporting the development of this industry strongly aligns with that.

The \$19 million committed to this strategy will give Queensland the best start possible to succeed in becoming a hydrogen exporter of choice for the world.



**The Honourable Anastacia Palaszczuk MP**

Premier of Queensland and Minister for Trade



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Hyundai NEXO fuel cell. Image courtesy of Hyundai.

# Foreword from the Minister

Creating jobs of the future while propelling and diversifying our economy remains a key focus of our government.

That's why we're committed to growing Queensland's hydrogen industry as it holds significant potential for our state: for employment, investment and overseas export.

The development of a domestic hydrogen industry, including the production of competitively priced renewable hydrogen, will have widespread economic benefits.

Hydrogen is a versatile energy carrier with a diverse range of applications, including energy supply and transport and industrial applications like biorefineries.

Gladstone, one of Queensland's industrial powerhouses, will be a focus point for hydrogen development, and for good reason.

Existing industries, gas infrastructure, access to a deep-water export port and skilled local workers make it an attractive location for this emerging industry.

Gladstone also has a strategically placed State Development Area, that through the powers of the Coordinator-General, gives our government the ability to facilitate large-scale industrial development.

Working in partnership with local researchers and international partners, and leveraging advanced manufacturing technologies, systems, products and services, Queensland is primed to develop a safe and sustainable hydrogen industry that has the potential to generate wealth, jobs and economic growth for our state.



**The Honourable Cameron Dick MP**

Minister for State Development,  
Manufacturing, Infrastructure and Planning

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Image courtesy of Toyota.

# About the strategy



A Queensland hydrogen industry has the potential to deliver significant economic, employment, energy security and environmental benefits for Queensland and Australia.

The Queensland Government is committed to developing a sustainable hydrogen industry.

Queensland has a unique competitive advantage in the production of renewable hydrogen. With its close proximity to Asia, established infrastructure, manufacturing capabilities and renewable energy potential, Queensland is well-positioned to benefit from the global transition to a low-emission energy future.

In September 2018, the Advancing Queensland's hydrogen industry discussion paper was released by the Queensland Government<sup>i</sup>. Thirty-three submissions were received from a broad range of stakeholders, identifying opportunities for, and the challenges faced by the hydrogen industry. The feedback, along with an extensive program of meetings with industry and researchers, has shaped the development of the Queensland Hydrogen Industry Strategy 2019–2024 (the strategy). The strategy is underpinned by comprehensive research on national and international trends and best practice approaches adopted in jurisdictions with growing renewable hydrogen industries.

The objective of the strategy is to drive the development of an economically sustainable and competitive hydrogen industry that creates economic growth, opportunities for new export markets, generates the highly skilled jobs of the future, while supporting the transition to a low-emission economy. The strategy will ensure that government and industry work towards a common vision for Queensland's future hydrogen industry, with specific actions in five focus areas.

Implementation of this strategy will help us take advantage of the many opportunities for domestic energy uses, new export markets and skilled jobs from hydrogen, while also benefiting from cleaner energy generation and lower carbon emissions.

Success will be seen through a demonstration of industry confidence, measured by strong investment in the hydrogen industry, growing production of cost-competitive renewable hydrogen and the creation of new high-tech jobs across the industry.

Growing a sustainable hydrogen industry is consistent with the Queensland Government objectives for the community<sup>ii</sup>.

# Vision

By 2030, Queensland is at the forefront of renewable hydrogen production in Australia, supplying an established domestic market and export partners with a safe, sustainable and reliable supply of hydrogen.

## What is renewable hydrogen?

Renewable hydrogen is produced without the use of fossil fuels. Most commonly, renewable energy such as solar or wind is used to generate carbon-neutral (and sometimes carbon-negative) hydrogen or hydrogen derivatives. Hydrogen (or biofuels) can also be produced from residual biomass of other waste streams such as municipal solid waste. When used within a fuel cell, hydrogen is part of a catalytic process that generates electricity without combustion, eliminating greenhouse gases (GHGs) and air pollutants.

With so many ways to produce hydrogen, it is common to differentiate between renewable hydrogen and other sources.

Hydrogen produced from water electrolysis and renewable energy is known as green hydrogen. This term has been used to distinguish between carbon-neutral hydrogen and hydrogen produced from fossil fuels, which is known as brown hydrogen. Approximately 95 per cent of global production is brown hydrogen that is manufactured by steam methane reformation, where high-temperature steam (700°C–1,000°C) is used to produce hydrogen from a methane source, such as natural gas.

Blue hydrogen is produced by incorporating carbon capture and storage into the steam methane reformation production processes. Blue hydrogen is seen as a step towards achieving carbon-free energy.

Options for a hydrogen-based fuels green certification system for Australia are currently being investigated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) through Hydrogen Mobility Australia. The Queensland Government views a national accreditation system that is recognised in key export markets as important for the development of the hydrogen industry.

# The race to a global hydrogen economy

The appetite to explore hydrogen as an energy carrier is growing at pace, with billions of dollars being spent worldwide on pioneering projects to integrate hydrogen into energy markets.

Conditions are favourable in Queensland to capitalise on domestic technological breakthroughs and the global momentum to grow the hydrogen economy. In August 2018, the CSIRO demonstrated their world-first technology for refueling fuel cell electric vehicles (FCEV's) from ammonia at the Queensland Centre for Advanced Technologies. This project was supported by Hydrogen Mobility Australia members (including BOC, Hyundai and Toyota). The unique membrane technology enables the production of ultra-high purity hydrogen from ammonia. The membrane technology breakthrough has the potential to allow hydrogen (as ammonia) to be safely transported and used as a mass-production energy carrier.

South Korea, Japan, the United States and Europe have all made significant commitments to establishing successful hydrogen industries and have implemented programs to support the rapid scaling up of hydrogen production and use.

Some exciting recent hydrogen developments include:

- Germany has rolled out the world's first hydrogen-powered trains, which were put into service in the Lower Saxony region in September 2018. The two hydrogen trains can run for about 600 miles (1000 km) on a single tank of hydrogen, similar to the range of diesel trains.
- Norway has commissioned HYON AS, a Norwegian group to design and build two hydrogen-fueled vessels, a zero-emission passenger ferry and short trip cargo ship.
- New Brunswick Power recently announced it is building the world's first hydrogen-powered distributed electricity grid, using readily available seawater. The system will include multiple distributed stations incorporating renewable energy to provide net zero emission base load power. New Brunswick Power is the primary electric utility in New Brunswick, Canada and was established in 1920.
- The 7-Eleven chain in Japan has announced it is partnering with Toyota to introduce hydrogen-fueled refrigerated delivery trucks for its distribution process. The trucks will be operational in 2019. The 7-Eleven company has almost 20,000 stores across Japan, including more than 2500 in Tokyo alone.



# The global hydrogen agenda

The potential for hydrogen as an energy carrier and fuel has been recognised for decades. In the past few years this interest has escalated, resulting from three key drivers: decarbonisation, emerging export markets and falling renewable electricity costs. The image below highlights some recent hydrogen policies or policy positions both in Australia and globally. This list is not exhaustive, and does not take into account general emissions reduction or renewable energy policies.

