Gas Vision 2050

Hydrogen Innovation Delivering on the Vision

October 2019

Energy Networks Australia

APGA

INNOVATION IN GAS:

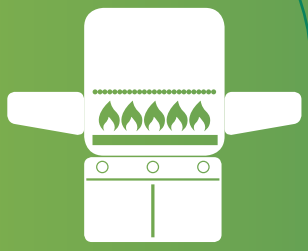
CLEAN, SECURE ENERGY

Hydrogen is the most common element in the universe

1st

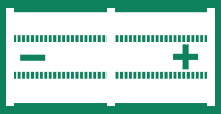
Renewable hydrogen can be created by splitting water into hydrogen and oxygen using renewable electricity

Hydrogen appliances exist today



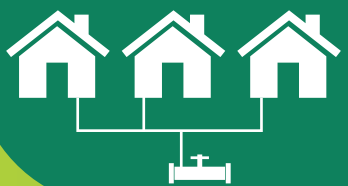
$180 million

committed funding for infrastructure led hydrogen projects



Over **2 MW of electrolysers** producing renewable hydrogen

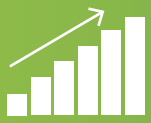
Three projects injecting hydrogen into **gas networks**



Gas networks are growing by over

100,000

connections per year



Australian states and territories with innovative projects underway

Foreword

Two years ago, Energy Networks Australia and our industry partners launched Gas Vision 2050 – a vision that describes how transformational technologies can be deployed to achieve reliable, secure energy and cost-effective carbon reductions from gaseous fuel use.

Since then, industry has invested in research and development, policy analysis and pilot projects to demonstrate these new technologies, with a focus on the role of hydrogen.

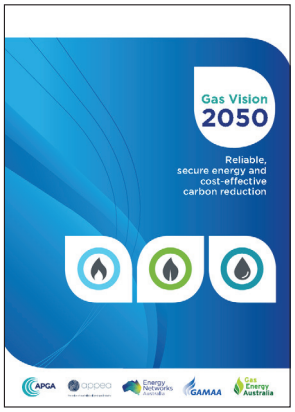
Our plan is to demonstrate the viability of these technologies by the mid-2020s and then start reducing emissions in individual networks, with the objective of full conversion across the country to zero emissions gas in the longer term.

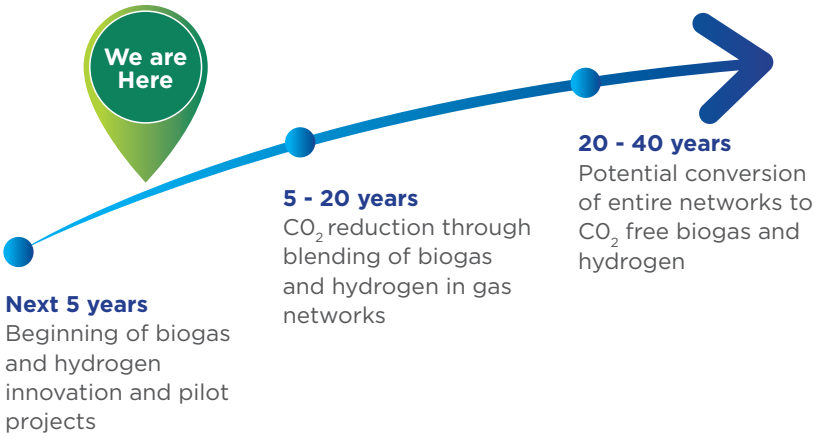
More than 70 per cent of Australian homes are connected to gas, either through a network connection or from gas in cylinders. Gas network connections are growing by more than 100,000 a year. The infrastructure that provides gas to homes for cooking, heating and hot water will continue to provide gas for many decades to come. A unique feature of this infrastructure is that it can supply high levels of energy when needed to ensure customers can access gas for heating and hot water during the colder winter months.

In the future, the energy supplied by gas will need to be decarbonised. There is global momentum to reduce emissions from electricity with renewable generation technologies and there is growing recognition that the energy supplied by gas networks cannot be practically electrified.

Gas businesses are undertaking innovative projects to ensure they are ready to take advantage of current and future decarbonisation opportunities. The innovation includes research and development, hydrogen production and use technologies and studies to demonstrate the full conversion to hydrogen.

