National Hydrogen Strategy Review
Engineers Australia submission
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ENGINEERS
AUSTRALIA

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National Hydrogen Strategy Review submission

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About Engineers Australia

Engineers Australia is the peak body of the engineering profession representing the collective voice of over 115,000 individual members. Constituted by Royal Charter, our mission is to advance the science and practice of engineering for the benefit of the community.

Engineers and engineering are indispensable contributors to Australian prosperity and lifestyles. Engineering services are embodied in almost every good or service consumed, used or traded by Australians, now and in the future. Engineers are the enablers of productivity growth because they convert "brilliant ideas" into new commercial products, processes and services. Engineers also ensure society gets the most out of existing facilities by optimising their operations and maintenance.

As Australia's signatory to the International Engineering Alliance, Engineers Australia maintains national professional standards benchmarked against international norms. This includes accreditation of undergraduate university engineering programs.

Under the Migration Regulations 1994, Engineers Australia is the designated assessing authority to assess potential migrant engineering professionals' skills, qualifications, and work experience to ensure they meet the occupational standards needed for employment in Australia.

As society and technology have advanced, so has the practice of engineering. This has driven the development of new and specific subgroups of engineering across a wide range of industries. These subgroups are also known as areas of practice. Engineers Australia is currently working with stakeholders to develop a Hydrogen Engineering Area of Practice and may develop others in the clean energy space.

Engineers are passionate participants in public discourse, contributing to meaningful community and policy discussions that impact the economy and society. Engineers Australia formulates its policy positions through engagement with members and non-member engineers, industry, educators, government officials, and other experts across Australia and internationally. By synthesising these diverse perspectives, we develop evidence-based policy aligned with the highest professional standards.

Engineers Australia is a strong supporter of developing new industries that can grow the workforce, increase trade, strengthen domestic fuel security and reduce emissions. Engineers Australia is engaged in hydrogen industry initiatives, including:

- establishing a Hydrogen Engineering Area of Practice, with sub-working groups dedicated to Hydrogen Engineering Competency Development and Hydrogen Codes of Best Practice in support of DCCEEW
- representation on Standards Australia technical committee ME-093 Hydrogen Technologies
- running national hydrogen technical events including co-hosting the current National Hydrogen Industry Technical Series.

We are pleased to have the opportunity to contribute to the review of the National Hydrogen Strategy.

Executive Summary

Driven by the need to decarbonise, more and more countries are developing hydrogen strategies. While Australia was one of the first countries to do so, the context has changed since 2019. COVID-19 and the war in Ukraine have increased the focus on supply chains and sovereign capability. Other countries have launched ambitious agendas, most notably the Inflation Reduction Act in the US, and Australia will need to act quickly to remain a credible contender in the hydrogen space.

Decarbonisation should drive the agenda, not picking potential winners and losers in technology development. Targets and mandates in specific sectors or technologies risks creating inefficient investments and unintended outcomes. It is essential to view the development of the hydrogen industry from a ‘system of systems’ perspective. As Australia experiences economy-wide decarbonisation, a new level of sector coupling with other parts of the energy system will be required. The Safeguard Mechanism

only applies to a comparatively small group of high emitters. An economy wide carbon price or trading mechanism would be beneficial in driving relevant developments in low emissions technologies such as hydrogen and fuel cells.

As the international hydrogen market develops, the government will need to provide more support to get the sector going right across value and supply chains. More pilot plants and research and development are required, as well as assistance to help commercialise promising innovation. Early adopters need economies of scale, including off-take agreements, in order to be sustainable. Supportive and nationally consistent policies, regulations and investments, as well as efficient project procurement and approval processes, will be needed to develop a sustainable industry. The Hydrogen Headstart initiative is a good first step, but further long-term support will be required to develop a robust pipeline of projects.

The development of international and domestic markets can leverage each other and should be considered in tandem. At this stage in the industry, we will need to be smart about which plans are driven by real needs and solutions and which are seeking relevance in a changing environment. A Guarantee of Origin scheme aligned to international standards could provide a competitive advantage for Australia.

Australia has vast and abundant renewable energy resources, but if we are only a supplier of green hydrogen, we may miss out on the opportunities afforded by developing the manufacturing sector. Australia should focus on moving up the value chain for sovereign capability, supply chain resilience and economic development. We can build on the world class expertise and skills we already have across all engineering disciplines to be a supplier and innovative user of hydrogen. China's production of hydrogen dwarfs Australia's, currently 70 times greater. Australia will not be able to outspend larger players in the global hydrogen market. However, we can be targeted and strategic to develop cost competitiveness in clean hydrogen and grow our local manufacturing capabilities, as well bolster fuel security and self-sufficiency.