## 1 2017 UK

- > Clean Growth Strategy identifies 100 per cent conversion of the gas distribution network to hydrogen as a credible decarbonisation option.

## 2 2016 UK

- > United Kingdom publishes Hydrogen and Fuel Cells: Opportunities for Growth – A roadmap for the UK.

## 3 2018 CHINA

- > China announces 'hydrogen city' to be developed by 2025.

## 4 2017 JAPAN

- > Japan develops hydrogen strategy mapping out goals for hydrogen production and consumption for 2020, 2030 and beyond (with 2019 update).
- > Japan aims to showcase hydrogen as a clean fuel alternative at the 2020 Olympic games.

## 12 2019 EUROPE

- > In January 2019 the Fuel Cells and Hydrogen Joint Undertaking released the Hydrogen Roadmap Europe: A sustainable pathway for the European energy transition.

## 11 2013 CALIFORNIA (USA)

- > California's state law AB8 provides funding for 100 hydrogen refuelling stations.

## 10 2017 INTERNATIONAL

- > The Hydrogen Council launches – 'a global initiative of leading energy, transport and industry companies with a united vision and long-term ambition for hydrogen to foster the energy transition.'

## 9 2016 TAIWAN

- > Taiwan Government lists hydrogen as one of its focuses in its green energy development plan.

## 8 2019 SOUTH KOREA

- > The South Korean Government releases the Hydrogen Economy Roadmap of Korea.

## 7 2019 SINGAPORE

- > Singapore Government issues a tender calling for a consultancy study on how the country could harness hydrogen as a sustainable source of energy.

## 6 2018 AUSTRALIA

- > Hydrogen Mobility Australia established.
- > 'Hydrogen month' sees the release of three significant reports:
  - > National Hydrogen Roadmap (CSIRO)
  - > Hydrogen for Australia's Future (Hydrogen Strategy Group for the Council of Australian Governments (COAG) Energy Council)
  - > Opportunities for Australia from Hydrogen Exports (ACIL Allen Consulting for ARENA).
- > Hydrogen Mobility Australia partners with Standards Australia for adoption of hydrogen standards.
- > COAG Energy Council approves a proposal for a national hydrogen strategy.
- > Queensland releases hydrogen industry discussion paper.

## 5 2017 AUSTRALIA

- > South Australia launches Hydrogen Roadmap.
- > CSIRO launches new Future Science Platform for hydrogen energy systems.



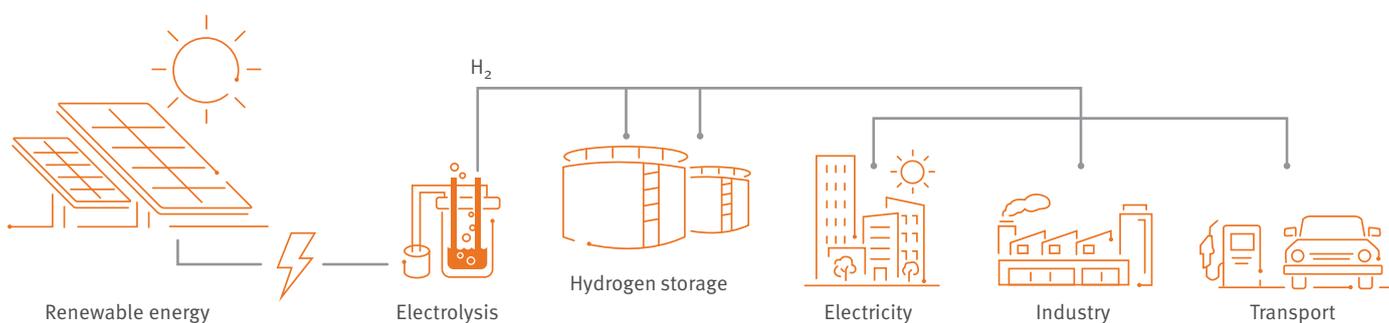
# Hydrogen's role in our clean energy future

## A versatile energy carrier

Almost anything that uses energy can be powered by hydrogen. Hydrogen produced from biomass, or made using renewable energy sources, is a clean and flexible energy carrier that can help reduce carbon emissions from transport, power generation and industrial sectors.

Power from renewable energy sources, such as wind or solar, is used to power an electrolyser which generates hydrogen by splitting water into hydrogen and oxygen. While historically more expensive, this process has no carbon emissions. Rapid improvements in cost and performance of renewable hydrogen technologies has occurred and is projected to continue.

The co-location of hydrogen production facilities with waste water treatment plants is an emerging opportunity that will increase efficiencies for both operations. Waste water can be used as an input to the hydrogen production process, with the by-product oxygen supplied back to the treatment plant for optimal processing efficiency.



## A response to emissions targets

The Queensland Government has set a state target to reach zero net emissions by 2050, with an interim target of a 30 per cent reduction in emissions by 2030. Renewable hydrogen has the potential to play a significant role in achieving these targets and will reinforce Queensland's position at the forefront of global climate action<sup>iii</sup>.

The Queensland Climate Transition Strategy will guide policy and drive the investment needed to put Queensland on the path to a zero net emissions economy<sup>iv</sup>. Programs such as Solar 150 are supporting a solar investment boom through long-term revenue certainty for proponents<sup>v</sup>.

## A grid stabiliser

As renewable generation capacity increases, attention is being focused on how surplus electricity generated by renewables can be captured for later use or to provide a source of dispatchable power. Balancing supply and demand across the electricity grid will require new solutions if energy systems are to fully decarbonise while maintaining current levels of cost and reliability. Hydrogen technologies can assist with both the integration and expansion of low-carbon electricity generation by providing grid stabilisation and demand management mechanisms.

When excess electricity is produced from renewable resources, such as solar, the electricity can be stored as hydrogen rather than feeding it back into the grid. Once stored, hydrogen energy can be produced with very little initialisation time, making it possible to store renewable energy until demand increases. The ability to manage grid demand will smooth out pressure currently placed on the grid during times of peak use.

## A supplement for natural gas

Hydrogen can also be used to supplement the current domestic gas supply. The Hydrogen Strategy Group COAG briefing paper *Hydrogen for Australia's future* states: 'Hydrogen can be safely added to natural gas supplies at 10 per cent by volume without changes to pipelines, appliances or regulations.' A detailed study has been commissioned as part of the development of the national hydrogen strategy to review any barriers to hydrogen injection in gas distribution networks from a regulatory, technical or legal viewpoint in each state. With further research and testing, there is potential to increase the concentration of hydrogen in the gas supply.

Energy Networks Australia, the premier national body representing Australia's gas distribution and electricity transmission and distribution companies, identified hydrogen innovation and pilot projects were immediate opportunities for the transformation to a net zero emissions energy system<sup>vi</sup>. Domestic gas entities including Jemena, ATCO, Evoenergy and the Australian Gas Infrastructure Group are currently progressing these types of projects on the integration of hydrogen into the gas network.

Given 18 per cent of Australia's carbon emissions are a result of direct combustion<sup>vii</sup>, hydrogen could provide a potential alternative to demands currently placed on fossil fuels.