Producing renewable hydrogen is already being demonstrated in Canberra and Perth, and by early-2020, two more projects – in Adelaide and western Sydney – will come online. Across these projects, more than 2 MW of hydrogen production capacity will be installed that can deliver renewable hydrogen. Supporting research and development can produce new technologies to further lower the cost of hydrogen production and accelerate the transition to hydrogen. The technical learning and social engagement from these projects will lead to larger scale projects aimed at injecting renewable gas into networks and delivering cleaner gas to our customers. Through these activities, it is expected that the cost of hydrogen will be competitive with natural gas within the next five to 10 years.





Industry and government investment in the past two years has exceeded $180 million with new projects announced regularly.

The Australian Government is preparing a National Hydrogen Strategy that will position Australia to leverage our competitive advantage in hydrogen production to grow domestic consumption and export markets. This strategy may provide a boost to the domestic hydrogen industry, but we are not waiting and will continue to push ahead with investment in innovation.

The next few years of development are crucial if Australia is to have a world-leading hydrogen industry.

This report provides an overview of industry-led innovation delivering customer outcomes with a focus on hydrogen technologies. The successful completion of these projects will shape the next steps in Australia's gas decarbonisation journey.

This is an exciting time for the gas industry and we look forward to continuing on this journey.

Andrew Dillon

CEO
Energy Networks Australia

Steve Davies

CEO
Australian Pipelines and Gas Association

Why hydrogen?

Hydrogen is not a new, magical substance. It is the most prominent element in the universe and most materials on earth contain hydrogen. Its use as a fuel has also been established. As the International Energy Agency reports, there has been waves of hydrogen development in recent history mainly linked to the price of oil and concern about climate change[1].

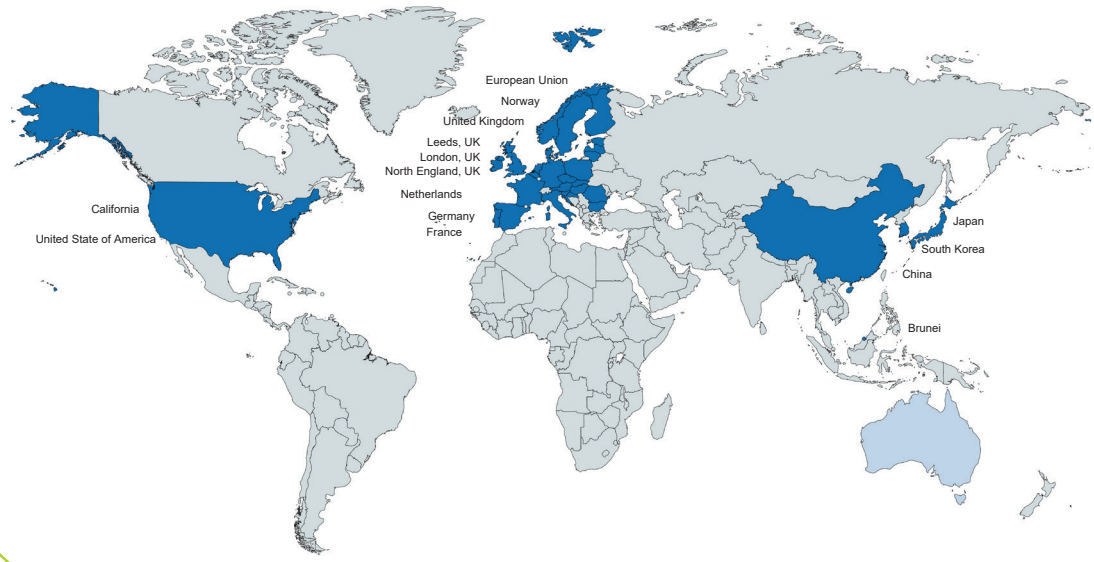
But this time the momentum is different and at a much grander scale. Hydrogen is being pursued by many countries and businesses as an opportunity to reduce greenhouse gas emissions from energy and to create new energy businesses. The Hydrogen Council[2] recently announced that it had 60 global member companies, many of which are multinationals including a wide range of energy and infrastructure businesses. Numerous countries have also established their own hydrogen strategies as recently summarised[3] by the Future Fuels CRC. The reason most often cited for pursuing hydrogen is to reduce greenhouse gas emissions across many sectors including mobility, industry, electricity and heat.