Developing and maintaining community support is an increasingly important task. Ensuring the community understand the benefits and risks will help ensure a sustainable industry. Local communities, including indigenous communities, need the understanding and capacity to be genuine participants in place-based solutions. The emerging hydrogen industry must set high standards when creating mutually beneficial partnerships with Indigenous communities and their cultural heritage.

Access to water is a critical issue, particularly in extended periods of drought. We understand how much water is currently needed to create hydrogen and ammonia, but further work is required in order to understand access to water sources (fresh, desalinated and recycled) for a developing industry.

Developing a skilled hydrogen workforce has significant competition from other sectors of the economy, including the broader energy transition and infrastructure development. A national hydrogen skills roadmap, that integrates national and state government education, skills and training initiatives, is needed to guide development. Government, industry and professional associations all have a role in developing and training the workforce through higher education, vocational education, and short courses as well as other initiatives geared toward continuous professional development.

Engineers Australia notes a concerning lack of engineers, with the supply of engineers from both tertiary education and skilled migration decreasing at an alarming rate. See Q13 for a range of solutions to these issues.

We also note the critical importance of technical understanding and advice. The scale and complexity of the energy transition is increasingly well understood. In the face of these and other contextual issues, the public service is addressing numerous big challenges and also leveraging significant opportunities. Engineers are technical experts and problem solvers. Senior engineers should be engaged across the public service to ensure these critical processes get the best technical advice possible.

Key Recommendations

The Australian Government should:

1. *Focus on decarbonisation as the main objective for its hydrogen strategy. This could be done by:*
   a. *Developing an economy wide carbon price or trading mechanism, and/or*
   b. *Prioritising support for hydrogen produced using renewable energy and electrolysis, and other green technologies.*

2. *Increase funding to pilot plants, research and development and to commercialise promising innovation, as well as work with other nations to accelerate a more interconnected hydrogen ecosystem.*

3. *Identify and remove regulatory and policy barriers to the development of hydrogen production and manufacturing.*

4. *Develop an internationally aligned Guarantee of Origin scheme that ensures access of Australian products to international markets.*

5. *Develop a national strategy to support manufacturing in the hydrogen sector, with a particular focus on moving up the value chain and developing niche markets where Australia has competitive advantage, to ensure we can become both a supplier and innovative user of hydrogen.*

6. *Develop national guidelines for community engagement in the hydrogen sector, including specific provisions for indigenous communities and cultural heritage.*

7. *Develop a national water access strategy that considers all sources and uses across the economy, including the potential for desalinated and recycled water.*

8. *Develop a national hydrogen skills roadmap in consultation with the education sector and relevant professional associations.*

9. *Immediately establish senior engineering roles within the public service to provide technical advice to guide the energy transition, including the development of the hydrogen industry.*

10. *Graduate 60,000 more engineers by 2030.*

Decarbonisation

1. Is prioritising the decarbonisation of ammonia production the most prospective way to achieve both hydrogen industry growth and industrial decarbonisation in the short term?

Emissions reduction in the production of ammonia utilising hydrogen as a reagent and feedstock is one of many viable short-term measures to assist in the realisation of broader national industry decarbonisation goals. The more green ammonia plants that are built and operated, the faster our decarbonisation goals can be achieved. However, it remains unclear if this is the most productive way. It is certainly attracting the attention of numerous investors and project developers, even in the absence of a national carbon price or trading mechanism. Many proponents are planning large scale green hydrogen production projects across Australia largely incentivised by the potential for export and sale of ammonia to international markets. However, only the Yuri solar hydrogen plant in Western Australia has progressed to financial investment decision.

The commonly utilised Haber process for ammonia production is inherently energy and therefore emissions intensive, with a considerable quantity of water also required for gas shifting that in itself adds to process emissions. The provision of sufficient water supply can also present challenges particularly in dry, hot and remote regional areas that may be devoid of a plentiful and affordable supply of water.

Natural gas steam methane reformation remains a more cost-effective route than electrolysis for hydrogen production whether for the purposes of ammonia production or any other end-use. The clear benefit of a green versus traditional ammonia plant is the reduced emissions in the hydrogen production part of the overall process.

Increasing the installed capacity of green ammonia, and therefore green hydrogen, plants will improve Australia's hydrogen engineering capability and provide invaluable experience across each element of the hydrogen project development process. The knowledge acquired in the planning, engineering design, commissioning and operation and maintenance of commercial scale water electrolysis plants, inclusive of bulk hydrogen storage and hydrogen piping, would be transferable to many other hydrogen projects and applications. This is a critical element to hydrogen industry building.