## An off-grid power solution

Hydrogen's storage benefits make it ideal for providing low emission options for regional and remote electricity generation. Queensland currently has 33 remote power stations that are not connected to the national electricity grid and an approximately 64,000 kilometre Single Wire Earth Return (SWER) network servicing regional Queensland. Through the Community Service Obligation, the government makes a significant investment to ensure Queenslanders in these communities pay the same price for electricity as the rest of Queensland<sup>viii</sup>. Achieving reliable and cost-competitive renewable hydrogen generation in regional and remote environments, represents a significant opportunity for Queensland.

## A transport fuel

Motor vehicle emissions account for 15 per cent of Queensland's greenhouse gas emissions<sup>x</sup>. Hydrogen fuel cells can provide an alternative to batteries for powering electric motors, meeting the world's growing transport needs while reducing carbon emissions and improving air quality. FCEV's have similar refueling and driving ranges to current internal combustion engine vehicles.

Hydrogen fuel cells can also overcome many of the limitations of battery electric technologies for heavy vehicles, making this technology ideal for public transport, long distance freight and small vehicles such as forklifts. The Queensland Government is demonstrating this commitment to adopting low-emission technologies through the integration of zero-emission vehicles in the government fleet<sup>x</sup>.

## Energy and fuel security

Australia is a member of the International Energy Agency (IEA) and, as part of this, has an obligation to maintain stocks equivalent to 90 days of our annual net imports. While Australia has enjoyed 40 years without a major disruption to domestic liquid fuel supplies, the Australian Government recently commenced a review of liquid fuel security in order to be prepared for new and emerging threats<sup>xi</sup>.

The Liquid Fuel Security Review—Interim Report, Commonwealth of Australia 2019 refers extensively to the potential for hydrogen to improve liquid fuel security. The report states that 'Opportunities also exist in biofuel and hydrogen, which have been successfully used in the United States, China and Europe to support fuel security.' Hydrogen can be an important fuel in its own right, but hydrogen is also important in the upgrading of biofuels, another source of fuel that can improve domestic fuel security and be a direct replacement for fossil fuels. The report states that 'Hydrogen would be able to provide important fuel for our domestic needs, but there may also be opportunities to export hydrogen as other countries around the region seek alternative forms of transport energy.'

# Queensland's hydrogen industry

As an industrial gas, hydrogen is already produced in large volumes, primarily to meet demand for the production of ammonia, methanol, plastics, and in metal processing and petroleum refinery operations. However, traditional hydrogen manufacturing processes release substantial carbon emissions.

The use of hydrogen as an energy carrier has been envisaged for a long time, and growing momentum to decarbonise global energy markets is expected to see additional growth in demand for renewable hydrogen. The existing hydrogen and gas industry and its supply chain are expected to serve as a platform for future uses of hydrogen.

Some of Queensland's and Australia's largest companies, as well as major global companies, are pursuing hydrogen, indicating its future potential within the energy markets. The global hydrogen production market was valued at \$US115.25 billion in 2017 and is expected to grow to over \$US200 billion by 2026<sup>xii</sup>.

The Queensland Government, through the Advance Queensland Biofutures 10-Year Roadmap and Action Plan, is working with industry to grow the Biofutures sector. As the bioenergy industry grows, demand for hydrogen is expected to increase as it is widely used to upgrade biocrude to finished fuels. In 2017, funding of \$1 million from the Biofutures Commercialisation Program was provided to the Northern Oil Refinery for a project involving steam over iron chemical looping to produce hydrogen using internal gas from the refinery<sup>xiii</sup>.



# COAG Energy Council look to a hydrogen future for Australia

## National hydrogen strategy

At the December 2018 COAG Energy Council meeting, members accepted a proposal from Australia's Chief Scientist, Dr Alan Finkel AO, to develop a national hydrogen strategy. The national strategy will consider international trends and best practice, reducing red tape and encouraging innovation. Development of the national strategy will focus on six areas:

- developing a hydrogen export industry
- hydrogen in the gas networks
- hydrogen for transport
- hydrogen to support electricity systems
- hydrogen for industrial users
- cross-cutting issues.

A public discussion paper was released for comment in March 2019. The national strategy will be presented to Ministers of the COAG Energy Council for consideration in December 2019.

## Kick-start projects

The COAG Energy Council will also oversee three 'kick-start' projects in 2019, which will set the stage for implementation of the national hydrogen strategy and establish Australia's standing as a major player in the global hydrogen industry. The projects are:

- commencing work to allow up to 10 per cent hydrogen in the domestic gas network, both for use in place of natural gas and to provide at-scale storage for hydrogen
- scoping potential for building hydrogen refueling stations in every state and territory
- undertaking coordinated international outreach to keep building Australia's profile with major trading partners as a potential supplier.

These projects will be done in partnership with industry and the community while the national strategy is being developed.

## Queensland's role in the national hydrogen strategy

Queensland is represented on the COAG Energy Council by The Honourable Dr Anthony Lynham MP, Minister for Natural Resources, Mines and Energy.

Queensland is supporting the development of the national hydrogen strategy with two representatives on the Steering Committee and officers participating in each of the six work streams.

The Queensland Hydrogen Industry Strategy has been prepared taking account of the work streams under the national hydrogen strategy. It is proposed that the Queensland Hydrogen Industry Strategy will be reviewed following the public release of the national hydrogen strategy, to ensure the most efficient use of resources to support the development of the hydrogen industry.

More information on COAG Energy Council's hydrogen agenda can be found here: <http://www.coagenergycouncil.gov.au/publications/establishment-hydrogen-working-group-coag-energy-council>

# Queensland's competitive position

The Queensland Government is committed to attracting international investment and growing overseas trade. Queensland offers many advantages, which make it an ideal location for hydrogen projects.

**HIGHLY SKILLED WORKFORCE**  
Over 15 per cent of Queensland's workforce have STEM qualifications such as science or engineering.

**ESTABLISHED ENERGY EXPORTER**  
20.58 million tonnes of LNG exported in 2018.

**WORLD LEADING SOLAR PV CAPACITY**  
Queensland enjoys over 300 days of sunshine per year.

**PROBUSINESS GOVERNMENT**  
Queensland boasts a supportive policy and regulatory regime, with a strong focus on innovation.

**QUEENSLAND IS THE MANUFACTURING STATE**  
Manufacturing is the sixth largest contributor to the Queensland economy.

**PROXIMITY TO MARKETS**  
Brisbane is the closest eastern capital city to Asian markets.

## Probusiness investment environment

The Queensland Government wants innovative and dynamic businesses to establish and expand in Queensland and is acting to make that a reality by providing a supportive policy and regulatory environment. Queensland offers business owners and investors many advantages, including the lowest rate of payroll tax in Australia, competitive labour costs, low cost of living, simple development approvals, project facilitation processes and strong private sector investment.

Assisted by the Queensland Government's \$650 million flagship Advance Queensland initiative, the economy is experiencing increased levels of innovation and research and development. This has been vital to support the growth of existing, new and emerging industries and is increasingly important in a global economy characterised by innovation and technological change.

The Queensland Government recognises innovation in industry and manufacturing as central to driving productivity.

