WATER SERVICES
ASSOCIATION OF AUSTRALIA

WATER

FUELLING THE PATH TO A HYDROGEN FUTURE

THE ROLE OF THE URBAN WATER INDUSTRY IN AUSTRALIA AND NEW ZEALAND'S RENEWABLE ENERGY FUTURE

Water
Fuelling the path to a hydrogen future

The role of the urban water industry in Australia and New Zealand's renewable energy future

November 2021

Water Services Association of Australia (WSAA) is the peak industry body representing the urban water industry. Our members provide water and sewerage services to over 24 million customers in Australia and New Zealand and many of Australia's largest industrial and commercial enterprises.

Contents

Traditional Custodians acknowledgement

WSAA acknowledges and pays respect to the past, present and future Traditional Custodians and Elders of this nation. We recognise their continuing connection to land and waters and thank them for protecting our waterways and environment since time immemorial.

Acknowledgements

This report is a synthesis of many other studies, reports, and presentations from a multitude of sources. The published information is acknowledged in the references and bibliography sections. We recommend these as sources for further technical or policy information. We also want to acknowledge the many people who have either contributed significantly to knowledge and/or the writing of this report. We appreciate their time and effort, with specific mention to Francis Pamminger and Simon Prunster from Yarra Valley Water for their considerable dedication in working with the team to deliver an urban water industry perspective on Hydrogen. WSAA also appreciates the time and contributions of the steering committee members in helping to shape and guide the development of this paper. This paper was developed in partnership with expert input from Aurecon.

More information

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A hydrogen revolution is gathering pace, with governments and industry bodies announcing a plethora of new hydrogen projects, strategies and policy frameworks.

In the wake of the IPCC Assessment Report 6 and the COP26 global climate conference, the world is fast pivoting towards new, non-fossil-fuel dependent energy sources.

But what does this mean for urban water? Does our industry know enough, or are unanswered questions holding us back? At this crucial point in time, this paper outlines the basics of hydrogen for the urban water industry, answers some key emerging questions, and points to questions that warrant exploration in the years ahead.

The path to thinking about water in a hydrogen future

Why is the urban water industry exploring hydrogen?

Our industry manages the primary source for hydrogen production – water. The need for our input and perspective on hydrogen is key to facilitate and create awareness on the role of our industry to sustain ongoing hydrogen developments.

Australia and New Zealand need to decarbonise fuel sources to meet globally agreed climate change targets. Green hydrogen is a potential game changer to meet emission targets.

Australia is looking to be a powerhouse exporter of green hydrogen as a clean fuel that can be produced and used with zero emissions, with the capability to store and transport it as an energy source.

Recognize the commitment of our industry to foster the circular economy for a decarbonisation transition and collaborative culture to work with other sectors who will benefit from a hydrogen future.

What is hydrogen all about and how does it impact the urban water industry?

$1.2bn

Australia's National Hydrogen Strategy notes increasing global investment to make clean hydrogen the next energy export. The federal government is investing $1.2 billion in the hydrogen industry, with ARENA committing over $103 million for commercial-scale projects.

Rapidly advancing policy and strategy require the urban water industry to be prepared and to better inform decision-making on developing the hydrogen economy.

A fundamental role for our industry is ensuring a balance of supply and demand to not exacerbate water stress, while supporting the decarbonisation of the economy.

260GL/yr

Under a strong growth scenario water consumption for hydrogen production in 2050 would be equivalent to just under the current annual supply for the whole of South East Queensland, at approximately 260GL per year.

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How does the urban water industry help fuel a hydrogen future?

1KG H_2 = 9KG H_2O

Green hydrogen, produced by electrolysis powered by renewable energy, will rely on a stable supply of water. Recycled water presents an excellent opportunity for sustainable use of a valuable resource.

The industry must engage with government and other industry partners to strengthen policy settings and foster collaboration to explore new revenue possibilities and extend value to customers.

H_2 under $2

As an industry we are uniquely positioned based on our capacity for renewable energy generation, recycled water production and strategic land locations to advance H_2 under $2 as a key measure to unlock a hydrogen future.

Successful hydrogen projects will require suitably skilled partners and operators, such as those from the gas and energy industry, in conjunction with favourable site attributes a utility can provide for co-location or hydrogen hub development.

3% suitable

For hydrogen production, 11% of Australia is suitable when considering energy needs only. This is reduced to only 3% when factoring water and transport infrastructure.

The range of participation by the urban water industry will vary based on local conditions, such as type of renewable energy supply and proximity to supporting infrastructure (such as gas distribution networks and transport).

More investigation is needed to fully quantify unlocking potential from valorising by-products, like oxygen from hydrogen production, utilising biomethane from biogas and hydrogen at scale, and complementing recycled water processes.

Key considerations for water utilities to consider for participating in hydrogen developments include emissions commitments, changing community expectations and circular economy aspirations.

Our industry has a legacy built on securing the safe and reliable supply of water with an opportunity to build a new generation's legacy of securing a safe and reliable future by helping to decarbonise the economy.

Executive summary

Hydrogen is a relatively new concept to the urban water industry. Various water utilities are considering or trialling new processes, and forming partnerships for further exploration. This time of discovery provides a unique opportunity for our industry to be able to proactively engage and create awareness about the crucial role we have to play in supporting a hydrogen economy.

A number of different projects are already stretching the horizons of urban water industry innovation and participation, including the Hazer trial on Water Corporation land in Western Australia, using biosolids for gasification at Logan in Queensland, and the Australian Gas Industry Group and Engie producing hydrogen at the North East Water treatment plant in Wodonga to inject into a gas supply main. Jemena and Sydney Water are producing biomethane for supply into the gas distribution system, and Yarra Valley Water are investigating a hydrogen hub at Aurora.

It is against this spectrum of diverse hydrogen projects, that this paper has been written. In particular, to answer the what, why and how questions of hydrogen for the water industry. What is hydrogen? Why all the different projects? And crucially, how can the urban water industry best proceed from here. As the hydrogen economy gathers pace, it is the right time for our industry and its stakeholders to consider the implications for urban water, and share our perspective on supporting expanded hydrogen production.

Hydrogen and its potential role in decarbonising industry and transport is already dominating policy and investment forums, and strategy development at all levels of government. US$300 billion investment in hydrogen is expected globally by 2030. As the peak body for the urban water industry, WSAA seeks to raise awareness of the key issues for our industry in partnering to advance the hydrogen economy. We are grateful for expertise and input from our member utilities, in particular Yarra Valley Water, and from Aurecon.

Hydrogen is experiencing a renaissance in today's era of renewable energy ambition. Where once hydrogen was largely derived from carbon intensive processes, an array of new processes and projects are now spearheading different types of hydrogen with lower carbon impacts. Green hydrogen in particular, from electrolysis using renewable energy, is stimulating new fields of investment and 'hydrogen hubs' around Australia.

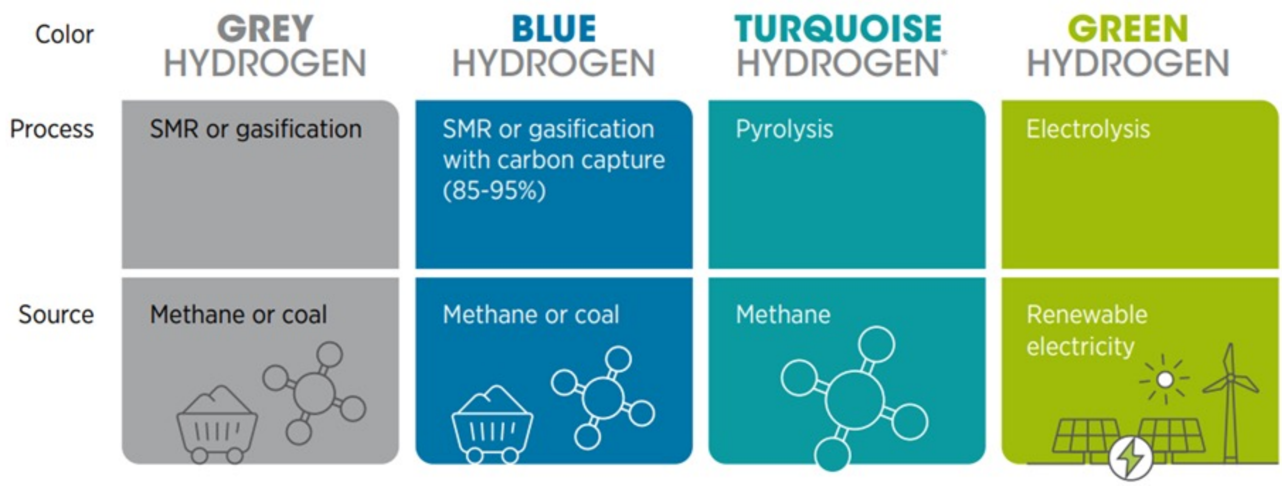
The stakes are high – the International Energy Agency and the global Hydrogen Council have identified Australia as a potential global hydrogen production powerhouse. The Australian Energy Market Commission is outlining economic policy settings for a 'hydrogen superpower' scenario, which could see Australia achieve net zero in the early 2040s, supporting targets to limit warming to 1.5 degrees by 2050.

We are now poised at a crucial point in time as the hydrogen economy gathers scale. The CSIRO's National Hydrogen Roadmap set a stretch goal of 'H_2 under 2' – fostering technical advances and scaling of production systems, to produce green hydrogen for under $2 (Australian dollars) per kilogram. Many of the trials now underway are expected to bring the price down towards this level, where it can compete effectively with fossil-based fuels, thus stimulating the demand that will accelerate the transition away from carbon-heavy sources.

What is hydrogen?

Hydrogen is a colourless, odourless, tasteless, non-toxic and highly combustible gas found in chemical compounds such as water and methane. Hydrogen itself is not harmful to the environment. However, the production methods for producing it can be. It is already used in a wide array of industrial applications including petroleum refining, ammonia and methanol production.

Hydrogen can be produced by steam methane reforming, gasification or electrolysis of water. There are four main colours of hydrogen:



Note: SMR = steam methane reforming.
** Turquoise hydrogen is an emerging decarbonisation option.*

SOURCE IRENA, 2019

What is the hydrogen opportunity for the urban water industry?

Green hydrogen has caught the attention of policy-makers worldwide as it is likely to be a game changer in the transition to renewable energy. It is also the type of hydrogen of most interest to the water industry: while utilities have to carefully plan their water supply to meet consumer needs, many have an abundance of recycled water that with appropriate treatment, could be the ideal feedstock for large-scale hydrogen production. The water requirements for early hydrogen projects may be small, but the demand for water of a suitable quality will grow significantly if projects achieve their planned scale.

Utilities also have treatment plant sites that not only produce recycled water, but may also be able to accommodate production facilities such as electrolysers. These sites may be advantageously placed close to transport, industry and potential users of the hydrogen produced. Hydrogen could have many future uses: to power cars, whether through direct fuelling or fuel-cell batteries; for stationary power or heat generation used for customer properties and/or industrial processes; and blending into the existing gas distribution network as a greener energy source substitute.

There is also a growing strategic synergy between customer and internal expectations for the water industry to adopt circular economy approaches to make full use of all the resources at our disposal. This includes harnessing all elements of the water cycle such as using recycled wastewater and also stormwater for productive purposes.

This paper outlines a key synergy emerging in the Australian context in particular. As the impacts of climate change are felt ever more keenly, with two severe droughts in the last twenty years, the water industry is seeking to consider rainfall-independent sources to supplement its drinking water supplies. This typically involves desalination and purified recycled water, both of which have been adopted in various parts of Australia.

Reverse osmosis is the process often used to treat water across both these sources to meet drinking water standards. Installing reverse osmosis technology is reasonably costly. However, reverse osmosis would also be needed to produce water of a quality suitable for hydrogen production. In addition, many water utilities are being driven towards reverse osmosis due to increasingly stringent environmental regulation limits on their discharges of treated wastewater to waterways.

Thus, there are multiple drivers towards the adoption of reverse osmosis technology, which could enable water utilities to satisfy multiple challenges and objectives. Desalination is sometimes mentioned as key to unlocking sufficient water supplies. But given the mindset shift towards circular economy principles, today's communities may see more appeal in recycling the water that we already have, than taking water from oceans. Even more appealing than the notion of green hydrogen, may be that of green hydrogen from renewable energy and water.

It is a promising scenario to envisage the water utility of the future, harnessing the full potential of its abundance of highly treated recycled water, and treating it further so that it is fit for several valuable purposes either singly or in combination, depending on the weather conditions and demands at the point in time.

This could also mean that the costs are shared across the projects and their beneficiaries, which could help projects pass financial viability thresholds. This is an important consideration as the funding arrangements for any hydrogen projects could be complex. Each project will need to consider who owns the infrastructure to produce the hydrogen; how the hydrogen could be used, such as for internal processes or for export to other sites and customers; what the regulatory treatment should be for this activity, which is somewhat outside the core business of a water utility; and what role could be played by other enhancements or by-products of these processes, for example whether oxygen capture and use in wastewater processing could offset hydrogen production costs. It should also consider the social costs of carbon, and how these externalities can be incorporated into funding frameworks.

There are other aspects that water utilities should start considering as the hydrogen revolution gathers momentum, to be prepared for potential opportunities or demands that may arise. Utilities will already be considering how best to meet their own emissions reduction commitments, and may find a Marginal Abatement Cost Curve a useful tool to explore the contribution hydrogen could make.

Utilities may also have the capacity to produce surplus renewable energy. Even if they do not participate directly in producing hydrogen, they may be able to offer this resource as a valuable input into hydrogen production by others.

As some water utilities consider how they might be called upon to support or participate in the hydrogen economy, and others strive to involve themselves in this exciting new field, there are many important aspects to consider, which this paper outlines. Underpinning all of it is making sure that as an industry, we engage proactively and robustly with our stakeholders, regulators, customers and governments, and explore our potential role as a partner for the hydrogen economy of the future.

Introduction

Hydrogen is today enjoying unprecedented momentum. The world should not miss this unique chance to make hydrogen an important part of our clean and secure energy future

Faith Birol, Executive Director, International Energy Agency

The potential of hydrogen for transitioning to cleaner and more renewable forms of energy is dominating policy debates and investor forums alike. With the rapid acceleration of technological advancements, plus the release of various federal and state government strategies, now is the right time to present a perspective from the urban water industry on how to effectively engage in the hydrogen economy.

Water supply plays a fundamental role in producing hydrogen. As the peak policy body for the urban water industry in Australia and New Zealand, WSAA has developed this paper with technical expertise from Aurecon and member water utilities. The paper outlines key points the urban water industry needs to consider for participation and support of the hydrogen economy, and seeks to raise awareness among other sectors and policy-makers, on how partnering with the urban water industry can advance the hydrogen economy.

Water utilities are already participating across the hydrogen value chain, as illustrated by the existing case studies in this paper. These examples will enable policy-makers, investors and other stakeholders to better understand the relevance and role of our industry, beyond the supply of water alone.

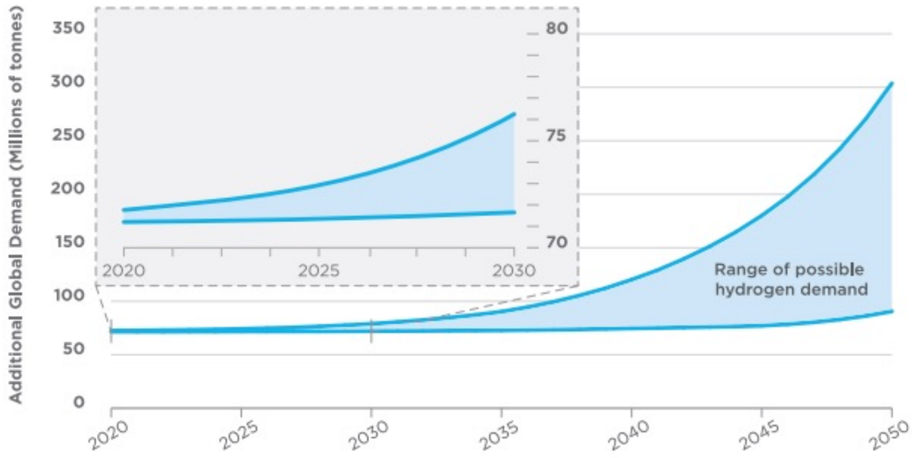
Context of the hydrogen economy in the global marketplace

The 'hydrogen economy' refers to the use of hydrogen as an energy source in transportation and storage, in the form of liquid or gaseous hydrogen. The attractiveness of hydrogen as a fuel is that the only by-product from its use is energy and water – a valuable attribute at a time when we are seeking to decarbonise our fuel sources. As such, when describing its use, it is referred to as a clean fuel.

Hydrogen, however, does not exist by itself in a natural form, and requires energy to separate it out from naturally occurring compounds. Around 98% of current hydrogen is produced using carbon intensive processes.

But this is changing – as the world moves away from carbon fuel sources, towards renewable energy. It is this possibility that is positioning hydrogen as a fuel that can help decarbonise our economy. The forecast growth of hydrogen production over the coming decades (Figure 1) demonstrates the likely acceleration of the hydrogen economy.

FIGURE 1 Range of possible hydrogen demand over the next three decades



SOURCE COAG, 2019

Leading organisations such as the global Hydrogen Council and International Energy Agency are committed to fostering the development of the hydrogen economy as a key element of a clean energy transition, and governments are responding on policy and investment fronts.

In 2021, over 30 countries have released versions of hydrogen roadmaps, and the hydrogen industry has announced more than 400 hydrogen projects globally. These are supported by ambitious investment plans, with more than US$70 billion already committed in public funding from around the world. This momentum exists along the entire value chain and is accelerating cost reductions for hydrogen production, transmission, distribution, retail, and end-use applications within the hydrogen economy.

The Hydrogen Council has estimated total global investment in the hydrogen value chain will exceed US$300 billion by 2030 (ARUP, 2021). A forecast of this magnitude clearly signals the need and opportunity for investment within the hydrogen value chain. It also recognises large-scale hydrogen infrastructure investment as a key enabler for a clean energy transition, to decarbonise industry and the broader economy.

Australian context

The Australian government has identified clean hydrogen as one of Australia's five pathways towards decarbonisation. Australia's vision for a hydrogen future, articulated in the National Hydrogen Strategy (COAG, 2019), highlights that Australia has the resources and the experience to take advantage of increasing global momentum for clean hydrogen, and make it our next energy export. These sentiments are echoed by the International Energy Agency and the World Energy Council, both identifying Australia as a potential hydrogen production powerhouse.

The Australian Energy Market Operator (AEMO, 2021) noted the potential contribution of hydrogen to achieving net zero emissions in the release of its 2021 Inputs, Assumptions and Scenarios Report. This included a progressive 'hydrogen superpower' scenario, which considers a renewable energy system to support the development of a clean hydrogen export economy. This scenario would enable Australia to achieve net zero by the early 2040s, and is linked with targets to limit warming to 1.5ºC by 2050.

The science underpinning our national strategy was provided by the CSIRO National Hydrogen Roadmap (Bruce et al, 2018). The Roadmap sets the goal of producing hydrogen for A$2 per kilogram, a threshold allowing cost parity and competitiveness with conventional energy sources, that would enable scalable production. The federal government's 2020 Low Emissions Technology Statement also cites 'H_2 under 2' as the priority stretch goal of producing clean hydrogen (see Appendix 1 for further detail).

The New Zealand Government have also recognised the potential for hydrogen production, export, and utilisation. Hydrogen will form part of a wider renewable energy pathway to a clean, green carbon neutral New Zealand by 2050 (New Zealand Hydrogen Council, 2018).

Urban water industry context

Water is increasingly subject to an array of competing demands for supply across industry, commercial and residential uses. These demands are typically driven by population growth, increasing economic activity and the impact of climate change, leading to intensified water stress in regions with already high water supply variability.

Hydrogen production relies on water availability. Consequently, a key consideration as with any water intensive industry, is how to manage water in a sustainable way so that it does not exacerbate water stress, while striving to decarbonise the economy and mitigate the adverse impacts of climate change.

A fundamental role of the urban water industry is ensuring a balance of supply and demand across residential, industry and commercial uses for water. Various climate-resilient water supply options (e.g. recycling of water and desalination) are being planned and developed around Australia and New Zealand, to meet future needs.

With careful long term planning, these solutions can address potential tensions and competing demands for water for hydrogen production.

Early and consistent dialogue and collaboration between the urban water industry and hydrogen industry stakeholders will be key to avoiding potential impacts on water security. Additional to our future energy sources being decarbonised, our water supply also needs to be sustainable. It may not meet contemporary community expectations to use drinking water to produce large amounts of hydrogen, especially for export, when sustainable alternatives such as recycled water are available. The water industry can play a significant role in achieving and indeed balancing all these goals.

What is hydrogen?

Hydrogen is the lightest of all gases: colourless, odourless, tasteless, non-toxic and highly combustible. However, it does not occur by itself. It is almost exclusively found in chemical compounds for example water (H_2O), and methane (CH_4), the main component of natural gas.

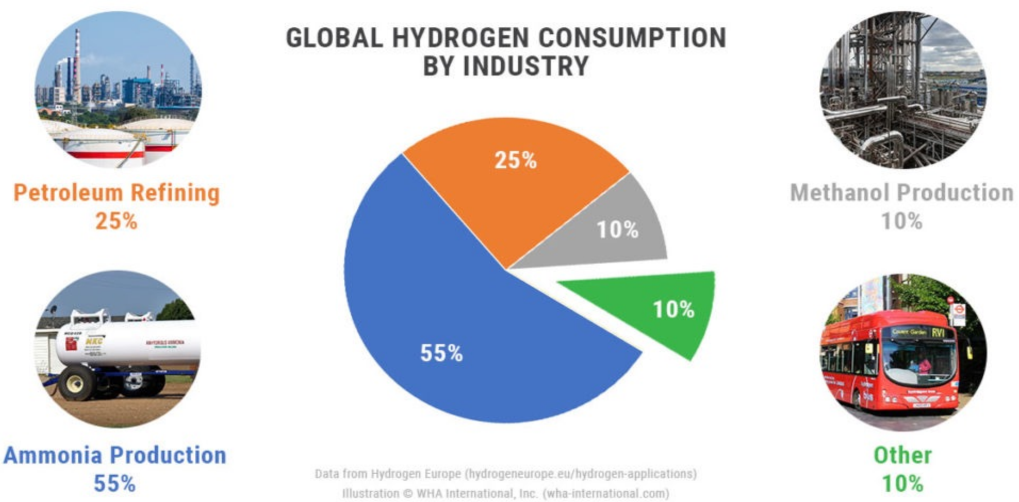
While hydrogen itself is not harmful, the different production methods can involve different levels of carbon emissions with associated environmental impacts.

Interest in hydrogen has fluctuated over time. Lessons learned through the overall rise of renewable energy, and decarbonisation efforts, have assisted the advancement of the hydrogen economy.

Benefits such as the momentum and confidence gained in policy, strategy and regulatory settings for renewable energy, have helped drive stronger investment and accelerated cost reductions for hydrogen

As a result, hydrogen is already being used across the economy (Figure 2). However, the step change for expansion of the hydrogen economy is the emerging need for cleaner production pathways.

FIGURE 2 Figure 2. Existing uses of hydrogen across various industries



SOURCE https://wha-international.com/hydrogen-in-industry/

How is hydrogen produced?

Hydrogen is often referred to as 'clean energy' as the by-products of using hydrogen are energy and water vapour, but not all the production technology and pathways can be labelled 'clean'. There are three main production pathways for hydrogen, with further variations and associated lifecycle emissions. Steam methane reforming and gasification are thermochemical processes which involve chemical reactions and the use of heat. Electrolysis is an electrochemical process (Figure 3).

Steam methane reforming

This is the most common hydrogen production process and uses high-temperature steam. When exposed to steam and heat, the carbon (C) atoms of methane (CH_4) separate. After two successive reactions, they reform separately to produce hydrogen (H_2) and carbon dioxide (CO_2). This operation utilises natural gas as the primary energy source (which is predominantly methane).

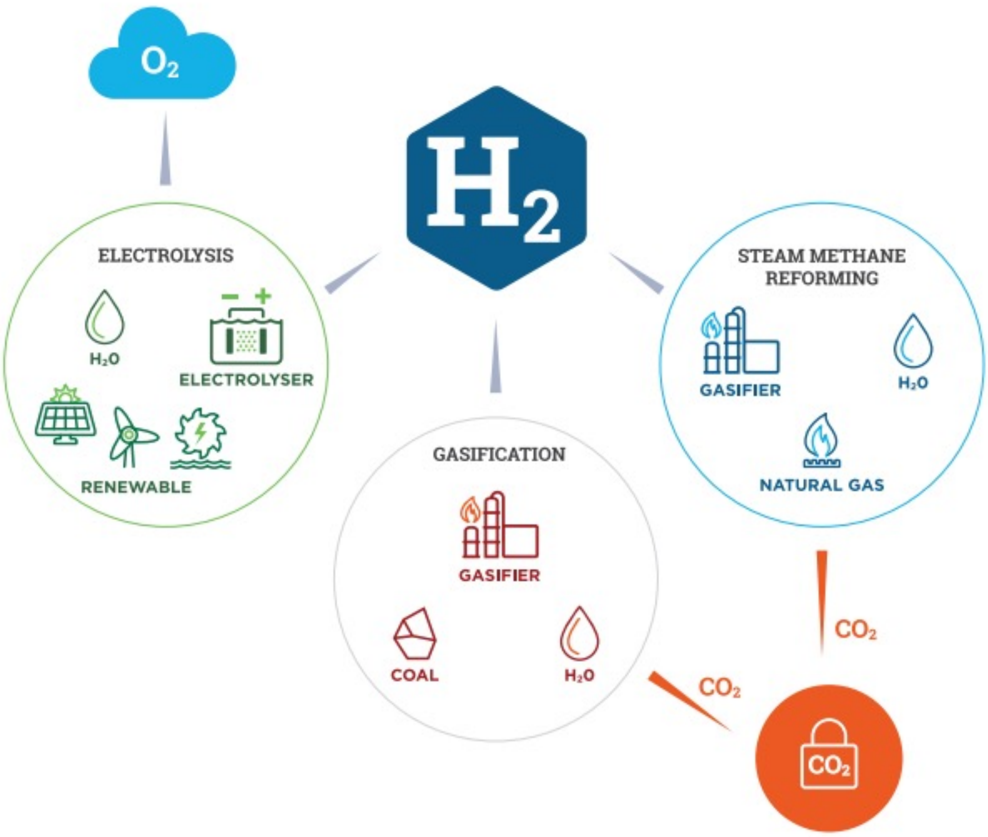
Gasification

This process uses charcoal or biochar which consists mainly of carbon and water. Burned in a reactor at a very high temperature of between 1,200 and 1,500°C, in the absence of oxygen, the charcoal releases gas that separates and reforms to produce hydrogen (H_2) and carbon monoxide (CO).

Electrolysis

Hydrogen can also be produced using electricity, through electrolysis of water. An electric current is used to split water (H_2O) into oxygen (O_2) and hydrogen (H_2).

FIGURE 3 Three different ways of producing hydrogen



SOURCE COAG 2019

Colours of hydrogen

There are four broadly accepted 'colours' of hydrogen, as shown in Figure 4.

Grey hydrogen

A process of steam methane reforming or coal gasification which uses fossil fuels as the main feedstock. This process entails significant carbon dioxide emissions which is an area of increasing concern to governments, businesses and organisations. Grey hydrogen accounts for more than three-quarters of hydrogen currently produced from natural gas.

Blue hydrogen

The same feedstock and process as grey hydrogen, but the carbon dioxide emissions are reduced through carbon capture and storage. This lowers greenhouse gases emissions by up to 85 to 95% (H-Vision, 2019) but does not eliminate them completely. A major drawback of blue hydrogen is its dependency on finite fossil energy resources, which has existing concerns surrounding energy security and volatility of market prices for natural gas.

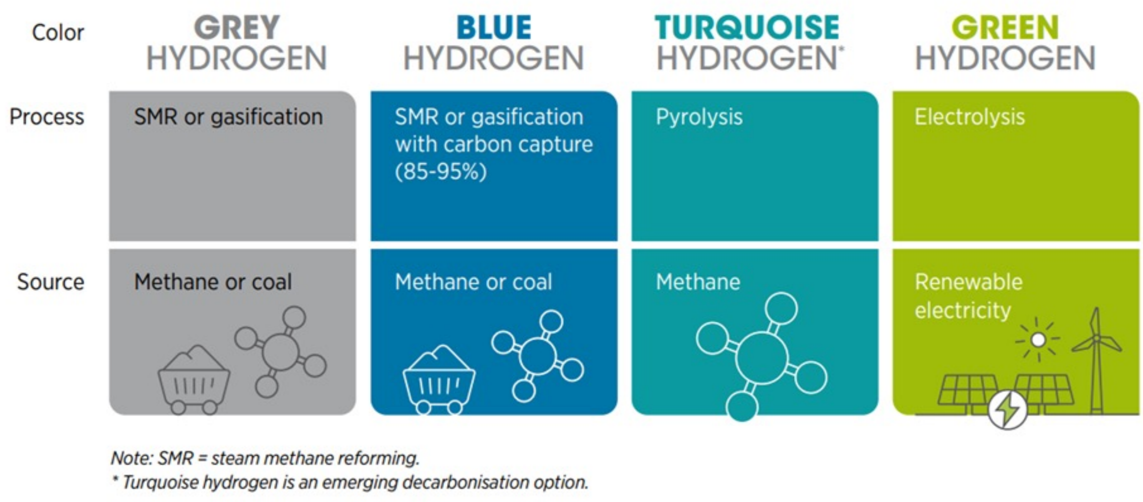
Turquoise hydrogen

An emerging process, still at pilot stage, involves pyrolysis of methane with natural gas as feedstock, leading to hydrogen and solid carbon as by-products. (Philibert, 2020; Monolith, 2020). Whilst this process does not produce carbon dioxide as a by-product, the carbon contained in the methane is converted into solid carbon black or graphite which provides a potential additional revenue stream. Graphite can be used for carbon fibre and a range of other potential product applications.

Green hydrogen

Green hydrogen is dependent on water electrolysis powered by renewable electricity. Electrolysis separates the water molecule into its constituent hydrogen and oxygen elements. Whilst other technologies to produce green hydrogen do exist, these processes are at early development stages and have not reached a commercial scale (IRENA, 2020). As countries make the energy transition, green hydrogen has become the main production pathway of interest, given its ability to be a gamechanger in the energy transition.

FIGURE 4 Colours of hydrogen



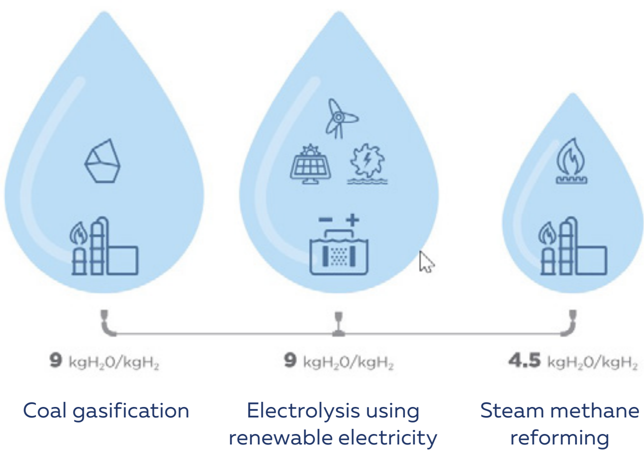
SOURCE IRENA, 2020

Water use requirements and implications for production

All hydrogen production pathways require water. The potential water requirements for the three production methods are shown in Figure 5. One kilogram of hydrogen requires nine kilograms of water when produced through gasification or electrolysis, while steam methane reforming only requires half this amount of water.

These figures only cover the actual reaction process from water to hydrogen and oxygen. When factoring the full production lifecycle, and depending on the source and quality of water, electrolysis can require 18 to 24 litres of water for every kilogram of hydrogen. For blue hydrogen this process can be less, at around 13 to 18 litres of water per kilogram, as the water quality does not need to be as high as for electrolysis (ARUP, 2021).

FIGURE 5 Water required to produce one kilogram of hydrogen



SOURCE COAG, 2019

Green hydrogen is considered the most suitable form to meet national decarbonisation objectives, and maximises the potential economic returns (especially from green certified exports). Some other forms of hydrogen currently being developed in Australia may prove economic for water utilities to participate in or lead themselves. Careful analysis is required to assess how well these will meet decarbonisation objectives.

> Green hydrogen production is likely to provide the best opportunity for the water industry to participate in the hydrogen economy, by delivering the highest value while meeting decarbonisation objectives.

However, green hydrogen by electrolysis still uses a similar amount of water to coal gasification, and this intensive water usage requires careful consideration at a regional and localised context for Australia and potentially New Zealand.

The limiting aspect of water supply is demonstrated in Australia's National Hydrogen Strategy (COAG, 2019) which provides a tool for identifying potential hydrogen production sites through a set of assessment criteria. The tool highlights that while 11% of Australia's land is considered suitable for green hydrogen production based on renewable energy availability, only 3% of land was considered highly suitable when considered in terms of water, ports, and associated infrastructure.

While the water required for initial hydrogen projects may be relatively small, the demand on the system will grow significantly if the projects achieve their planned scale.

> Under a strong growth setting, COAG (2019) estimates water consumption for hydrogen production in 2050 across Australia to be equivalent to just under the current annual supply for the whole of South East Queensland.

Balanced across various regions of Australia, the challenge of reliable supply can be overcome (Figure 6). However, this does represent additional demand to accommodate and water utilities in active hydrogen production locations will want to consider how to balance competing water priorities including population growth, future economic growth across other industries, and social, recreational, and cultural values.

Using recycled water as opposed to raw water or drinking water is likely to be preferable as it meets other objectives sought by water utilities, their customers and their shareholders:

- Mitigates supply challenges on rainfall-dependent water sources due to climate change
- Aligns with the transition towards the circular economy, resource recovery and making best use of 'waste' products
- Progress towards achieving the UN Sustainable Development Goals
- Changing customer and community expectations.

FIGURE 6 Options for the easing of fresh water supplies to produce hydrogen

RECYCLED WATER	DESALINATION	FLEXIBLE PRODUCTION
Harnessing recycled water for electrolysis	Could create a year-round source of demand for desalination facilities, reducing the marginal capital cost of investing in new desalination capacity	Subject production to water controls relative to activities deemed to have higher value in economic or social terms
Can result in reduction in logistics costs due to proximity of wastewater facilities to urban centres	Incremental operating cost of using desalinated water estimated at around an additional 5c/kg H_2, not a material increase on the target cost of hydrogen production	Curtailment of hydrogen production, would hinder the economics of clean hydrogen but could improve the sustainability, flexibility and perception of the industry
May achieve additional sustainability benefits through reduction in wastewater discharge to waterways and oceans		

SOURCE Adapted from PwC, 2020

Insight and factors of the hydrogen market

There is a well-regarded consensus that hydrogen will be better suited to decarbonise applications where electrification through renewable energy is not feasible (eg wind and solar), and there are limited alternatives for storing energy to balance the demand. Investing on this basis minimises the risk of future regrets, while allowing hydrogen supply chains to be established and increased in scale with concomitant growth in demand.

In fact, the use of hydrogen for decarbonisation is complementary to electrification through renewable energy. It does not represent an either-or option for emissions reduction; both can play a valuable role. The opportunity for hydrogen is in recognising applications where electrification and use of typical batteries as energy storage is limited or not yet suitable.

This is driven by two macro factors – the cost of production and demand – which together create a viable market. Both are experiencing significant investigation, interest, and investment, fostering the current opportunity for hydrogen.

Cost of production

The main cost input to produce hydrogen is energy. As we are seeing signs of renewable energy costs decreasing, hydrogen is becoming increasingly topical. One key sign for change is the growing policy support across many Australian states for increased renewables. This incentivises more variable renewable energy (such as wind and solar) as it increases the value of managing operations through flexible loads.

With the increasing demand for renewables comes the opportunity for scale efficiencies and technology improvements. The CSIRO National Hydrogen Roadmap forecasts significantly lower capital costs and expected improvements in technology by 2025. Examples include improvements in the energy efficiency of electrolysers that will require less electricity to produce the hydrogen, or process improvements to capture waste heat and offset electricity use. These improvements combined with advancements in the methanation process are expected to lower the cost of hydrogen production in the future.

Despite water being generally regarded as a low-cost component of green hydrogen, securing the required quantity and reliability of quality of supply are important considerations in determining future cost (Victorian Renewable Hydrogen Industry Development Plan 2021). These considerations extend beyond that of supply and will need to consider the cost of security of supply (i.e. paying more to guarantee surety of supply).

Furthermore, it may not be appropriate for this cost burden to be borne by customers and communities through water bills. Hydrogen production is a valuable activity for Australia and New Zealand to pursue, but it is not the core business of water utilities. If any subsidies or offsets are required to ensure water supply to catalyse the emerging hydrogen industry, these may warrant consideration of transparent external funding arrangements.

Pressures driving demand

Australia is the world's largest exporter of liquefied natural gas, valued at $50 billion annually. The transition to decarbonise and focus on green hydrogen, puts the gas grid at risk of becoming a substantial and costly stranded asset. This places significant pressure on the gas industry for its ongoing viability. The gas industry is at the forefront of demand for suitable alternatives such as green hydrogen, and potential biomethane opportunities.

The Australian Renewable Energy Agency (ARENA) has published the first Bioenergy Roadmap, which calls for scaled up investment in biomethane, as a short term, net zero emissions complementary fuel while hydrogen is further developed (ARENA, 2021).

As the local market for hydrogen develops, water utilities have a comparative advantage to consider the opportunities for both biomethane and hydrogen. Biomethane from biogas produced during wastewater treatment, can be injected directly to the existing gas distribution and supply network. There are already several examples of this occurring in the urban water industry (see Malabar Wastewater Treatment Plant case study) . The co-location of water treatment and gas distribution infrastructure can also improve the economic viability, increasing the demand for new supply developments (see Treatment plants for co-location and hydrogen hubs).

With increasing awareness of climate change, energy consumers are starting to demand new green products. These include the likes of green steel, which is increasing the potential demand for hydrogen as part of the production process. Green steel is produced using hydrogen instead of coking coal as the reducing agent, thus reducing CO_2 emissions. Other products include customer demand for 'green gas', which is increasing and governments have been committing resources to develop the required knowledge and policy.

Through the development of a renewable gas certification scheme (ARENA, 2021), the demand for clean fuel as a 'green gas' for gas networks is set to enable further market investment and development. Biomethane together with blending of hydrogen into the gas networks will be given significant opportunity under the scheme. The certification scheme is already being trialled through the Malabar Wastewater Treatment Plant case study to assess market prospects..

Hydrogen market prospects

There is more to assessing hydrogen market opportunities than just the cost of production and price that can be achieved. Each potential hydrogen market is at a different stage of readiness and potential likelihood of development.

Short term prospects

- Forklifts
- Blending into the natural gas network
- Stationary power and heat generation

Medium term prospects

- Buses
- Trucks and long haul freight
- Shipping and aviation fuels

Longer term prospects

- Full-scale substitution in the existing network with biomethane and/or hydrogen blend
- Hydrogen fuel cell passenger vehicles, subject to competition from more established technologies, such as lithium-ion battery electric vehicles

At COP26, methane was singled out as having likely contributed to around one degree of the 1.5 degrees global warming that has already occurred. In response, over 100 countries signed a Global Methane Pledge to reduce overall methane emissions by 30% on 2020 levels. Although Australia was not a signatory, water utilities around the world can help support this goal through their operations.

SOURCE **Boris Johnson speaking at COP 26** https://www.gov.uk/government/speeches/pm-address-at-cop26-world-leaders-summit-opening-ceremony

Role of hydrogen in decarbonisation

There can be no doubt that broad use of hydrogen will be essential to achieve global climate stabilisation and a decarbonised economy. Hydrogen has unique attributes that cannot be gained through other energy and industrial transformations:

1. It is a stored energy - a fuel. In the context of decarbonisation, it complements wind, solar, and hydro energy production as hydrogen can be stored to balance demand, which is essential for any energy supply.
2. It can be produced from several different compounds, allowing greater flexibility to transport and then be used as a feedstock for many different end uses.

Hydrogen as stored energy – a fuel

As a stored energy source, hydrogen is suitable for transport, producing electricity and heat. Transport can be fuelled directly or indirectly, either using the hydrogen in a combustion engine, or via a fuel cell that produces electricity to drive an electric motor. While it can be used in many applications, its attributes of having a high energy density make it most suited to heavier vehicles (trucks, buses) and propulsion vehicles (planes, ships, rockets).

Stationary electricity and heat can be produced from hydrogen using either gas turbines and reciprocating engines, or hydrogen fuel cells. Hydrogen fuel cells are well suited to sites that also use wind and/or solar, to balance energy peaks and troughs.

Hydrogen can be used to provide process heat and space heating. as a blended combustion fuel in many gas burner applications. It can also be distributed in a pipe network, totally replacing natural gas as the distributed gaseous fuel. These networks need to be uniquely designed as hydrogen does make some materials brittle, an important consideration for network and customer-side infrastructure.

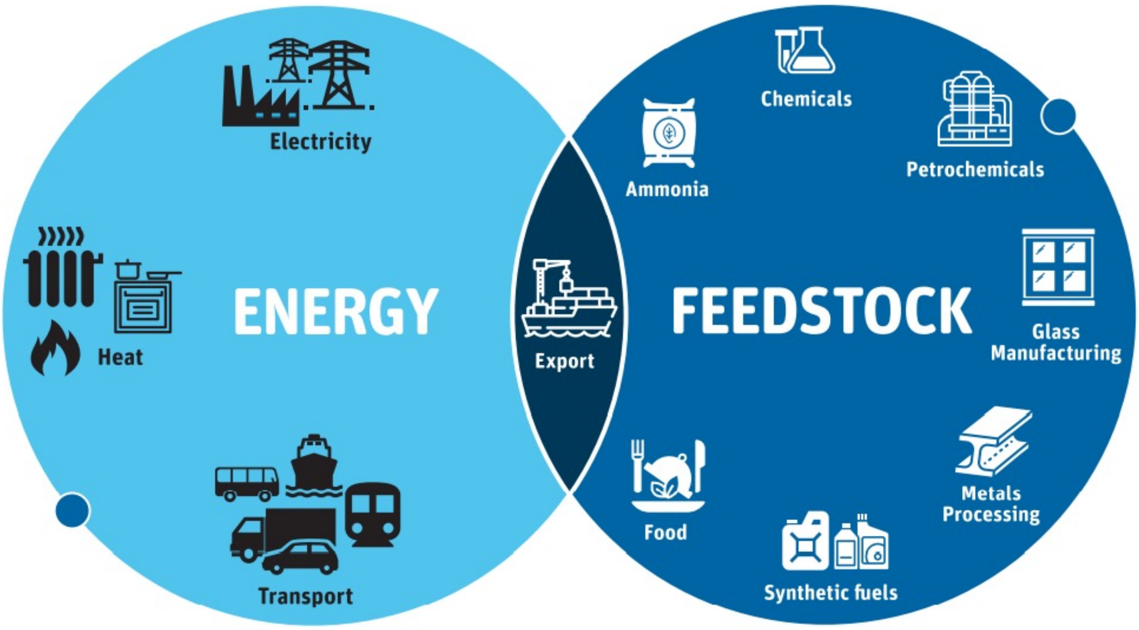
The biomethane opportunity for the urban water industry

Water utilities can supply renewable gas to the natural gas grid in the form of either biomethane (CH_4) or hydrogen (H_2). Sydney Water's Malabar biomethane project with Jemena is a good example. Wastewater treatment facilities can produce raw biogas by using anaerobic digestors to process organic waste. Biogas typically consists of 50-70% methane and 30-50% carbon dioxide. The biogas can be upgraded by separating the methane from the carbon dioxide to produce two valuable gases – biomethane and green carbon dioxide. The biomethane can be injected into the existing natural gas grid without blending limits, and the green carbon dioxide can be sold or used in a methanation process with hydrogen to produce more biomethane.

Hydrogen as a feedstock

Hydrogen compounds are already used as an industrial feedstock, with the potential of more diverse uses through hydrogen economy in the future. Common uses include ammonia and related explosive and chemicals derivates (e.g. ammonium nitrate), together with the production of many plastics, iron/steel, petrochemicals, and liquid fuels. A summary of applications of hydrogen is shown in Figure 7:

FIGURE 7 Applications for hydrogen



SOURCE Bruce et al, 2018

Balancing decarbonisation and electrification – hydrogen and lithium

Hydrogen is not the only solution to store renewable electricity. Lithium, when used in lithium-ion batteries has larger market penetration and will likely prove better for certain applications.

Lithium enjoys a relative advantage to hydrogen in energy efficiency performance and access to existing infrastructure to charge, meaning that for smaller passenger vehicles lithium-ion batteries are a good solution. However, lithium's low energy density and relatively slow charging rate make it less practical for large vehicles.

Hydrogen particularly excels in large vehicles as it has high energy density, meaning less weight, and can be refuelled quickly. However, a drawback is that new infrastructure such as charging stations will need to be rolled out to support the refuelling.

Diversity in renewable energy storage applications is a better solution than a monoculture. It will be important for the pending hydrogen economy to focus on applications where it will enjoy a competitive advantage to lithium-ion batteries.

Key considerations for water utilities

The viability of participating in the hydrogen economy for a water utility is dependent on several factors. There are generally three major attributes for success.

1 Participation needs to be shaped around an identified challenge or opportunity

2 Site attributes need to be favourable

3 Access to suitably skilled partners is key

These three attributes are expanded in nine key considerations below. The more suitable factors that a water utility has at a particular site, the more likely that it will be a viable proposition and should be further explored.

1 Achieving greenhouse gas reduction and emission commitments

Each water utility will be already considering the suite of options it will need to meet its emission reduction commitments and renewable energy targets. The production and utilisation of hydrogen can be one of these options.

A Marginal Abatement Cost Curve is a useful tool to assist with compiling the optimal portfolio of initiatives, including hydrogen production and use, to achieve net zero emissions target.

2 Incorporate the social cost of carbon into decision-making

While acknowledging that individual projects need to be financially viable, it is also important to consider the wider economic impacts of a decision. That includes the impacts on those far beyond the company boundary. Climate change does come with externalities that others outside those generating the greenhouse gas emission have to bear. It should accordingly be incorporated into the decision-making, and commensurate methods of funding explored.

3 Use available capacity to generate surplus renewable energy

Renewable energy is one of the two key components required for the electrolysis process to produce green hydrogen. A water utility can often have either generating capacity at an anaerobic wastewater treatment facility, or land around such a facility where solar panels can be installed. Where this energy is surplus to internal needs, it makes for an excellent input into generating hydrogen.

4 Know the surplus of recycled water potential

Water is the other key component required for the electrolysis process to produce green hydrogen. Many inland water utilities face challenges of how to dispose of their treated effluent, as the discharge volume can far exceed the assimilative capacity of local waterways. This well-treated recycled water is a valuable resource that is often underutilised, in a country where water is scarce. Again, where this water is surplus, it has significant potential for input into generating hydrogen.

5 Sympathetic drivers for the use of recycled water

There is a significant complementarity emerging for water utilities to consider. The water treatment processes required for hydrogen electrolysis are the same processes the water industry is likely to use in the future to treat discharged wastewater for the environment, and for potential use as a supplement to drinking water supplies.

As the impacts of climate change are felt ever more keenly, with two severe droughts in the last twenty years, the water industry is turning to rainfall-independent sources to supplement its drinking water supplies. This typically involves desalination and purified recycled water, both of which have been adopted in various parts of Australia.

Reverse osmosis is the process often used to treat water across both these sources to meet drinking water standard. Installing reverse osmosis technology is reasonably costly. However, reverse osmosis would also be needed to produce water of a quality suitable for hydrogen production. In addition, many water utilities are being driven towards reverse osmosis due to increasingly stringent environmental regulation limits on their discharges of treated wastewater to waterways.

Thus, there are multiple drivers towards the adoption of reverse osmosis technology, which could enable water utilities to satisfy multiple challenges and objectives. Utilising recycled water in the production of hydrogen is an opportunity to create green hydrogen through circular processes.

Water utility planners are already moving towards 'all options on the table' to ensure a robust and reliable water supply; in fact, 'all options planning' should consider all options, and all water sources, and all end uses. It is a promising scenario to envisage the water utility of the future, harnessing the full potential of its abundance of highly treated recycled water, and treating it further so that it is fit for several valuable purposes either singly or in combination, depending on the weather conditions and demands at the point in time. This could also mean that the costs are shared across the projects and their beneficiaries, which could help projects pass financial viability thresholds.

Water Research Australia (WaterRA) and Monash University recently started a project co-funded by the Commonwealth government that will explore the technical feasibility and viability of recycled water as a water source for hydrogen production in Australia. This study will also consider the availability of recycled water in the context of environmental flows and existing downstream user requirements (WaterRA, 2021).

6 Engage interested stakeholders and regulators

As with any new industry, guaranteed production volumes to meet demand are critical to establish investment and development. Accordingly, any future hydrogen project will require a sufficient range of interested stakeholders that want to participate.

Hydrogen is an energy and is commonly stored and transported as a gas. Both energy and gas have well developed industries associated with them. The energy and gas industry have an imperative to decarbonise their product, for their very survival. Accordingly, they are now eagerly seeking opportunities to pursue such options. As such, energy companies may often be willing drivers for leading such opportunities – with water utilities as able partners.

Utilities should utilise existing industry expertise around the production and distribution of gas, underpinned by unique policy, design, construction, and operation considerations for hydrogen. Each involve a different skill set that the water industry currently does not have.

Governments and industry have the responsibility to ensure community safety, confidence, and trust in the new industry, and deliver benefits for all Australians. In August 2021, the Australian Energy Market Commission was tasked to review the National Gas Rules and National Energy Retail Rules to develop initial rules that will extend the regulatory frameworks to include low-level hydrogen blends and renewable gases.

Careful stakeholder, market and regulatory engagement will be needed to consider and address:

- The regulatory treatment for any water industry assets, costs and revenues involved in the production of hydrogen – this will vary based on each utility's unique regulatory framework
- The provision of water infrastructure as a non-regulated activity under the pricing control mechanisms that many water utilities operate under.

7 Treatment plants for co-location of hydrogen hubs

Wastewater treatment facilities are usually constructed on sizeable plots of land in the urban fringes, or peri-urban areas. The sites are often strategically located with good connectivity to transportation, gas, industrial and manufacturing infrastructure. The sites themselves typically have buffer areas of empty space around them, to allow for noise and odour diffusion and future asset needs.

Having an existing buffer of land around wastewater treatment plant sites provides a synergistic benefit as the space could also be utilised for co-production of hydrogen. This is a significant advantage and cost saving that other hydrogen producers may not have. Proximity to other relevant industries or customers is a further advantage, particularly as the transportation costs of green hydrogen are reduced and there is an opportunity to explore the development of hydrogen hubs/clusters. COAG (2019).

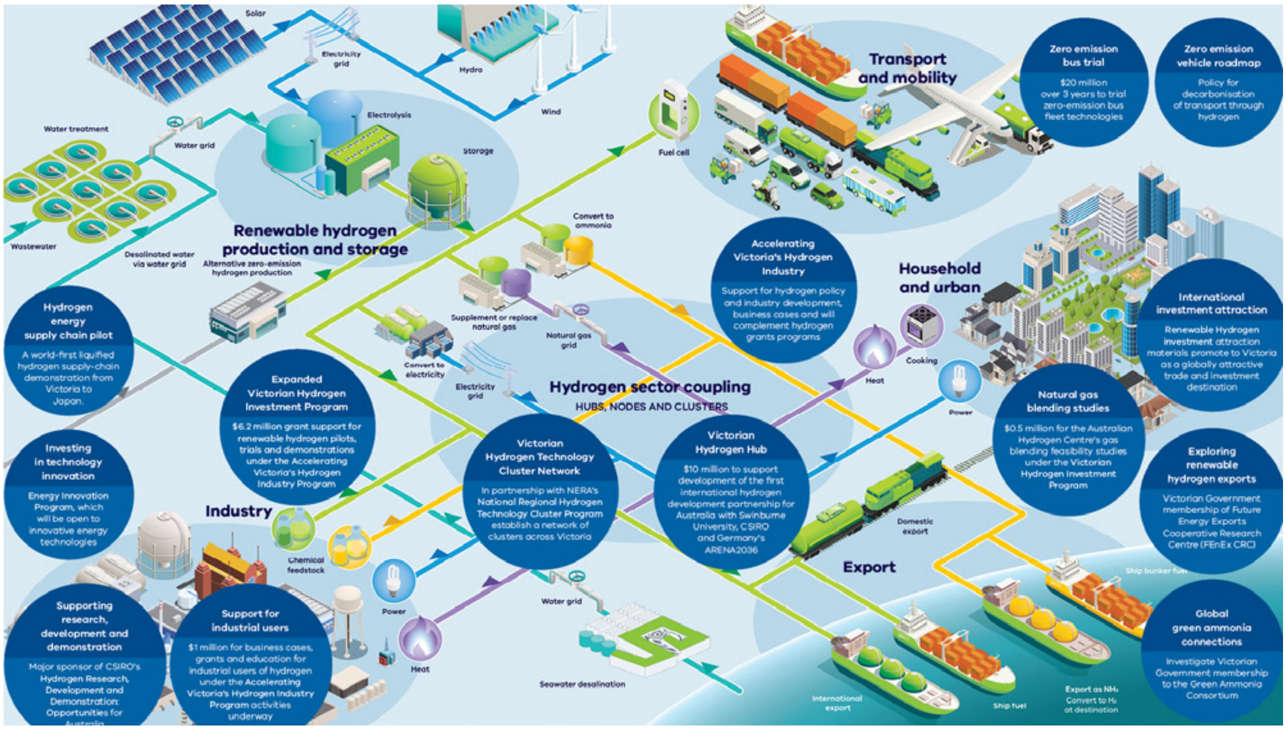
The urban water industry is increasingly recognising that opportunities lie not only within existing supply chains, but also the potential to service new industries and new supply chains that may result from industrial growth driven by co-location potential. Key considerations in relation to co-location opportunities include:

- Who owns and operates the infrastructure required to produce the hydrogen
- Whether the hydrogen is compressed for storage (risk, health and safety) and transfer
- How it is transferred, the form it is delivered to a customer (low pressure or high pressure)
- Who sells the product.

As with all engineering projects, scale is important for financial viability. Australia is developing its future hydrogen production by creating hydrogen hubs – clusters of large-scale production, demand, and transport, co-located to promote efficiencies from economies of scale and synergies through sector coupling, COAG (2019). The location of these hubs is being managed through state government hydrogen strategies with federal support.

Taking account of recent technological advancements in hydrogen production technology and equipment design, a land take of up to 1 hectare (100m by 100m) is likely needed to support a 100 MW green hydrogen production plant. Alignment with state and national government hydrogen hub locations can add further to the scale of opportunity for co-location with water utility wastewater treatment plants. A potential hydrogen hub is illustrated in Figure 8.

FIGURE 8 Conceptualisation of a hydrogen hub or ecosystem



SOURCE Victorian Government, 2021

Trade-offs to consider

Of course, the benefit of strategically located and available water utility-owned land would need to be balanced against competing demands for expansion of treatment operations in future, to meet growing populations. The potential commercial benefits would also depend on the project specifics, especially the proximity and access to low-cost, preferably renewable energy generation.

Co-locating hydrogen production with existing water utility infrastructure, utilising available utility-owned land, can help to accelerate and support the transition to tomorrow's hydrogen market. Such co-located business models already in existence with urban water utilities at:

- Barwon Water's Renewable Organics Network
- Sydney Water's new gas certification scheme
- Yarra Valley Water's Waste to Energy (ReWaste) plant.

8 Explore multiple enhancements or benefits to maximise viability

Finding additional enhancements or products to realise multiple cost benefits will be critical to achieving an economically viable project. This could include:

Capture, storage, and use of oxygen for a cost benefit

Producing green hydrogen from recycled water creates oxygen as a by-product. If a value can be placed on this oxygen, it can increase the viability of the hydrogen facility. The potential benefits are created by inputting the oxygen to the blowers for processing wastewater, which in turn reduces operating costs and decreases emissions (such as nitrous oxide).

The potential benefits and opportunities for using oxygen from hydrogen production are significant, but further detailed assessment is still needed on the extent of its usefulness and the adjustment of wastewater treatment plants that would be involved.

This is a live topic of discussion within urban water industry forums right now, and any increases in understanding will help utilities to gauge the prospects of success for hydrogen projects.

Improve the operation of the electricity grid through the production of hydrogen and recover an additional revenue by providing ancillary services

Renewable energy sources, such as solar and wind, can fluctuate given the dependency on weather conditions. A hydrogen facility using electrolysis will be complementary to intermittent solar and wind generation, as it can be turned on an off to balance these loads, meaning it can function like a "battery in reverse". Because hydrogen is a fuel (i.e. a form of stored energy), large-scale use of hydrogen electrolysers can increase the reliability of the electricity grid (COAG (2019). This not only benefits the grid, but also the urban water industry, in terms of increased resilience through an improved level of redundancy for operational systems that rely on uninterrupted supply or require back-up power. This ability to maintain grid stability is termed an 'ancillary service' and may be able to attract new sources of revenue.

Possibility for methanation process to deliver additional benefit

Converting hydrogen (H_2) to methane (CH_4) could be a potential pathway to market that makes the best use of existing infrastructure associated with the natural gas grid. Methanation of green hydrogen with either carbon monoxide (CO), or (more typically) carbon dioxide (CO_2) to produce biomethane could be a way to achieve this. An option currently under development is the direct methanation of biogas to efficiently access the estimated 30-50% of carbon dioxide content.

There will be challenges to solve before direct methanation becomes a viable process, as biogas will typically contain impurities that need to be scrubbed out prior to injection into the natural gas grid. However, given that the water industry has access to biogas as a feedstock this could be a potential area for further investigation.

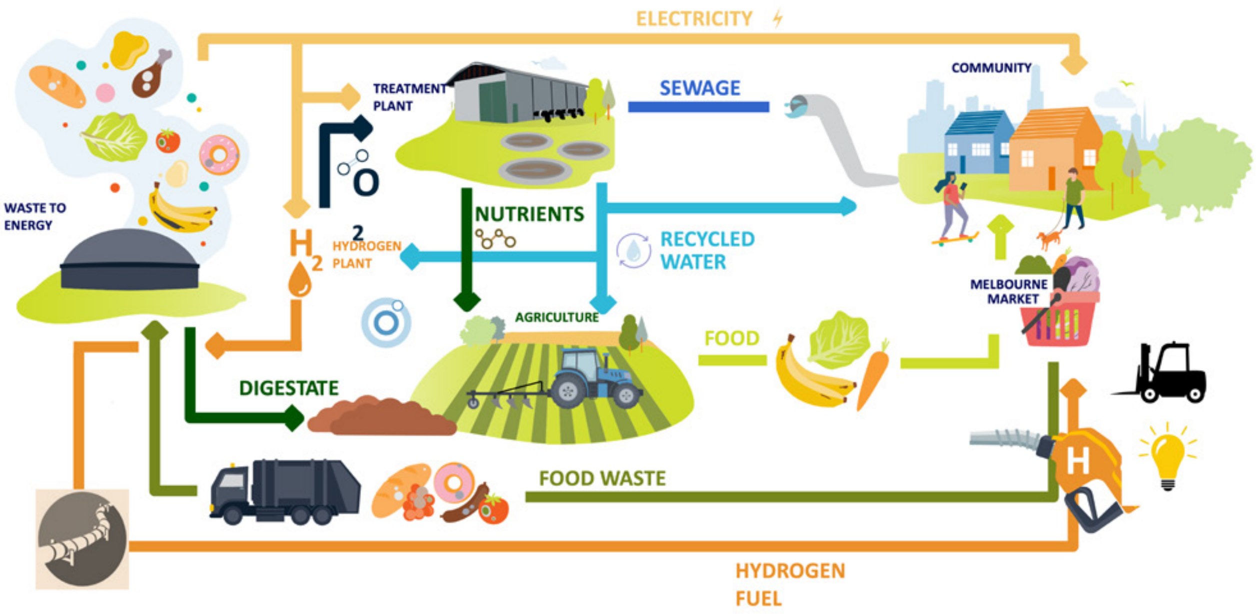
9 Transitioning to a circular economy

The 'circular economy' is a framework that aligns economic and environmental interests by keeping products in use as long as possible, retaining maximum value in products, components, and materials, and regenerating natural capital. This is achieved by establishing systems in which assets and products are designed to last longer; be shared, repaired, repurposed and remanufactured; and only after other 'lives' are exhausted, recycled to recover materials.

Green hydrogen is one of the key enablers of a decarbonised future for the energy, transportation, industrial and water sectors and is an important way to link energy, water, and materials cycles for beneficial gain.

WSAA's Transitioning the Water Industry with the Circular Economy report Jazbec et al (2020) is a guide to help water utilities to unlock the circular economy to better manage resources, make and use products and regenerate natural systems. WSAA will soon follow this up with a Circular Economy Action Plan. Figure 9 shows how integrating hydrogen production at a sewage treatment facility can contribute to a circular economy:

FIGURE 9 Yarra Valley Water example of hydrogen production contributing to the circular economy



The road ahead

These nine issues are relevant to consider at this current point in time. It is beyond the scope of this paper to be able to provide definitive detail for all of them. These aspects will play out differently in every case because each water utility has its own unique geography, context and local supply chain, price and environmental regulation, state energy targets and pricing frameworks.

In exploring hydrogen production, the water industry is stepping outside its comfort zone. We certainly have the technical skills and resources to be able to create valuable products in tomorrow's hydrogen economy. However, the commercial aspects – like bringing new products to market, setting prices, and treat revenues earned through them – are relatively unfamiliar areas for our industry.

As such, there is a road ahead to explore how individual water utilities can best make inroads into the emerging hydrogen economy. Given the pressures on the oil and gas industries to rapidly decarbonise their activities and exploit emerging market opportunities, they are likely to be key partners and potential customers for the water industry in fostering the hydrogen economy of tomorrow.

But none of the players can do this in isolation. Much good will come of increased dialogue with well-targeted stakeholders like the Australian Renewable Energy Agency, the Hydrogen Council, and the various circular economy entities and government departments. Better information-sharing within the industry will also pave the way.

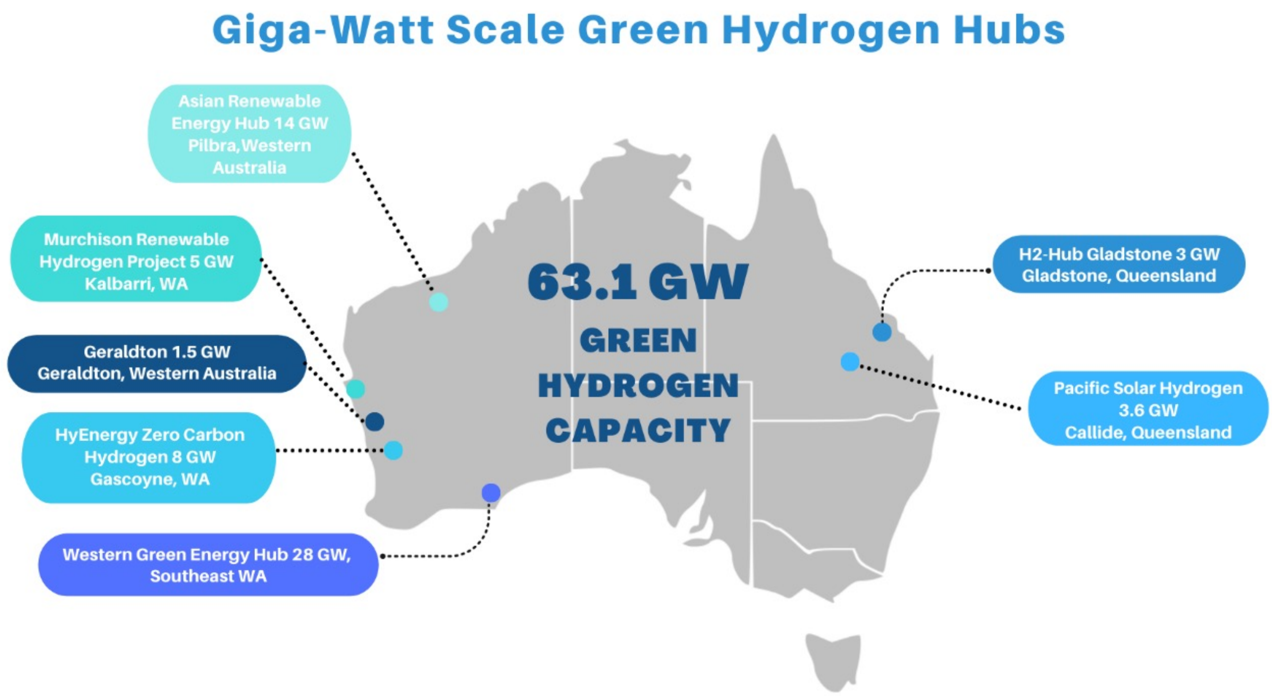
Water utilities are recognised for their extensive links across industries through the supply and treatment of water. These linkages provide the opportunity to serve in a central coordination role to rally stakeholders together for supporting and participating in future hydrogen developments. This brokering role is especially relevant in regional and rural areas, given the understanding that utilities and councils have through servicing their communities. The developments can range from co-location, to supporting local supply chains, to active participation in the forming of hydrogen hubs. In certain cases, water utilities are already actively involved in coordinating funding applications for new hydrogen development opportunities.

WSAA will pursue actions such as these through our WSAA's Circular Economy Action Plan, to be released soon, along with actions to help water utilities learn from each other, key stakeholders and other adjacent industries. We will also pursue and facilitate the most valuable research opportunities, to help answer critical questions as quickly as possible. The learning curve may be steep at some of these early stages of the journey, but ultimately necessary to achieve the required transition.

Australian outlook and case studies

There are currently seven gigawatt scale green hydrogen projects planned across Australia, as shown in Figure 10 (COAG 2019), and the Australian Renewable Energy Agency is implementing 25 future projects and reports into hydrogen (ARENA, 2020).

FIGURE 10 Location of proposed and planned gigawatt green hydrogen projects across Australia



SOURCE COAG, 2019

Key water industry case studies

The participation of water utilities in the hydrogen economy can vary greatly: in the extent of utility involvement in projects, and production processes used. This can range from the simple supply of water, to potential for biomethane, co-location of facilities, or taking a larger involvement in the production of hydrogen and utilising by-products from production to subsidise the cost.

CASE STUDY 1 WATER CORPORATION WESTERN AUSTRALIA

Woodman Point Wastewater Treatment Plant,

Scheduled for completion: 2022

Hazer Group Ltd (Hazer) are conducting a hydrogen trial at Water Corporation's Woodman Point Water Resource Recovery Facility, as a step to commercialising their new propriety process that originated from the University of Western Australia.

The Commercial Demonstration Plant (CDP) being built by Hazer aims to demonstrate their proprietary process, utilising the methane component of biogas generated from sewage treatment to produce hydrogen, and capturing the carbon as graphite, which has further commercial and industrial value. The process uses iron ore as a catalyst, which is a great Western Australia export product, and Hazer aims to create an alternative hydrogen pathway to the traditional approaches of steam methane reforming and electrolysis.

Hazer has entered a Memorandum of Understanding with the Water Corporation for the supply of biogas and to provide the project site for construction. It has received ARENA funding of $9.41 million of a total estimated cost of $21-22 million. It will have a hydrogen production capacity of 100 tonnes per annum and a graphite production of 38 tonnes per annum.

Although modest in scale at present, this project has commercial potential with the hydrogen as low emission fuel and the graphite for sale into the advanced materials market for carbon fibre and related products.

The major benefits to Water Corporation include an offtake agreement for its biogas, productive use of excess biogas that may have otherwise been flared, collaboration with industry to assist development of new technologies and demonstration of the potential of a circular economy approach. A full-scale plant following the commercial demonstration plant would significantly increase these benefits.

CASE STUDY 2 SYDNEY WATER NSW

Malabar Wastewater Treatment Plant

Scheduled for completion: September 2022

Sydney Water is partnering with Jemena to convert biogas into biomethane at Malabar, for export to Jemena's gas network. This project will process raw biogas from the anaerobic digestion plant by removing non-methane gases, to produce a resultant gas stream suitable for injection into the existing gas distribution network. The project will complement existing biogas cogeneration at the site, utilising excess biogas beyond the current capacity of cogen engines.

The project will produce 95TJ of renewable green gas per year, enough to meet the gas demand of approximately 6,300 homes. It is the equivalent of removing 5,000 tonnes of carbon emissions, or around 4,500 cars off the road. The $14 million project is jointly funded by Jemena ($8.1 million) and the Australian Renewable Energy Agency (ARENA), who provided $5.9 million in grant funding.

The initiative is complemented by NSW government plans for a new gas certification scheme to provide customers with a verified option to purchase accredited zero emission gas. The certification will enable the replacement of natural gas with biomethane and hydrogen to support the decarbonisation transition of natural gas networks. This provides a pathway for the certification of green hydrogen.

CASE STUDY 3 **LOGAN CITY COUNCIL** QUEENSLAND

Loganholme Wastewater Treatment Plant

Scheduled for completion: Mid-2022

Logan Water is partnering with Downer, WSP, Cardno and Pyrocal (the gasifier developer) to use a gasification process to reduce the volume of sewage sludge needing to be trucked off site, and produce syngas to power the facility. Syngas, or synthetic gas, is made up of mostly hydrogen, carbon monoxide, methane, and carbon dioxide. This innovation provides a new avenue of hydrogen production through extraction from syngas.

The Loganholme Wastewater Treatment Plant produces 34,000 tonnes of biosolids each year. Current operational practices require it to be dried and trucked 300 kilometres to Darling Downs for land application. As this costs the council $1.8 million annually and accounts for 30 per cent of the plant's operating costs, Logan City Council is seeking to find a viable and sustainable way to deal with the by-products from the wastewater treatment process.

In conjunction with a new solar installation, the project will cut the plant's carbon emissions and make the wastewater treatment process heat energy neutral and carbon negative. The council aims to market the residual biochar from the gasification process as an environmentally friendly soil fertiliser. ARENA is providing $6.2 million towards the $28 million project.

CASE STUDY 4 **YARRA VALLEY WATER** VICTORIA

Wollert Waste to Energy Facility co-located at the Aurora Sewage Treatment Plant

Scheduled for completion: July 2023

Yarra Valley Water is bringing together a group of interested stakeholders to deliver a hydrogen project in the northern suburbs of Melbourne. They include an anchor tenant that wants to be greenhouse gas neutral, a new technology provider that wants to scale up their electrolyser, and a gas distribution company that wants to decarbonise its product. The project will utilise surplus recycled water from the Aurora Sewage Treatment Plant, together with surplus renewable energy from the Wollert Waste to Energy Facility, to produce hydrogen and oxygen using a new electrolyser technology.

The hydrogen is being made available to multiple markets, to improve the viability of the production process. They include fuelling a fleet of 1,200 forklifts, buses, back-to-base trucks; a 1MW power and heat generation system to balance power supply for a 2.5MW solar system; and blending into a natural gas network. The project will also use the oxygen in the adjoining Aurora Sewage Treatment Plant to displace the need for grid electricity.

The project will be staged, beginning with a small technology trial, before scaling up to a production rate of 700 tonnes a year in 2023. Yarra Valley Water are presently seeking funding requests around half of the estimated $23m project funds required for their portion of the project.

CASE STUDY 5 NORTH EAST WATER VICTORIA

West Wodonga Wastewater Treatment Plant

Scheduled for completion: Second half of 2023

Australian Gas Networks, part of the Australian Gas Industry Group, is partnering with global low carbon energy company ENGIE to build a 10MW electrolyser alongside North East Water's West Wodonga Wastewater Treatment Plant.

The electrolyser will use recycled water from the treatment plant and renewable electricity from AusNet's electricity distribution network to produce renewable hydrogen. The hydrogen will be blended with natural gas, at volumes of up to 10%, for supply to the gas distribution networks supplying Wodonga and Albury, supplying more than 40,000 connections including industry and transport markets.

The trunk gas pipeline also passes through the West Wodonga Treatment plant, enabling North East Water to explore the possibility of leveraging this co-located infrastructure to inject biogas directly into the gas grid. This flexibility could allow North East Water to choose between using the biogas to generate energy or go into the gas grid as a market commodity.

Oxygen produced from the electrolysis process will be used in the nearby wastewater treatment plant. This hydrogen park builds on the two other hydrogen parks that Australian Gas Networks are developing in South Australia and Gladstone, Queensland. The project has received $32.1 million in grant funding from the Australian Renewable Energy Agency for the $44m project.

Conclusion on our path to a hydrogen future

The need to decarbonise will only accelerate over the next few years. This report has been compiled to advance knowledge within the water industry, stakeholders and decision-makers, about the water-related issues that need to be considered in expanding Australia's green hydrogen capability. It should also help coalesce the future questions that still need to be resolved, which could help frame a future hydrogen research agenda for the urban water industry.

In particular, the industry could benefit from advancements in knowledge about how oxygen can be used in wastewater treatments plants, how this could defray the costs of hydrogen production, and how methanation could be added to existing water industry facilities. We anticipate the proliferation of grants to companies and innovators, to pursue trials and research new ideas that support the advancement of hydrogen into the Australian economy, will only continue; and this paper should help better position water utilities as future grant opportunities arise.

There is an innovative and productive future ahead, where the water and hydrogen industries develop optimal ways to partner and support Australia and New Zealand to become important players in the hydrogen economy of the future.

The urban water industry, as evident by existing case studies is willing to take on the opportunity the hydrogen economy provides. The reputation of the industry in leading on sustainable commitments and securing customer trust, places water utilities as key brokers in facilitating transactions for mutually beneficial partnerships. No single industry can implement the required change, but our industry can utilise the collaborative nature we have fostered in driving the change that is needed.

Glossary

Biogas	Mainly composed by methane and carbon dioxide, with smaller amounts of other gases. It is produced through the decomposition of organic waste in a process named anaerobic digestion. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste, or food waste. SOURCE Wikipedia
Biomethane	A sustainable fuel that is produced by biogas upgraders which remove the CO_2 from biogas. Biomethane is produced from biogas that is derived from organic matter such as human waste / sewage, food waste, distillery waste or agricultural materials. As the carbon in this material has been recently taken from the atmosphere and is part of the short-term carbon cycle biogas and biomethane are deemed to be renewable fuels. SOURCE Clark Energy
Methanation	The conversion of carbon monoxide and carbon dioxide (COx) to methane (CH_4) through hydrogenation. (Hydrogeneration is a chemical reaction between molecular hydrogen (H_2) and another compound or element, usually in the presence of a catalyst such as nickel, palladium or platinum.) The methanation reactions of COx were first discovered by Sabatier and Senderens in 1902.
COx methanation	Has many practical applications. It is a means of carbon oxide removal from process gases and is also being discussed as an alternative to PROX in fuel processors for mobile fuel cell applications. Methanation as a means of producing synthetic natural gas has been considered since the 1970s. More recently it has been considered as a way to store energy produced from solar or wind power using power-to-gas systems in conjunction with existing natural gas storage. SOURCE Wikipedia
Syngas	Synthesis gas is a fuel gas mixture consisting primarily of hydrogen, carbon monoxide, and very often some carbon dioxide. The name comes from its use as intermediates in creating synthetic natural gas (SNG) and for producing ammonia or methanol. (Wikipedia) It is a product of gasification and can be produced from many sources. SOURCE Quora

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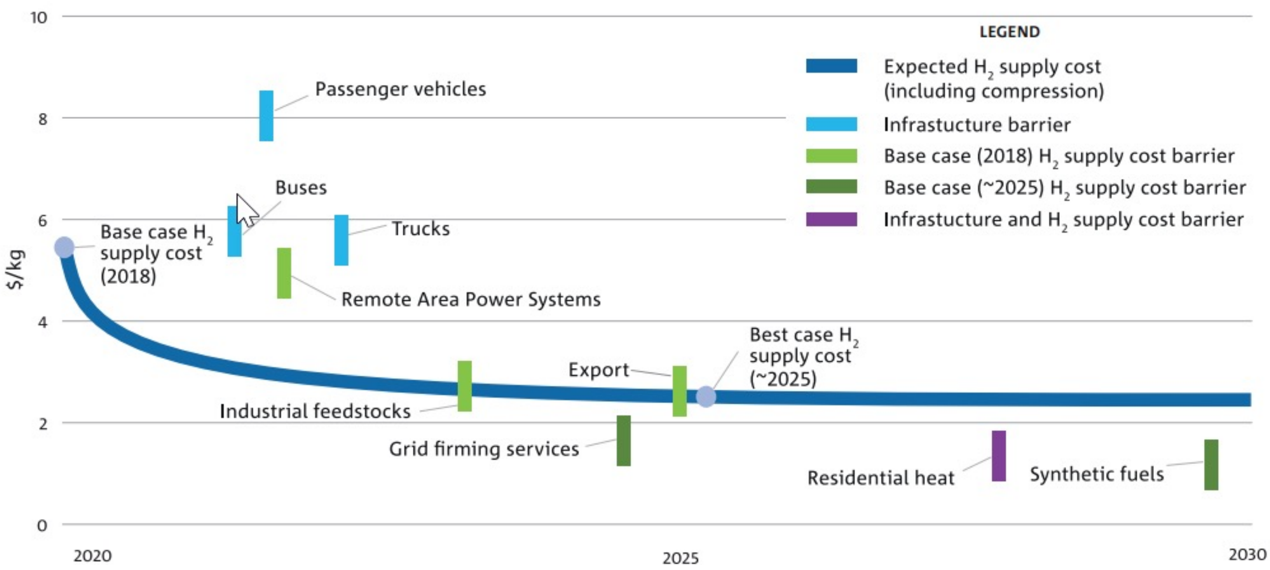
Competitiveness in targeted applications

Each potential application for hydrogen has different price points required before it can be successful. The CSIRO National Hydrogen Roadmap, (Bruce et al, 2018), summarises the price point for each application as shown in Figure 11.

FIGURE 11 Hydrogen competitiveness in targeted markets



SOURCE Bruce et al, 2018

The Australian government's stretch goal of producing clean hydrogen of 'H_2 under $2' is based on this analysis.

Different products have different price points, and therefore provide a different market opportunity. The value of hydrogen to trucks, buses, and remote area power systems, are a factor higher than the base case of supplying grid firming services, such as a gas network.

Considered timelines and likelihood for hydrogen entry into identified markets

FIGURE 12

MARKET	TIMELINE	LIKELIHOOD	OTHER COMMENTS
Blending into natural gas networks	Early	Highly prospective	Offer significant flexibility around supply
			No technology barrier (trials happening in Australia; happens elsewhere)
			Willing counterparty due to the climate faced under the 'do nothing' scenario
			Downside is that it may return a lower economic value than some other options
Distribution centres Forklifts	Early	Highly prospective	Mature technology (hydrogen forklifts are already used.)
			No need for a large distribution network (Eg No geographically disbursed refuelling stations.)
Stationary power and heat generation	Early	Prospective	Technology already available to accommodate a blended feedstock (natural gas and HF up to around 80%)
			Stationary power generation using hydrogen as fuel is flexible and can provide firming to variable renewable electricity generation and peaking capability
			Heat capture can displace a requirement for heating fuels and improve site energy efficiency
Buses	Medium term	Lower	Back-to-base more easily accommodated (than other transport solutions)
			Technology is currently available, although not common in Australia
			Downside is that the market would require a high security of supply
Freight Long haul	Medium term	Lower	H_2 better suited to long-haul heavy transportation than battery electric vehicles due to weight
			Downside is that the economics relies on a network of refuelling stations, and requires a high security of supply if only a small number of re-fuelling options
Waste transport	Medium term	Lower	Back-to-base a positive for the economics
			Downside is that the market would require a high security of supply
Passenger Fuel cell electric vehicles	Long term	Low	Fuel cell electric vehicles falling behind battery electric vehicles due to large economies of scale (and price reductions) in battery
			Network of refuelling stations required to support mass take-up (battery electric vehicles are ahead)

SOURCE Harris, 2020

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