Like natural gas, hydrogen is an odourless and colourless gas that burns with air to provide heat. This heat can be used in many applications. Hydrogen can also be reacted in a fuel-cell to produce both heat and electricity. A major advantage of hydrogen is that it provides this energy without releasing greenhouse gases.

There are several commercial pathways to produce hydrogen and new avenues also being developed. Electrolysis can be used to produce hydrogen by splitting water into hydrogen and oxygen using electricity. With the application of renewables, the hydrogen produced does not have any greenhouse emissions and is a renewable gas.

Electrolysers can act as flexible demand that can be paired with intermittent wind and solar to take advantage of excess renewable generation, providing value to renewable generation as well as hydrogen production and use sectors. As the renewable generation sector expands, the opportunity for large scale renewable hydrogen production grows with it.

Figure 1: Hydrogen strategies covered in the report (Source: Future Fuels CRC, 2019)

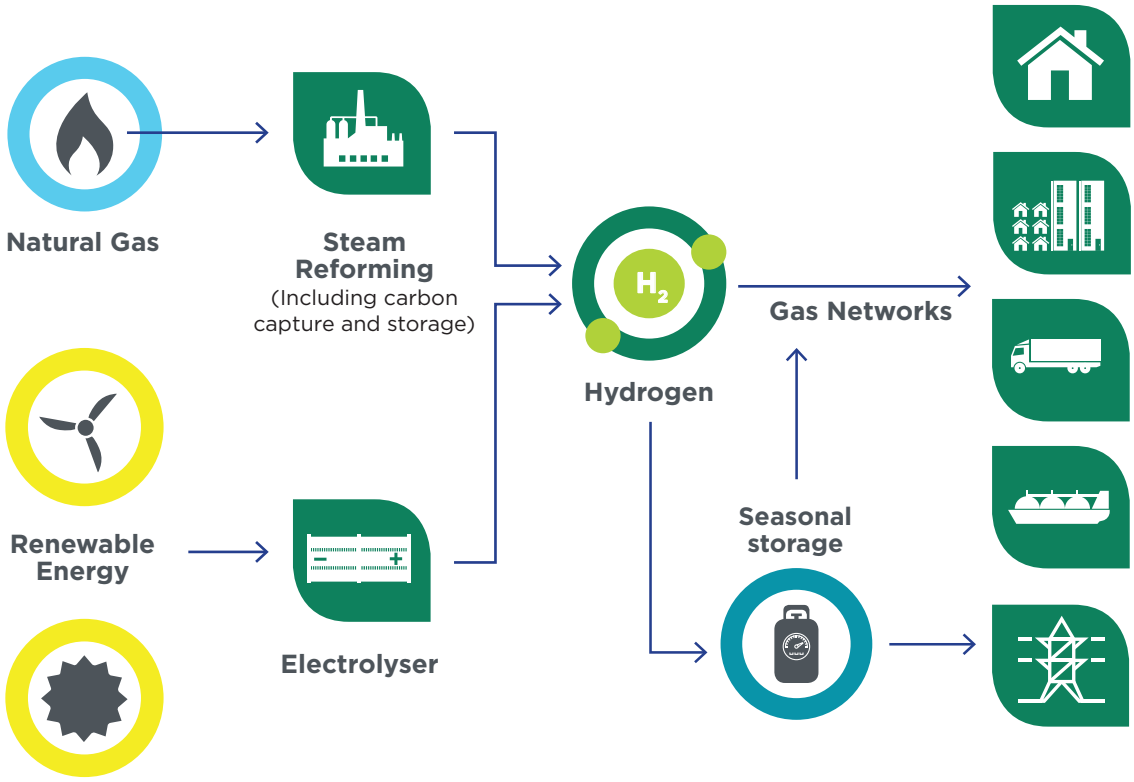


1 International Energy Agency (2019), *The Future of Hydrogen*

2 Hydrogen Council, http://hydrogencouncil.com

3 Future Fuels CRC (2019), *Advancing Hydrogen: Learning from 19 plans to advance hydrogen across the globe.*

Figure 2: Hydrogen production pathways.



Equally when natural gas is used to produce hydrogen, the greenhouse gas by-product can be captured and geologically stored, resulting in a similarly clean fuel.

Hydrogen offers an opportunity to reduce emissions from various applications such as industrial use, passenger vehicles, household appliances and can even cultivate a new export sector. Hydrogen produced via renewables also provides a new source of gaseous fuel that can be used to supplement tightening domestic gas supplies.

Realising the potential of hydrogen will require collaboration between industry, government and academia. Hydrogen creates opportunities across many sectors of the economy, although there are also several challenges to be resolved. Innovation will lead to cost reductions in the production and utilisation of hydrogen.

It is important to remember that innovation will only prepare the technology and infrastructure. Customer engagement is equally important for hydrogen to be adopted as a successful energy source. Many of the innovation project teams are actively engaged with their local communities to ensure customers are part of the journey.

This brochure summarises the range of innovation projects led by the gas network and pipeline sector.

Project Summary

ATCO

Project	Location	Page
Clean Energy Innovation Hub	Jandakot, WA	6

Australian Gas Infrastructure Group

Project	Location	Page
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evoenergy

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Jemena
bringing energy to life

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FUTURE FUELS CRC

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Woodside

MONASH University

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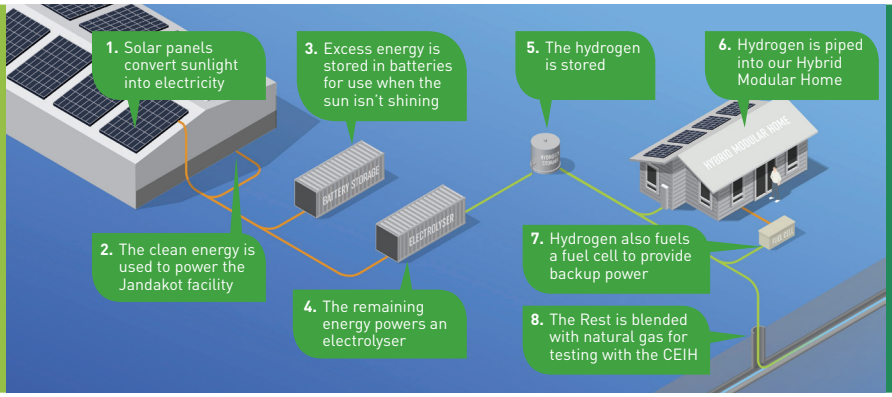
Network injection
Renewable
Appliance trial
Engagement
R&D
Regulation
FCAS
Export
Mobility (Vehicles)

Clean Energy Innovation Hub



Principal Company
ATCO

Project Timeline
July 2018 to June 2021

Location
Jandakot, Western Australia

Funding
» $2.2 million – ATCO
» $1.7 million – ARENA

Stakeholders
» ATCO
» ARENA

Milestones
» July 2019 – Commissioning complete
» October 2019 – Testing began
» June 2021 – Testing finalised

Project purpose

To investigate the potential role of hydrogen in the future energy mix by developing and utilising an industry-leading research facility.

Testing will be conducted on microgrids enabled by renewable gas technology and on the integration of renewable gas with solar and batteries.

Description of project

An Australian first that integrates renewable hydrogen production plus fuel cell technology with a renewable energy stand-alone power system in a "living lab" microgrid setup.

1003 solar panels will produce renewable energy to operate ATCO's Jandakot operations centre. Excess renewable energy generated from 300kW of rooftop solar PV is used to produce renewable hydrogen through a 260kVA electrolyser. Excess renewable energy is also stored for non-sunshine hours usage in 480kWh of onsite battery storage.

The pure hydrogen is stored in a high-pressure storage vessel and is then either distributed within the microgrid as a blended fuel for normal consumption or used as a direct fuel for testing as well as for back-up power to a residential display home.

Testing

Appliance Testing

- How appliances operate on a wide range of hydrogen and gas blends.
- Controlled validation of test results in ATCO's hybrid home to demonstrate installations are fundamentally safe.

Materials or construction are suitable

- Leakage rates – small releases, large releases and ignition potential.
- Performance tests to ensure hydrogen system components operate within the specification limits of appliances.
- Analysis to determine whether the materials and parts used in appliances such as burner fittings and pipes are optimal for hydrogen use.

The project has produced seamless integration of hydrogen production and renewable electricity generation.

Hydrogen Park South Australia

Principal Company
Australian Gas Infrastructure Group

Project Timeline
Q1 2018 to Q2 2025

Location
Tonsley Innovation District in South Australia

Funding
- $6.5 million – Australian Gas Infrastructure Group, Australian Gas Networks
- $4.9 million – SA Government Renewable Technology Fund

Stakeholders
- Australian Gas Networks
- GPA Engineering
- Valmec

Milestones
- Q1 2018 – Project funding agreed with the South Australian Government
- Q4 2018 – Electrolyser purchased
- Q3 2019 – Community engagement with the customers who will receive the blended 5 per cent renewable gas
- Q4 2019 – Construction commences
- Q2 2020 – Commissioning
- June 2020 – Commercial Operation Date

Project purpose

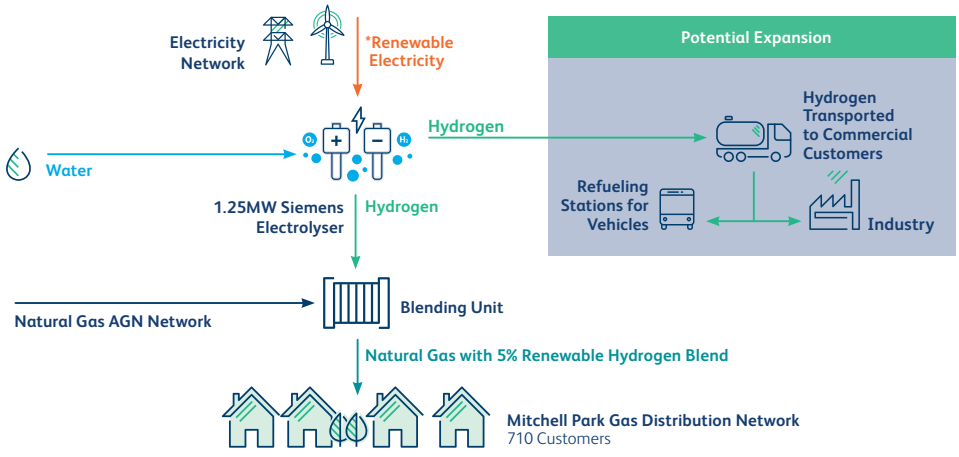
To remove carbon from our gas supply as Australia works towards carbon dioxide reduction of between 26 to 28 per cent below 2005 levels by 2030 and South Australia works towards net zero emissions by 2050. Hydrogen Park SA will demonstrate how we can produce and use hydrogen as a carbon-free source of energy in an Australian context. It will also show how the gas network can couple with the electricity network and respond quickly to excess renewable power generation by converting it to hydrogen and using or storing it in our gas distribution network.

Description of project

Hydrogen Park SA will be Australia's largest renewable gas project and the first to blend hydrogen with natural gas for supply to customers using the existing gas network. Renewable hydrogen will be produced using a 1.25MW electrolyser and will be blended with natural gas and supplied to more than 700 nearby homes and businesses via the existing gas network. The facility will also include a small vessel for hydrogen storage and a unit for blending with natural gas.

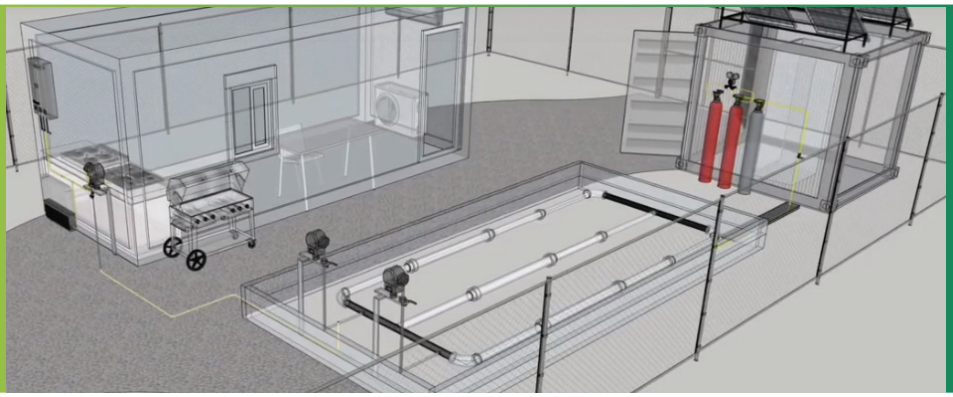
Customers receiving a 5 per cent renewable gas blend will not notice any difference to the quality of their gas supply and it will be the same price as 100 per cent natural gas. Planning is underway for transport facilities enabling hydrogen to be supplied to industry and refuelling stations as well as for the Australian Hydrogen Centre, which will provide education services and facilitate project work to underpin similar developments around Australia.

A dedicated customer and stakeholder engagement program was initiated in July 2019 which will continue for the life of the project. Learnings from the project will be shared with the public through the Australian Hydrogen Centre. The project has received Development Approval from the South Australian Government, with lead items already procured and construction commencing at site soon. Hydrogen production will commence mid-2020.



*AGN will purchase (and voluntarily surrender) Large-Scale Generation Certificates (LGCs) to offset the amount of electricity and ensure the 5% hydrogen supplied to customers is renewable.

Hydrogen Test Facility – ACT Gas Network



Principal Company
Evoenergy

Project Timeline
» September 2018 to August 2020

Location
» Canberra Institute of Technology, Fyshwick Campus, ACT

Funding
» $240,000 – Evoenergy
» $60,000 in kind – Australia National University and Canberra Institute of Technology

Stakeholders
» Evoenergy
» Zinfra
» Australian National University
» Canberra Institute of Technology

Milestones or Actions addressed
» September 2018 - Construction commenced
» December 2018 - Site commissioned, first hydrogen electrolysis to simulated network
» June 2019 - Phase one primarily completed
» September 2019 – phase 2 to commence in October 2019
» December 2019 – commence workmanship testing

Project purpose

To test ACT distribution pipes, joints and other components' functionality and integrity, including work practices, on 100 per cent hydrogen and hydrogen natural gas mixtures. To test hydrogen production from renewable energy in the ACT and storage including the ability to test the operation of small gas appliances on hydrogen or hydrogen mixtures.

Description of project

This project comprises of a test facility which incorporates an electrolyser producing renewable hydrogen using solar panels, a small replica network, representative customer piping, storage for hydrogen and a small replica distribution network.

The replica network is made from polyethylene and nylon pipes, valves and various joints and fittings in a sand box supported by meters and regulators at the outlets.

Renewable hydrogen will flow through the replica network and into a customer piping setup connected to various appliances including an instantaneous hot water system and a four-burner cooktop.

Approach

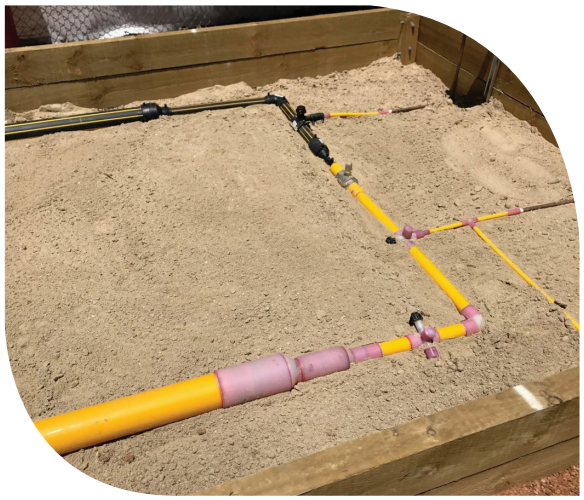
- Phase one of the project will test the distribution piping and valves on 100 per cent hydrogen pressure hold and check for leakage.
- Phase one also focusses on the broader Safety Management System for gas networks to test its adaptability to hydrogen.

Phase two will test the distribution piping, regulators, meters and customer piping with different blends of renewable hydrogen and natural gas to gauge how the equipment performs on different blends.

Results

- Minor leaks were found on some screwed fittings and were rectified on re-assembly.
- Pressure hold was tested for three months from April to June 2019 to determine how the piping and valves responded to hydrogen and whether repairs were required.

The existing gas network Safety Management System is readily adaptable to hydrogen.



Western Sydney Green Gas Project

Principal Company
Jemena

Project Timeline
October 2018 to late 2020

Location
Western Sydney

Funding
» $7.5m – Jemena
» $7.5m – ARENA

Stakeholders
» ARENA
» Endeavour Energy
» Energy Networks Australia
» Gas Users
» JGN Customer Council
» Local Community
» NSW Government
» Retailers
» The Australian Hydrogen Council

Milestones
» August 2018 - ARENA funding secured.
» October 2018 - Project launched with Fed Gov support.
» August 2019 - Order placed for first NSW electrolyser
» September 2019 - Community consultation and engagement
» August 2020 - Electrolyser installation and commissioning
» Late 2020 - Green gas to customers.

Project purpose

Customers have told Jemena they want to utilise green gas for manufacturing, heating, cooking and hot water. The Western Sydney Green Gas project has the potential to deliver renewably generated hydrogen to more than 1.4 million customers

Jemena's Western Sydney Green Gas project is the most comprehensive hydrogen trial in Australia. In partnership with the Australian Renewable Energy Agency (ARENA), the $15 million trial will test three distinct areas:

- Renewable energy generation
- Safe storage of hydrogen and natural gas blended together in existing infrastructure
- Production of hydrogen for low emission transport.

Commenced in 2018, the New South Wales project will enable green gas utilisation by large industrials, business and residential customers.

The project supports the NSW Government's objective of net zero emissions by 2050 and Gas Vision 2050.

Description of project

The Western Sydney Green Gas Project will test three distinct areas:

- **Storage** - Hydrogen will be stored in Australia's largest gas network - the Jemena Gas Network in NSW.
- **Renewable energy** - Solar and wind energy to be utilised to power the electrolyser and generate hydrogen.
- **Transport** - Hydrogen will be made available for mobility, including transport and vehicle industries.

Key Features

- **NSW first** - Jemena has purchased the first electrolyser to be installed in New South Wales. The 500kw electrolyser can initially generate enough power for 250 homes.
- **Scalability** - The Western Sydney Green Gas project will start small, with the potential to support the entire 1.4 million customers in the NSW gas network plus customers in interstate networks.

Approach

Excess renewable energy from the grid or behind the meter solar will be used to power an onsite electrolyser which splits water into oxygen and hydrogen. The hydrogen will be captured, injected and blended with natural gas in the existing Jemena Gas Network. The water will be supplied by onsite rainwater tanks and potable water with a daily consumption of about twice the average Sydney household.

Approximately 2 per cent hydrogen will initially be blended with natural gas to power homes, businesses and industry, with a view to increasing the blend in future.

Future Fuels Cooperative Research Centre

Project Timeline
July 2018 – June 2025

Location
National

Funding
- $45 million – Commonwealth CRC Program and program participants
- In-kind contributions of $47.5 million from participant universities and industry over its seven-year life

Stakeholders

Industry
- Australian Pipelines and Gas Association Ltd
- Energy Networks Australia Ltd
- Gas Appliance Manufacturers Association of Australia
- Australian Gas Networks
- Jemena

Government
- Energy Safe Victoria
- Department for Energy and Mining, South Australia

Research Organisations
- The University of Melbourne
- The University of Queensland
- The University of Adelaide
- The University of Wollongong
- Royal Melbourne Institute of Technology
- Deakin University

Project purpose
- Future Fuels CRC will provide enabling research and development to transition energy infrastructure to a low-carbon economy using fuels such as hydrogen and biogas.
- It will develop transition pathways for existing infrastructure and equipment to transport and use these new fuels today and well into the future.
- The outcomes from FFCRC research will help de-risk the gas industry's trajectory to transitioning to low carbon fuels.

Description of project
- A CRC is an industry-led collaboration between industry, researchers and the Commonwealth.
- Future Fuels CRC funding was announced on 12 April 2018.
- The work of the CRC will be delivered through three programs and will also provide education and training through delivering 48 PhDs and 1000 contact hours of industry training and seminars each year.

Future Fuels Technologies, Systems and Markets – Research Program 1
- **Research Program 1** focuses on the understanding of the technical, commercial and market barriers to, and opportunities for, the use of hydrogen.

Social Acceptance, Security of Supply and Public Safety – Research Program 2
- **Research Program 2** studies the social and policy context, including public acceptance and safety, for technology and infrastructure associated with hydrogen.