Queensland is a leading producer of advanced manufacturing niche products that require rapid prototyping and agile manufacturing processes. An established network of research and development institutions, a highly skilled workforce, and a strong infrastructure base are supporting innovation in the advanced manufacturing sector.

The government actively engages with companies to attract and enable investment in Queensland. Tailored support is available for major investment ideas and business propositions that demonstrate a strong potential of being delivered and that align with the Queensland Government's priorities.

## Proximity to key export markets and established trading partnerships

Queensland is in close proximity to some of the world's strongest growth markets and ideally positioned as an international gateway to the Asia-Pacific region. Already recognised as one of the world's great energy commodity exporters, Queensland is well-positioned for the production and export of renewable hydrogen having access to significant renewable resources, gas pipeline infrastructure and established ports.

Queensland's proximity to Asia and existing commercial energy partnerships mean Queensland has the potential to meet the energy import needs of countries such as Japan, which currently imports 94 per cent of its energy and is investing heavily in the transition to hydrogen.

## Renewable resources

Queensland has an enviable capacity to produce renewable and alternative energy, being rich in renewable energy resources with existing large-scale solar, wind, biomass, geothermal and hydroelectric energy projects.

With an average of 300 days of sunshine annually, Queensland has the natural resources to expand the renewable energy sector and become a global leader in the transition towards a clean energy future.

Since January 2016, Queensland has seen over 1330 megawatts of large-scale solar projects completed and operational. A further 17 large scale solar photovoltaic (PV) projects are either commencing construction or finalising commercial arrangements<sup>xv</sup>. When complete, these projects will deliver over 1380 megawatts of clean power to the state, more than doubling Queensland's current solar PV energy supply.

A broader pipeline of proposed solar PV projects, if realised, will add 19,000 megawatts of clean energy to the states supply<sup>xvi</sup>.



## The Coordinator-General

The Coordinator-General (CG) is an independent entity governed by statutory processes. The CG administers *the State Development and Public Works Organisation Act 1971* (SDPWO Act). Under the SDPWO Act, the CG has wide-ranging powers to plan, deliver and coordinate large-scale projects, while ensuring their environmental impacts are properly managed. Such powers enable the CG to play an effective role in facilitating major projects for the private and government sectors.

A project proponent may apply to have the project declared a 'coordinated project' under the SDPWO Act. The Coordinator-General coordinates whole-of-government evaluation for these major projects to ensure an efficient assessment pathway.

State development areas (SDAs) are clearly defined areas of land that are established to facilitate economic development in Queensland. Each SDA is subject to a development scheme that controls planning and development in an SDA. There are a number of strategically located SDAs in Queensland, including in Gladstone, where there is significant interest in hydrogen due to its existing industrial demand, gas infrastructure, port access and skilled workforce.

## Skilled workforce and world-class education and research facilities

The Queensland Government's Advance Queensland initiative positions Queensland as a leader in the knowledge economy, creating jobs both now and for the future. Queensland's workforce of over 2.5 million is highly skilled, motivated and employment-ready. Our lifestyle and world-class education and skills training institutes are instrumental in attracting and retaining highly-skilled workers.

Queensland is home to many internationally recognised universities and research institutions, several with existing expertise in hydrogen research, production and use. Research conducted at Queensland universities and research institutions has achieved worldwide recognition and made a significant contribution to economic growth within the state.

The outlook for hydrogen industry related jobs is positive. The Australian Renewable Energy Agency (ARENA) commissioned report *Opportunities for Australia from Hydrogen Exports*, estimates that for a medium growth scenario, there would be up to 788 direct and indirect jobs created by 2025, up to 2787 in 2030 and 7142 jobs by 2040<sup>xvii</sup>. The report says that if hydrogen production reaches the higher level of its range of estimates, the job numbers could be comparable to those generated by Liquefied Natural Gas (LNG) and its supply chain.

CSIRO has identified an opportunity for the advanced skills and capabilities that have been developed to service the oil and gas industry to be repurposed for the hydrogen value chain<sup>xviii</sup>. As a result, developing a local hydrogen industry could mean that the capabilities that were developed during the resources construction boom can now be redeployed to a new growth-oriented future energy industry.

The suitability of current qualifications and workforces for transfer to the hydrogen industry will need to be assessed in consultation with industry. Based on this assessment, any skill shortfalls of existing workers can be targeted for upskilling and included in the initial training of new entrants to the sector. For example, new competencies may need to be developed to address specific safety issues associated with hydrogen.

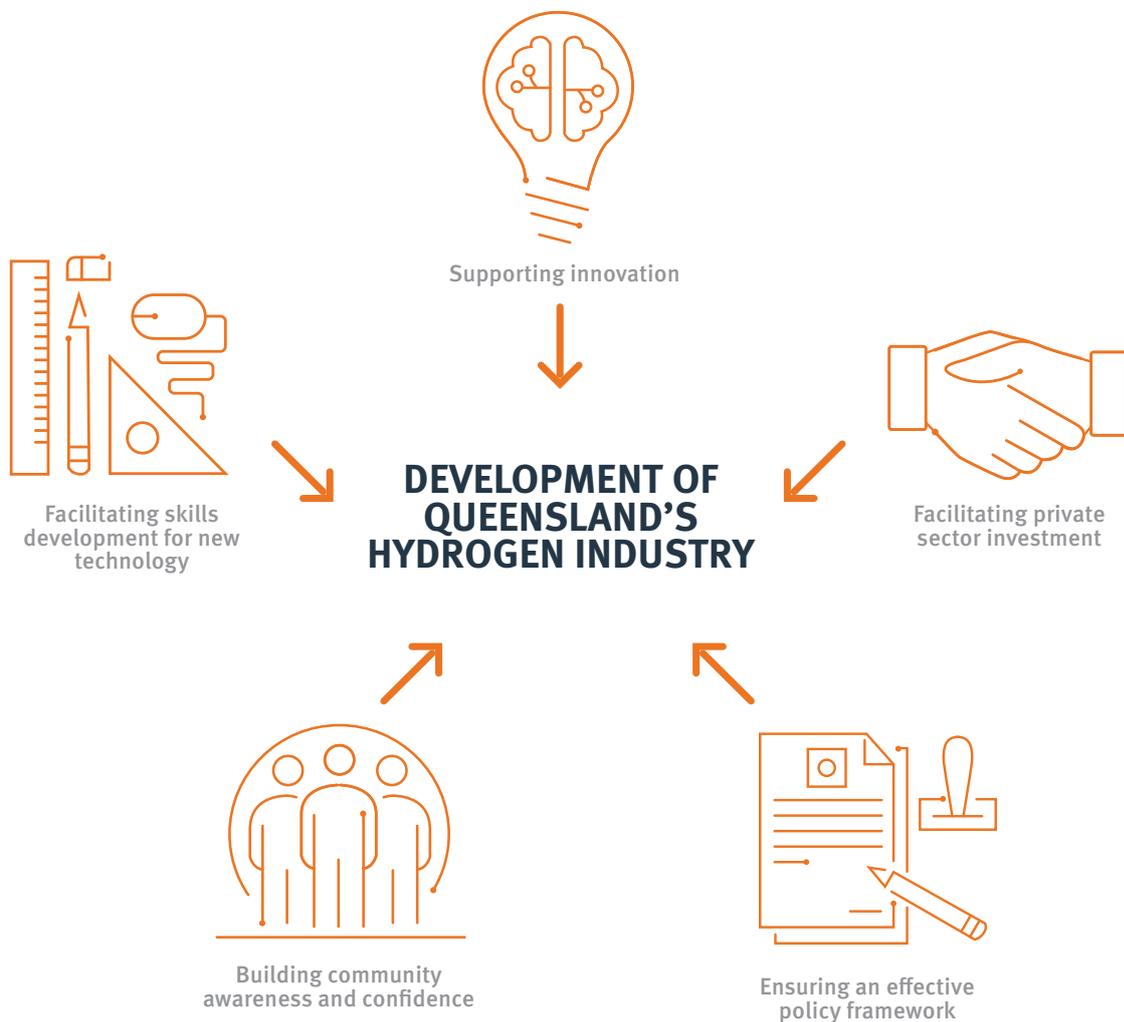
# Focus areas

The Queensland Government is committed to developing a sustainable hydrogen industry.

Five focus areas were identified in consultation with researchers and industry and confirmed through consultation on the Advancing Queensland's hydrogen industry discussion paper<sup>xix</sup>, which was released for public consultation in September 2018. Actions under each of the focus areas respond to challenges highlighted by industry during the consultation process.

Feedback indicated a strong desire from business and industry to develop a future-focused, sustainable hydrogen industry for Queensland. Appropriately facilitated, a successful industry could contribute to growing businesses, creating jobs and meeting environmental targets such as the Queensland Government's Renewable Energy Target. To achieve this, the focus areas are:

1. supporting innovation
2. facilitating private sector investment
3. ensuring an effective policy framework
4. building community awareness and confidence
5. facilitating skills development for a new technology.







Supporting innovation

# 1. Supporting innovation

Innovation in industry and manufacturing are central to driving productivity and decreasing the cost of producing renewable hydrogen. Achieving greater efficiency in the production, storage and transport of renewable hydrogen is the key challenge to developing the industry. The Queensland Government is directly supporting innovation in hydrogen technology, with the government's Redlands Research Facility hosting the QUT-led renewable hydrogen technologies pilot plant. The government is also supporting CSIRO with the further development of breakthrough membrane technology for the transport of hydrogen as ammonia.

The Queensland Government's \$650 million flagship Advance Queensland initiative is supporting programs that drive innovation, build on our natural advantages and help raise our profile as an attractive investment destination. Advance Queensland programs such as the Industry Research Fellowships, the Industry Tech Fund, Ignite Ideas and the Business Development Fund all have the potential to support the development of an innovative Queensland hydrogen industry.

A comprehensive review of the state's innovation system Our Innovation Future was announced in 2018. On 2 April 2019, Building our Innovation Economy – Advance Queensland Strategy (Draft) was released for public consultation. This outlines five priorities that will guide the next phase of Advance Queensland, including a commitment to solve big challenges. Under this priority, the draft strategy includes a commitment to address energy sustainability through the innovation system.

Energy is critical to Queensland families, communities and businesses. Finding innovative methods to use our resources wisely will improve our competitiveness and resilience to climate change, and position Queensland as a global leader in sustainable energy management. We will also support workers and communities affected by the transition to a sustainable low carbon economy, with a focus on creating new opportunities, including low-cost clean energy and a fair distribution of the costs and benefits of change.

The draft Advance Queensland Strategy includes a number of immediate actions that act on this priority, including a commitment to target research funding on identified priorities including energy sustainability, and to work with government-owned energy and water providers to maximise our state assets to build innovation opportunities. Hydrogen is identified as a priority industry in the draft Advance Queensland Strategy.

This is the government's blueprint for Queensland's future, to drive jobs and solve some of the state's biggest challenges through innovation. Following public consultation, the final innovation strategy will be released later in 2019.

The following actions will address the innovation challenge by recognising hydrogen as a priority and ensuring the government is responsive to industry needs. Innovation will also tackle the primary challenge of production costs for renewable hydrogen.

## Actions being undertaken to support innovation:

- 1.1 Continue to engage with industry and researchers to understand what is required to foster innovation; and ensure investment programs remain responsive to hydrogen industry development opportunities.
- 1.2 Work with the Australian Government to identify innovative projects that align with the priorities and objectives of the Queensland Government, and assist eligible proponents to access federal funding opportunities such as the ARENA Research and Development Program.
- 1.3 Establish hydrogen as a science and research priority to drive innovation that will support competitive production, storage, transport and use.

## CASE STUDY

### Redlands hydrogen research facility

On 15 March 2019, the state's first ever delivery of green hydrogen to Japan was announced by JXTG, Japan's largest petroleum conglomerate. The hydrogen for this shipment was produced using JXTG's proprietary technology at the QUT solar photovoltaic facility, which is located at the Queensland Government's Redlands Research Facility.

QUT and their project partners are also embarking on hydrogen research for Australian conditions. The project will develop a scalable process to evaluate the viability of decentralised renewable energy systems to generate hydrogen from renewable resources. Using two solar array technologies and battery packs, hydrogen will be produced using electrolysis technology. The resulting hydrogen will be used within the facility as well as exported. The facility will allow researchers and industry to optimise the production and use of renewable hydrogen with the aim of scaling up into megawatt scale development.

QUT have received financial assistance from ARENA and are working with Swinburne University of Technology, Sumitomo Electric Industries, Griffith University and Energy Developments Limited.

The Queensland Government has recently committed to financially support the establishment of the facility. The government owned corporation, CS Energy is also making a significant financial contribution to the research into renewable hydrogen production at the Redlands facility.

# Sir Samuel Griffith Centre

In mid-2013, Griffith University opened the Sir Samuel Griffith Centre—the first Australian teaching and research facility powered by photovoltaics and hydrogen storage technology.

The building is fitted with more than 1,000 solar panels, covering the roof and window shades. On sunny days this generates more than enough electricity to power the whole building. Excess solar energy produced by the photovoltaic system is stored in batteries and powers an electrolyser that splits water to make hydrogen. The hydrogen is then stored in a stable form as metal hydrides. When there's no sun the hydrogen can be brought back from storage and used to generate electricity in a hydrogen fuel cell.

The Sir Samuel Griffith Centre is designed to generate zero carbon emissions in operation. A hydrogen system provides a fail-safe energy backup to the photovoltaic array, which means that even on cloudy days, the building will never have to draw from the main power grid.

The Centre has been awarded a six-star green star by the green building council Australia.

The Sir Samuel Griffith Centre is a window into the future of a sustainable energy alternative for Australia and the international community.



Image courtesy of Griffith University.

## CASE STUDY



## International outreach

Austrade led an Australian contingent of exhibitors at the 15<sup>th</sup> International Hydrogen and Fuel Cell Expo in Tokyo from 28 February to 2 March 2019. This event was the first activity delivered under the Kickstarter Project for coordinated international outreach and promotion as part of the national hydrogen strategy.

Trade and Investment Queensland (TIQ) represented the state at the expo which attracted over 60,000 visitors over three days. The expo showcased over 250 hydrogen and fuel cell exhibitors, as well as a full conference program featuring a keynote session on Roadmaps for Hydrogen Societies. TIQ - Japan office, regularly monitor and attend events to build relationships in this growing sector. The International Hydrogen and Fuel Cell Expo will be held in Tokyo again next year.



Facilitating private  
sector investment

## 2. Facilitating private sector investment

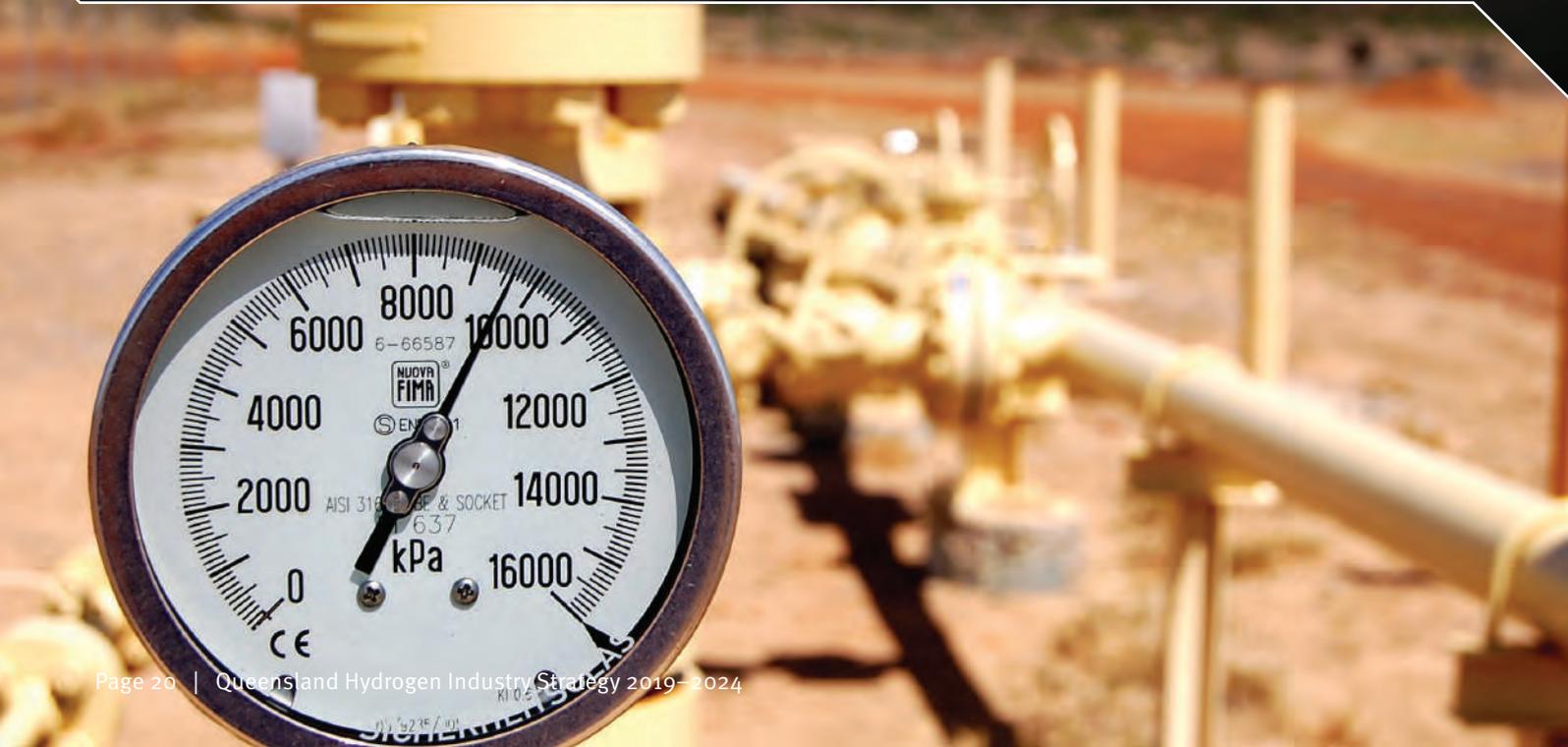
Private sector investment is integral to the growth of the Queensland economy and enables us to create sustainable jobs. As an emerging technology, additional support to deliver hydrogen projects in Queensland may be necessary. We are actively supporting existing and new businesses looking to develop hydrogen projects in Queensland. Assistance can include linking technology providers with commercial partners, identifying suitable sites, coordinating and streamlining development assessments and identifying eligible grants and funding programs for proponents.

### Actions being undertaken to facilitate private sector investment:

- 2.1 Prepare an investor toolkit to assist private sector proponents with information on developing projects in Queensland.
- 2.2 Provide project facilitation services, including investment facilitation and the application of the powers of the Coordinator-General, to eligible project proponents.
- 2.3 Promote investment attraction opportunities to international partners through trade missions, international offices, support of inbound delegations, and presence at international hydrogen events.
- 2.4 Support events to link technology providers, research and industry.
- 2.5 Work with research and industry to identify and develop supply chain capability and maximise Queensland's capability in hydrogen projects through opportunity provision.
- 2.6 Deliver the Hydrogen Industry Development Fund to facilitate private sector investment and leverage third party funding.



Image courtesy of Toyota.





Ensuring an effective  
policy framework

### 3. Ensuring an effective policy framework for sustainable development

A policy framework that provides certainty and flexibility is critical to the development of the hydrogen industry and for stimulating private sector investment. Hydrogen is a versatile energy carrier with a range of potential options for storage, transport and use, either directly for energy or conversion to hydrogen derivatives. However, this versatility creates challenges for regulatory frameworks to assess risks and accommodate proposed activities in the planning and development assessment system. The importance of the policy framework was highlighted in the Hydrogen Strategy Group COAG briefing paper *Hydrogen for Australia's future*<sup>xx</sup>, which emphasises the central role of the right policy settings to achieve forecast growth in the hydrogen economy.

The Queensland Government will collaborate with other jurisdictions to create a policy framework that will facilitate development of the hydrogen industry. A number of the work streams for the development of the national hydrogen strategy, including the cross-cutting issues, will assist to manage the risks effectively whilst allowing flexibility for the industry to innovate and grow.

A Queensland Government working group (Hydrogen Inter-departmental Working Group (HIWG)) has been established to coordinate hydrogen-related activities across the responsible departments. The group will support the development of the COAG Energy Council national hydrogen strategy and other national initiatives such as those of Hydrogen Mobility Australia and Standards Australia. The HIWG will seek the technical expertise of researchers and industry and coordinate across government to support the development of an effective policy framework for the sustainable development of the hydrogen industry.

#### Actions being undertaken to ensure an effective policy framework for sustainable development:

- 3.1 Evaluate and monitor Queensland's regulatory environment and undertake reforms required to streamline the safe and sustainable development of the hydrogen industry.
- 3.2 Support the development of the national hydrogen strategy by ensuring sufficient resources are allocated to deliver the State's contribution to the six work streams.
- 3.3 Support national initiatives that will create a regulatory framework that facilitates the safe and sustainable development of the industry, for example standards and certification systems for renewable hydrogen.



Image courtesy of The Linde Group.

## Queensland Government fleet sustainability

Motor vehicle tailpipe emissions make a significant contribution to climate issues, which is why QFleet—the Queensland Government provider of fleet services—is working towards a more environmentally friendly motor fleet.

The QFleet Environmental Strategy, and the QFleet Electric Vehicle Transition Strategy, establishes electric vehicle technology firmly on the government's fleet agenda with the intention of doubling the number of electric vehicles each year for the next four years.

Electric vehicles are building a culture of environmental sustainability and play an important role in our emissions reduction activities.



Building community  
awareness and confidence

## 4. Building community awareness and confidence

Hydrogen is safely produced, stored, transported, and used in large volumes by industry across the world. The COAG Hydrogen Strategy Group report *Hydrogen for Australia's Future*<sup>xxi</sup> states that '...hydrogen produced from fossil fuels.... has been used for many decades for fertiliser production and oil refining, and has an exemplary safety record.' With a continuing commitment to safety, the report states 'There is every reason to think this safety record can be preserved as we scale up the reach of hydrogen into buildings and vehicles...'

Despite the safety record of hydrogen, research undertaken by the University of Queensland found that a number of focus group respondents attributed the word hydrogen with negative elements<sup>xxii</sup>. This, as well as lack of familiarity with hydrogen compared to fuels such as petrol and natural gas, is a major challenge in gaining community confidence in the safe and sustainable use of hydrogen.

Support from the community is essential for the development and growth of the industry. The government is committed to ensuring hydrogen is produced, stored, transported and used safely through proper training, planning and oversight. The opportunities will be taken to work with other jurisdictions and national regulators to ensure nationally consistent standards are in place for the safe and sustainable use of hydrogen.

We will work with the industry to raise awareness about the measures in place for the safe and sustainable use of hydrogen to build community confidence in the use of hydrogen.

### Actions being undertaken to build community awareness and confidence:

- 4.1 Develop and promote hydrogen activities and opportunities in Queensland through communication with the community and attendance at events.
- 4.2 Support demonstration projects that showcase the applications of hydrogen and raise community awareness about the safe and sustainable use of hydrogen.



CSIRO hydrogen demonstration. Image courtesy of CSIRO.

## Queensland Skills Strategy

In 2018, the Queensland Government convened the Future of Work – Skills and Industry Summit demonstrating a strong commitment across business, industry, universities, the training sector, unions and government to ensure Queensland benefits from the opportunities presented by a changing economy.

The summit included a roundtable of industry leaders, followed by a larger session including presentations, a facilitated panel and workshops. Among other key themes, one of the considerations that emerged was the impact of new technologies on industry and skills – an important consideration in developing a future industry such as hydrogen production.

Outcomes from the summit are currently informing the development of a Skills Strategy to ensure Queensland has the skilled population required to attract investment, encourage job creation and take advantage of future economic opportunities.



Facilitating skills  
development for new  
technology

## 5. Facilitating skills development for new technology

A key challenge in growing and sustaining the hydrogen industry is ensuring the workforce is adequately skilled to produce, handle and use hydrogen and its related technologies.

The government makes a significant investment in priority skills through the annual VET investment plan. Investment under the plan is prioritised to those qualifications that provide a pathway to employment and align to skills in demand, based on advice from industry. We are committed to ensuring our investment in skills and training is responsive to the needs of the hydrogen industry as it grows.

The global hydrogen economy is still in its infancy, so there are limited international examples available to assist Queensland to develop its hydrogen industry workforce strategies. Research by US hydrogen company Cavendish Energy LLC<sup>xiii</sup> has sought to establish a breakdown of the occupations that may be required for a hydrogen economy. This work noted that emerging jobs in the hydrogen and fuel cell industries will require a wide range of educational attainment, from workers who will mainly need on-the-job training through to research leaders requiring post-graduate qualifications. The authors also expressed a need for further research to be conducted to enable more accurate forecasts of the scale and distribution of the potential job creation and the resulting need to match education and training provision to meet industry needs.

Queensland, through the Department of Employment, Small Business and Training (DESBT) liaises with national skills committees responsible for the development of skills standards across Australian industries. Of note is the work of Australian Industry Standards (AIS). The AIS Gas Industry Reference Committee, which is responsible for the Gas Training Package, identified in the 2018 skills forecast the emerging needs associated with injection of hydrogen into the gas network<sup>xiv</sup>.

The government will work with industry to understand the industry's training and skills requirements and develop a response that takes account of the national work related to the development of skills standards and training packages.

As a rapidly evolving technology, the government will continue the partnership with industry, to ensure the skills are available to maximise local advanced manufacturing opportunities and job creation. The Manufacturing Skills Working Group will play a key role in supporting this work.

### Actions being undertaken to facilitate skills development for new technology:

- 5.1 Work with industry and the Manufacturing Skills Working Group (MSWG) to identify training and skills required and develop a hydrogen skills plan.
- 5.2 Work with the industry as it develops, to ensure that training and skills programs are responding to the emerging skills required for the manufacture and maintenance of hydrogen technologies.
- 5.3 Ensure regulatory and first responder agencies are aware of emerging hydrogen related uses and equipped with the knowledge and skills to ensure the safe and sustainable development of the industry.

# QUEENSLAND HYDROGEN INDUSTRY STRATEGY ACTIONS

<b>Vision</b>	By 2030, Queensland is at the forefront of renewable hydrogen production in Australia, supplying an established domestic market and export partners with a safe, sustainable and reliable supply of hydrogen.				
<b>Strengths</b>	Abundant sunshine as a renewable energy source	Proximity to Asian export markets	Existing gas pipeline infrastructure and transferable gas industry skills	Access to export ports	Existing commercial energy partnerships
<b>Challenges</b>	Supporting industry to produce and use innovative technologies	Attracting private sector investment to Queensland to grow the industry	Providing a regulatory framework that provides certainty and flexibility	Growing community awareness and acceptance of hydrogen	Ensuring the workforce is adequately skilled to produce, handle and use hydrogen and its related technologies
<b>Focus area 1</b> Supporting innovation	<b>Focus area 2</b> Facilitating private sector investment	<b>Focus area 3</b> Ensuring an effective policy framework for sustainable development	<b>Focus area 4</b> Building community awareness and confidence	<b>Focus area 5</b> Facilitating skills development for new technologies	
<b>ACTIONS</b> <p>1.1 Continue to engage with industry and researchers to understand what is required to foster innovation; and ensure investment programs remain responsive to hydrogen industry development opportunities.</p> <p>1.2 Work with the Australian Government to identify innovative projects that align with the priorities and objectives of the Queensland Government, and assist eligible proponents to access federal funding opportunities such as the ARENA Research and Development Program.</p> <p>1.3 Establish hydrogen as a science and research priority to drive innovation that will support competitive production, storage, transport and use.</p>	<b>ACTIONS</b> <p>2.1 Prepare an investor toolkit to assist private sector proponents with information on developing hydrogen projects in Queensland.</p> <p>2.2 Provide project facilitation services, including investment facilitation and the application of the powers of the Coordinator-General, to eligible project proponents.</p> <p>2.3 Promote investment attraction opportunities to international partners through trade missions, international offices, support of inbound delegations, and presence at international hydrogen events.</p> <p>2.4 Support events to link technology providers, research and industry.</p> <p>2.5 Work with research and industry to identify and develop supply chain capability and maximise Queensland capability in hydrogen projects through opportunity provision.</p> <p>2.6 Deliver the Hydrogen Industry Development Fund to facilitate private sector investment and leverage third party funding.</p>	<b>ACTIONS</b> <p>3.1 Evaluate and monitor Queensland's regulatory environment and undertake reforms required to streamline the safe and sustainable development of the hydrogen industry.</p> <p>3.2 Support the development of the national hydrogen strategy by ensuring sufficient resources are allocated to deliver the State's contribution to the six work streams.</p> <p>3.3 Support national initiatives that will create a regulatory framework that facilitates the safe and sustainable development of the industry e.g. standards, certification systems for renewable hydrogen.</p>	<b>ACTIONS</b> <p>4.1 Develop and promote hydrogen activities and opportunities in Queensland through communication with the community and attendance at events.</p> <p>4.2 Support demonstration projects that showcase the applications of hydrogen and raise community awareness about the safe and sustainable use of hydrogen.</p>	<b>ACTIONS</b> <p>5.1 Work with industry and the Manufacturing Skills Working Group (MSWG) to identify training and skills required and develop a hydrogen skills plan.</p> <p>5.2 Work with the industry as it develops, to ensure that training and skills programs are responding to the emerging skills required for the manufacture and maintenance of hydrogen technologies.</p> <p>5.3 Ensure regulatory and first responder agencies are aware of emerging hydrogen related uses and equipped with the knowledge and skills to ensure the safe and sustainable development of the industry.</p>	

# Implementation and review

Development of the hydrogen industry will depend on the support of researchers and industry and will require the collaboration of many Queensland Government agencies.

The Queensland Government Hydrogen Inter-departmental Working Group, co-chaired by the Department of the Premier and Cabinet, and the Department of State Development, Manufacturing, Infrastructure and Planning, meets regularly to discuss hydrogen activities and ensures our activities are aligned and consistent with industry and community expectations. Delivery of actions under the strategy will be overseen by this group.

## Membership of the working group (as at May 2019) includes:

- Department of the Premier and Cabinet
- Department of State Development, Manufacturing, Infrastructure and Planning
- Department of Employment, Small Business and Training
- Department of Environment and Science
- Department of Innovation, Tourism Industry Development and the Commonwealth Games
- Department of Natural Resources, Mines and Energy
- Department of Transport and Main Roads
- Queensland Treasury
- Trade and Investment Queensland.

Other departments, researchers and industry representatives are invited to attend meetings to discuss issues relevant to their expertise.

Development of a global hydrogen industry will form a significant part of a low-carbon future in many countries and Australian jurisdictions. To prepare for this, the COAG Energy Council will prepare a national hydrogen strategy for consideration in late 2019.

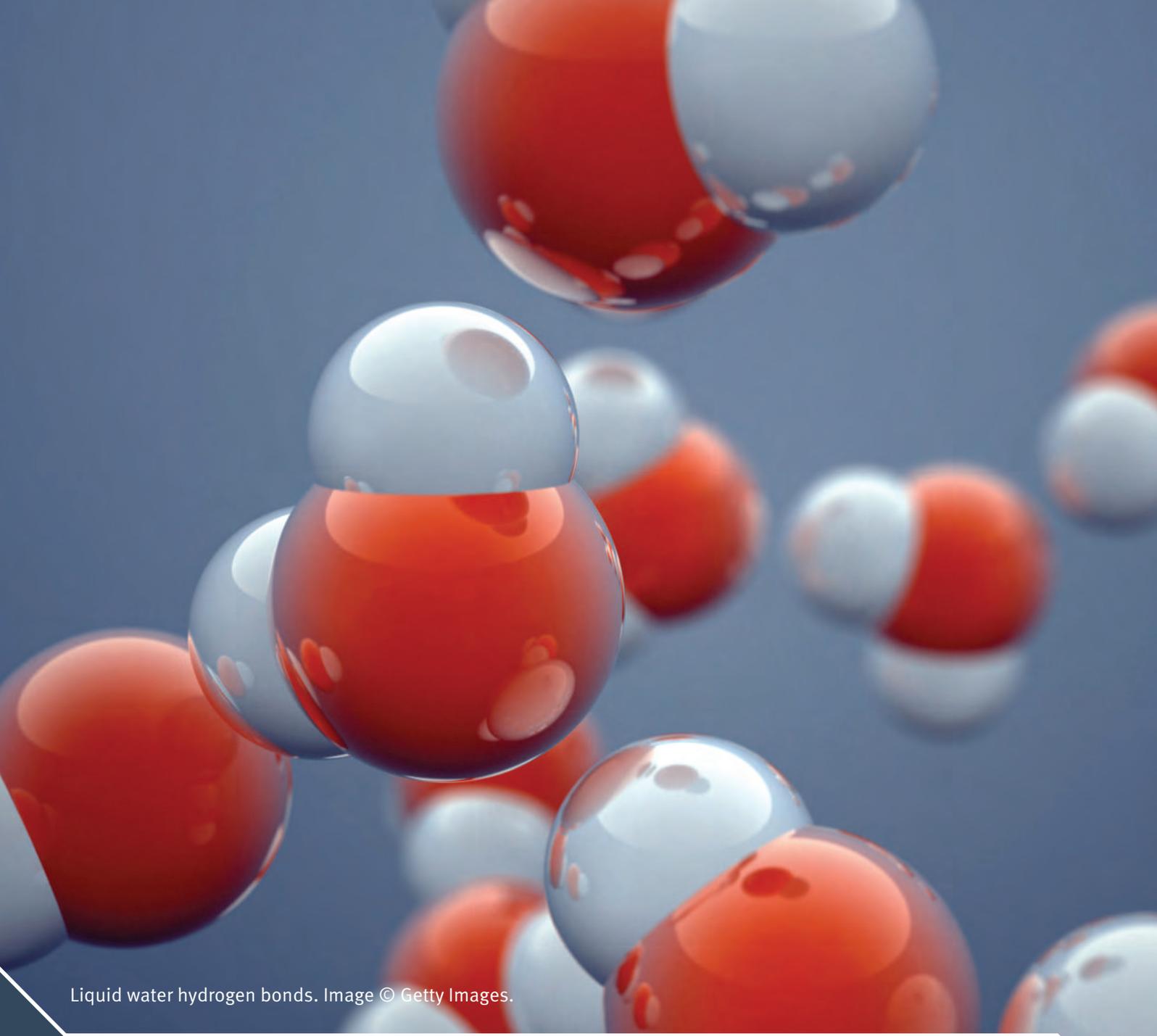
To maintain consistency with national efforts, the Queensland Hydrogen Industry Strategy will be reviewed and updated, if necessary, following the public release of the national hydrogen strategy.



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Liquid water hydrogen bonds. Image © Getty Images.

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