Improvements in the manufacture and research into more affordable and efficient hydrogen production routes to drive down capital and operating costs should also remain a focus.

Using ammonia as a hydrogen carrier facilitates decoupling the production from the consumption location, that is, producing ammonia in large quantities and transporting it to the consumption point for transformation and consumption as hydrogen.

Ammonia could also be used as an alternative to diesel in some applications, such as diesel generators. It is not as efficient but presents the advantage of not releasing carbon into the atmosphere when consumed. A problem with oxidising ammonia directly (in fuel cells or combustion engines) is the generation of nitrogen oxides which are also a greenhouse gas and/or can be harmful in other ways. This could be another alternative to replacing diesel generators in remote locations as raised in the review report. There are emission standards for NOx which already apply to diesel engines which could be more difficult or uneconomic to meet if using ammonia as the fuel without significant technical advances. A number of developments and innovations have been made in this area and would be worth further exploration, such as RMIT University's ammonia combustion engine development and CSIRO's Ammonia to Hydrogen Metal Membrane Separation Technology.

Green ammonia represents an import replacement of existing chemical feedstocks as well as an export opportunity, including as a maritime fuel replacing imported bunker crude.

Having said the above, the hazards associated with ammonia production, handling and transport will need to be carefully managed.

2. What other actions in the other sectors, will have the greatest decarbonisation impacts?

Support to all sectors which can decarbonise with hydrogen is crucial through government grants or government backed loans. Consideration of decarbonisation and circularity across the engineering lifecycle is required for meaningful change. Any feasible solution that has the potential to reduce emissions across the energy ecosystem should be considered.

A more broadly applied carbon price or trading mechanism would be beneficial to bridge cost gaps between incumbent and new clean energy sources and carriers. The Safeguard Mechanism only applies to large industrial emitters and although baselines will be reduced over time, the liability for carbon emissions at present is very limited for most emitters in the economy. Importantly, it is the small to medium enterprises currently excluded from the Safeguard Mechanism that are best placed to provide agile, innovative decarbonising solutions for the wider economy.

The term "green" is not defined in the consultation paper. It is unclear whether "decarbonisation" in the context of hydrogen production refers to "green" hydrogen alone, or "blue" hydrogen from fossil fuels with carbon capture. Both processes result in the reduction of emissions with different advantages and disadvantages. It is important to verify their respective carbon emissions.

- "Green" hydrogen production is currently energy intensive and uses electricity generated from renewable sources that in some cases could otherwise be utilised or stored in batteries more efficiently.
- "Blue" hydrogen could utilise Australia's significant gas resources provided the carbon produced is verifiably captured, such as in the Hazer process, in which carbon is captured as a byproduct as graphite. The use of bio-methane as the feedstock would enable a higher level of carbon capture. Even if the carbon capture process proves cost-effective, there is a clear preference for "green" rather than "blue" hydrogen as reflected in the Hydrogen Headstart consultation.

3. What sectors are best placed to be early adopters of hydrogen?

Ultimately this comes down to economic signals. Corporations will only make investments that generate returns for their shareholders. Australia should focus on applications for hydrogen where the commercial gap is the smallest (though it is still large for the majority of applications).

Early adoption could include:

- feedstock for chemicals manufacture including ammonia, methanol, explosives and fertilisers
- truck and coach fleet operations
- forklifts and other machinery
- backup power/UPS
- long term, bulk, seasonal storage of energy
- remote area power supply grids/microgrids
- long-distance transport such as rail, shipping and aviation
- back-to-base transport hubs, such as metro bus depots
- steel and alumina production.

Hydrogen can potentially support business productivity, improve consumer convenience and reduce emissions in the transport sector, given its greater specific energy density, shorter refuelling times and longer travelling range compared to battery-electric vehicle equivalents. In general, transport modes that are hard to electrify are more likely to see the development of green hydrogen in the longer term.

Electricity grid support could see limited uses, particularly for dispatchable peaking power. However, given the quality of the renewable resources in Australia, and relatively high capital costs of electrolysers, fuel cells and hydrogen turbines, the extent of this use is still uncertain. Excess renewable generation could be used to produce green hydrogen. See Q34 below.

Blending hydrogen into gas networks would offer a source of domestic demand. Even at 10-15 per cent this could be a large market. The proximity between the supply and the end user will improve the feasibility of this option.

Regardless of sector, the early adopter will be limited to corporations and institutions that can afford the capital expenditure, as the economies of scale for smaller applications will take time to establish. A key feature will be co-location of hydrogen generation with other industrial uses or energy generation facilities such as hydro, or a repurposing of existing facilities towards hydrogen generation.

4. