Australian Government

COAG Energy Council

NATIONAL HYDROGEN STRATEGY

Issues paper series

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This issues paper explores the opportunities for hydrogen as a chemical feedstock and as a source of industrial heat.

The COAG Energy Council Hydrogen Working Group seeks feedback on the potential role of national policies and actions in realising these opportunities.

A list of questions is presented at the end seeking further input from interested stakeholders.

Hydrogen for industrial users

This paper has been informed by submissions to the *Request for Information* released in March this year, as well as:

- targeted visits to countries that have already started to develop hydrogen technologies and markets
- the stakeholder roundtables that were held throughout May and June.

The COAG Energy Council Hydrogen Working Group would like to thank industry and community members for their engagement in the strategy development process.

In this paper, unless otherwise indicated, 'hydrogen' refers to 'clean hydrogen,' defined as being produced using renewable energy or using fossil fuels with carbon capture and storage (CCS). This definition reflects the principle of technology neutrality set by COAG Energy and Resources Ministers when they commissioned a comprehensive and ambitious strategy for the development of an Australian hydrogen industry.

Background

Hydrogen presents an opportunity for Australian industry to reduce emissions across a number of sectors. Hydrogen can support supply of low-emissions electricity, be used as a clean fuel for heavy transport and machinery, provide clean industrial heat, and reduce emissions from industrial processes. Internationally, recognition of the role hydrogen can play in reducing emissions, particularly in harder-to-abate sectors such as cement and steel, has led industries to chart their readiness to transition.[1]

Hydrogen also has the potential to open up new economic opportunities and boost Australian industry competitiveness. As raised by stakeholders during consultations, a cost-competitive source of hydrogen could facilitate manufacture of new products, like chemicals and synthetic fuels, and growth in domestic energy-intensive processing, such as metal manufacture. The International Energy Agency has identified the opportunity to create 'hydrogen hubs' by growing hydrogen demand in major industries that could or already use hydrogen. These hubs or coastal industrial clusters, co-located near ports, could bring down the cost of low-carbon hydrogen pathways and underpin or kick-start new sources of demand.[2]

This paper explores the opportunities for hydrogen as a chemical feedstock and as a source of industrial heat. The role hydrogen can play in supporting electricity systems (and thus large industrial users of electricity) will be discussed in *Hydrogen to support electricity systems.* Similarly, the role for hydrogen in industrial heavy vehicles is discussed in the *Hydrogen for transport* paper.

Hydrogen as chemical feedstock

Hydrogen is required in many industries as a feedstock to industrial processes. In these industries, its use is defined by its chemical characteristics, rather than its ability to provide energy. In Australia, the industries that currently use hydrogen as a chemical feedstock

include ammonia production, petrochemical refineries, chemical manufacture, glass manufacture, metals processing, synthetic fuel manufacture and food manufacture.

In addition to the current uses, there is potentially a wider role for hydrogen as a chemical feedstock in low-carbon industrial processes. For example, hydrogen could be used as alternative reductant in metals manufacturing. Although already used for some metals, such as nickel, there is an opportunity for adapting other processes to use hydrogen, like iron and steel manufacturing.

The opportunity specific to the steel industry is discussed further in CSIRO's *National Hydrogen Roadmap* and in the *Hydrogen for Australia's Future report*.[3,4] In short, the carbon in coking coal is currently used as a reductant in the first step in steel making, which is to reduce iron ore (iron oxide) to pig iron (pure iron). The by-product is carbon dioxide. Hydrogen can be used as an alternative reductant, in which case the by-product is water. In the second step, a small amount of carbon (from coking coal) and other elements are added to the pig iron to create steel alloys. Using hydrogen as the reductant in the first step in combination with using a clean source of energy for the process heat would eliminate the bulk of the carbon emissions in steel making. Due to the lack of technological maturity, the use of hydrogen in steel making is unlikely to occur before 2030.[3]

Another potential use of hydrogen is for producing fuels and chemicals, such as methanol. In its submission ADME Fuels noted that Australian industry no longer produces methanol due to the rising cost of natural gas feedstock, and relies on imports of over 100,000 tonnes per year. These imports are mostly used for the production of formaldehyde for particle board and other manufacturing processes.[5] This potential role for hydrogen signifies the opportunities that could open up for the Australian economy through the creation of a cost-competitive source of hydrogen.

Hydrogen feedstock supply

Large industrial users of hydrogen as a chemical feedstock currently either source their hydrogen from a supplier or produce it on-site. In both cases, the production method is most commonly steam methane reforming (SMR) of natural gas, during which carbon dioxide is emitted. In order to transition to clean hydrogen, these users could potentially capture their carbon for storage. The SMR process generates approximately 9 tonnes of carbon dioxide equivalent (CO_2-e) per tonne of hydrogen.[6]

Presently, however, a transition to clean hydrogen for those currently producing hydrogen on-site would most likely involve replacing SMR by production of hydrogen from water via electrolysis using renewable electricity. The production of hydrogen via this route is likely to become more economically feasible with the cost of renewable electricity falling. The breakeven point for industrial users will be driven by the price of natural gas against reductions in cost of hydrogen via electrolysis.[3]

Potential users of hydrogen would also have the option of on-site production or, once a hydrogen gas network is established, sourcing from suppliers. The potential for a hydrogen gas network in Australia is discussed in *Hydrogen in the gas network*.

Technical issues for hydrogen as a feedstock

During recent roundtables, current users of hydrogen explained that technology to produce clean hydrogen via electrolysis already exists and the method of operation is well understood. However, as electrolysers are not yet mass-produced, their cost remains high. Consultations with electrolyser manufacturers revealed they have capacity for higher production but demand has not yet reached a point to deliver cost reductions through economies of scale. While the demand for electrolysers builds, industrial users could look to transition their equipment incrementally, perhaps in line with retirement of existing SMR units.

Research and development

There is significant role for research and development (R&D) for potential industrial users of hydrogen. This role has been considered in the CSIRO's National Hydrogen Roadmap.[3] CSIRO has also commenced work to identify the opportunities for hydrogen R&D to underpin current and future commercial developments.

Hydrogen for industrial heat

In Australia, the largest users of heat are the energy and manufacturing industries.[7] The energy industry includes petroleum refining, gas processing and solid fuel manufacturing. The manufacturing industry includes steel, non-ferrous metals, chemicals, food processing, ceramics, cement, and pulp and paper.

The opportunity for hydrogen in these industries is to provide a cleaner alternative for fuels currently used for heating, which include natural gas, diesel, LPG, and coal. Similar to these fuels, hydrogen can be combusted to produce heat, but is not associated with any carbon emissions during combustion. Hydrogen presents an opportunity to reduce carbon emissions for these industrial users. However, hydrogen today is considerably more expensive and energy intensive than existing heat sources.[8]

While hydrogen might not be cost-competitive for industrial heating now, the price of hydrogen produced from electrolysis is projected to decrease considerably over the next decade.[3] Further, in the mid- to long-term, hydrogen and (hydrogen-based synthetic fuels) could offer a more stable energy costs for industrial users than other commodities like oil and gas, given it should not be exposed to global commodity price fluctuations if connected with on-site production from renewable energy sources. Therefore, there is an incentive for Australia to start thinking about what a transition to industrial hydrogen use will involve and take steps to be ready for that transition. As above, the R&D needs in the transition are not considered here.

Hydrogen supply for industrial heat

A transition to using hydrogen for heat generation would require a substantial volume of hydrogen. In its briefing paper to COAG Energy Council, the Hydrogen Strategy Group estimated that 154 petajoules of hydrogen per annum would be required to supply high temperature industrial processes that currently use natural gas.[4] As raised by stakeholders during consultations, this hydrogen would either need to be supplied from a network or produced on-site. The pathway for developing a hydrogen industry in Australia is explored in *Hydrogen at Scale* and *Hydrogen in the Gas Network*.

Technical issues for industrial heating using hydrogen

CSIRO noted in its *National Hydrogen Roadmap* that due to the variations in appliances, heat and flame profiles, design specifications and control systems, the conversion of commercial and industrial appliances is likely to be site-specific and ad-hoc.[3] This means the transition will require considerable forethought, a tailored approach and time to implement. It is also only likely to occur once there is a pre-existing hydrogen supply or if supply and use develop in tandem.

Environmental considerations for industrial heating using hydrogen

One environmental issue to consider in the transition to hydrogen for industrial heating, is the potential for increased production of nitrous oxides (NO_x). During combustion in air, NO_x production rates are an exponential function of temperature, and the flame temperature for hydrogen is 170°C higher than methane.[9] Increased production of NO_x is an issue as these chemicals are known to deplete the ozone layer, contribute to the greenhouse effect, and affect human health. Therefore, a conversion to a hydrogen combustion unit may require alterations to equipment design or upgrading emissions control systems to stay within permitted NO_x emission levels.

Safety considerations for industrial use of hydrogen

Hydrogen is a light, odourless, flammable gas with a wide flammability range that burns with an almost invisible flame. It is often kept at very high pressures. Like other fuels such as natural gas and petrol, mishandled, hydrogen has the potential to cause fires and explosions. Existing users are well aware of the hazards and should have the capacity and knowledge to transition to clean hydrogen without risk. For new users, however, the situation requires attention. While many industrial users will be adept at operating with natural gas, the unique characteristics of hydrogen may require additional or amended safety considerations. For example, the hazardous areas will require reclassification, and electrical equipment within the hazardous area reassessed.

There have been considerable international efforts on hydrogen safety and these can be built upon to establish best practice and regulation. This includes work by the International Association for Hydrogen Safety, the American Institute of Chemical Engineers' Centre for Hydrogen Safety and international standards organisations such as the International Organisation for Standardization and the International Electrotechnical Commission.

Regulation

In Australia, obligations relating to safety are the responsibility of suppliers, designers, manufacturers, and industrial users. The general duty is for each duty-holder to eliminate or, if the risk can't be eliminated, reduce the risk so far as reasonably practical.

Existing safety legislation (work health and safety, transport safety, electrical safety, and in some states also dangerous goods safety, and petroleum and gas safety) covers hydrogen generically as a flammable gas, dangerous good and hazardous chemical. The general duty is complemented by specific requirements for hazardous areas, electrical safety, maintenance, and plants. It is expected that duty-holders use appropriate engineering standards and principles when designing, maintaining and operating hydrogen related facilities. In a transition to wider use of hydrogen, it may be prudent to develop hydrogen specific legislation where design, operations, and maintenance duties are explicitly stated.

In the context of industrial heating, specific legislation exists in some states for fuel gases such as liquefied natural gas or compressed natural gas. These could include hydrogen when used as a fuel. In Queensland, for example, hydrogen is covered by the Petroleum and Gas (Production and Safety) Act 2004 (Qld). This Act requires appropriate risk assessments, compliance with certain standards, authorisations, maintenance, testing and safety functions.

For industrial appliances, existing Australian standards (AS3814 or AS1375) cover the combustion of fuel gases. These standards cover all fuel gases and if hydrogen is combusted they would be the reference standards. There are also a number of hydrogen specific international standards that the Standards Australia Hydrogen Technologies committee are looking at adopting. In the widespread adoption of hydrogen, a review of existing Australian and international standards will be needed to ensure they adequately cover how hydrogen may be safely used in Australian markets. Further, as discussed in the *Hydrogen in the gas network* paper, industrial appliances will need bespoke testing and certification before they can use blended or pure hydrogen for industrial heating.

Skills

In the wider adoption of hydrogen in industrial settings, there will be a need to educate all that interact with industrial hydrogen systems. For example, those who work with hazardous areas – electricians, operators and hazardous area auditors – need to be aware that the size and nature of the hazardous area for hydrogen differs from that for carbon-based fuels. Further, gas-fitters and mechanics who are used to working with carbon-based fuel gases need to be aware of the specific properties of hydrogen and cannot assume that they have the skill to work on a hydrogen system. It may be prudent to develop regulatory controls such as competency testing and hydrogen specific authorisation.

Additional training may also be required for emergency responders regarding how to approach a hydrogen-related incident, for example a leak, fire or explosion, in order to minimise risk to themselves and the public. The public will also be protected by thoughtful siting of significant quantities of hydrogen in industrial or remote areas protected from encroachment by sensitive land uses.

The potential role for governments in the transition of Australian industry

During consultations, stakeholders identified that until there is a defined market for 'green' industrial products, the driver for using clean hydrogen will be the cost-competitiveness of the finished product.

For current users of hydrogen, this means that the transition to clean hydrogen will only occur when it is cost competitive to do so. The role of governments could, therefore, include incentivising the use of clean hydrogen before it is commercially competitive with other alternatives. Beyond that, the main role for government is to support the creation of a hydrogen industry. The pathway for creating an at-scale domestic hydrogen industry is considered in *Hydrogen at Scale*.

In preparation for an eventual transition for all industrial users of hydrogen, there is also a role for governments to support demonstration projects, as this will generate learnings for other industrial users, build community acceptance, and review existing standards and regulations in relation to gas installations and appliances to ensure an appropriate regulatory framework.

Utilising existing government mechanisms

A number of Australian Government financing mechanisms exist for supporting the transition and are discussed in detail in the *Attracting hydrogen investment* paper. In short, the main Australian Government agencies and programs that could potentially finance or incentivise a transition to clean hydrogen in the industrial sector are the Australian Renewable Energy Agency (ARENA); the Clean Energy Finance Corporation; and the Emissions Reduction Fund, under the facilities method.

State and Territory governments also have avenues for supporting clean hydrogen developments. The Victorian Government, for example, launched the Victorian Hydrogen Investment Program in December 2018. Further, the Queensland Government will have a $15 million industry development fund available from 1 July 2019.

The transition pathway

Table 1 below presents some actions the Working Group have identified that could be taken to support industrial users' transition to clean hydrogen.

Table 1: Actions along the transition pathway for industrial users

2020-2023	2023-2025	2025-2030
• Support research and development in industrial use of hydrogen, building on existing national and international work • Demonstration projects with a focus on clean hydrogen as a chemical feedstock for current users • Develop incentives for industrial use of clean hydrogen • Examine the long term feasibility of industrial heating using hydrogen • Review existing national and international standards and regulations in relation to industrial use of hydrogen	• Establish new standards and regulations as needed for using hydrogen in industrial processes • Establish education and training for industry and knowledge sharing from current industrial users • Demonstration projects with a focus on potential users of hydrogen as a feedstock • Demonstration projects with a focus on industrial heating using hydrogen	• Share learnings from demonstration projects to other industrial users • Support the transition from demonstration to large scale use of hydrogen in industry • Identify other potential industries that can use hydrogen and continue demonstration projects • Continue research, development as required • Continue education and training activities • Review regulatory framework to ensure it is fit for purpose

Questions

The National Hydrogen Taskforce is seeking responses to the questions below. You can submit your comments via the Department of Industry, Innovation and Science's consultation Hub: https://consult.industry.gov.au/national-hydrogen-strategy-taskforce/national-hydrogen-strategy-issues-papers

1. *Hydrogen as a chemical feedstock*

    - *Other than using hydrogen or carbon capture and storage, are there other ways to reduce emissions from the manufacture of metals, particularly steel manufacturing?*

2. *Hydrogen for industrial heat*

    - *What other energy sources are industrial users considering to reduce emissions from their industrial heat processes, and how cost-competitive are they compared to the fuel currently used?*

3. *Supplying clean hydrogen for industrial users*

    - *What would industrial users of hydrogen need from a hydrogen supply network?*
    - *Are there locations around Australia where there is an existing or potential demand for hydrogen from industry that are close to renewable energy or carbon capture and storage resources?*

4. *Technical considerations in transition to clean hydrogen*

    - *What would a conversion to clean hydrogen look like in your industry, in terms of timing, effect on production, equipment changes?*
    - *What existing sites might be suitable to demonstrate industrial use of clean hydrogen?*
    - *Does existing equipment in industrial heating applications have the technical capability to handle increased NOx emissions?*

5. *Hydrogen safety and regulation for industrial users*

    - *Are there examples nationally and internationally that illustrate best practice for industrial hydrogen safety regulation and handling expertise?*

6. *Role for governments in supporting a transition to clean hydrogen*

    - *Are there any gaps in the existing mechanisms for government support for Australian industry to transition to hydrogen?*

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