Network Lifecycle Management – Research Program 3
- **Research Program 3** identifies and addresses gaps in relevant Australian industry codes and standards associated with design, construction and operation of gas networks.

Future Fuels Cooperative Research Centre Research Programs

Future Fuels Technologies, Systems and Markets

- Developing techno-economic models of hydrogen production processes and supply chains to identify major technical or cost hurdles to the commercial uptake of hydrogen.
- Developing network models that incorporate current plans for Australia's energy market and options for sector coupling with the electricity system in order to generate change at the lowest total cost to consumers.
- Research on the properties of hydrogen-methane mixtures to determine how they will impact residential, commercial and industrial customers, including a comprehensive appliance test program to determine if appliances can operate on natural gas with a 10 per cent hydrogen blend.

Social Acceptance, Security of Supply and Public Safety

- Research to assist industry and government to understand and address community-based issues and develop appropriate engagement solutions around hydrogen infrastructure projects.
- Research focused on regulatory best practice in other jurisdictions and adapting these regulations to the Australian environment.

Network Lifecycle Management

- Research is underway to provide knowledge on long term pipe and weld material performance with hydrogen.
- Research into release rates and dispersion characteristics of various hydrogen-methane blends after a rupture or venting operation.

Results

The first research report reviewing global strategies on hydrogen was delivered in July 2019. This report has been widely disseminated and gained significant traction highlighting the global support for hydrogen developments. This report demonstrated the capability and professionalism of FFCRC.

	Hydrogen production for export	H_2 in gas networks	Hydrogen for industrial heat	Hydrogen for household heating	H_2 for heavy vehicles	H_2 for passenger vehicles	H_2 for electricity generation	H_2 for industrial feedstocks
Brunei	■							
China	■				■	■		
European Union		■	■	■	■		■	■
France					■			■
Germany		■		■			■	
Japan					■	■	■	
Netherlands		■		■				
Norway	■				■	■		
Republic of Korea		■			■	■	■	
United Kingdom		■	■	■	■	■		
USA					■	■	■	

■ Primary hydrogen end-uses inferred from the country strategies. Note: simplified summary adapted to advance hydrogen from across the globe", Future Fuels CRC.

Woodside Monash Energy Partnership

Principal Company
Woodside Energy

Project Timeline
Multi-year partnership commenced 2019.

Construction of the Woodside Building for Technology and Design is due to be completed in 2020.

Location
» Monash University, Clayton Campus

Funding
» $40 million joint investment with Monash University
» $16.5 million towards the construction of the new Technology and Design Building

Stakeholders
» Woodside Energy
» Monash University

Project purpose

Announced in July 2019, the Woodside Monash Energy Partnership is an ambitious, multi-year partnership for research facilities and programs that will support Australia's low-carbon energy transition.

Description of project

Australia is a significant energy exporter today and future energy exports is the focus of the partnership, recognising that these solutions should also deliver competitive energy for domestic use. The partnership is anchored in the following research themes:

1. **Energy Leadership**
   - Understanding the interplay of economics, energy security, policy and governance on the transitioning energy system, including carbon markets.
2. **Energy Futures**
   - New Energy Technologies: Developing high-efficiency and low-cost solutions to generate, store, and export hydrogen and its carriers.
   - Carbon Capture, Conversion & Utilisation: Developing commercially sustainable solutions that reduce atmospheric carbon dioxide emissions through chemical, thermal, and biological approaches.

Each project will have a clear connection to the overall research themes, supported by project-specific outcomes and milestones.

The Woodside Technology and Design Building, which is currently under construction at Monash University, will provide a living laboratory environment to support research activities and the training of future energy leaders. You can view live construction progress at **www.monash.edu/it/woodside-building.**

These activities align with Monash University's commitment to achieve net-zero emissions by 2030.

Approach

The partnership will create an innovation culture that places the Woodside Monash Energy Partnership as a leader in national and international research within the affordable hydrogen and profitable carbon fields. This primary partnership will be leveraged to create additional Australian and international partnerships with academic institutions, industry, and government agencies.

Research projects will be identified and delivered through mechanisms ranging from short duration sprints to multi-year projects, with pilot scale demonstrations envisaged to lead into commercialisation.

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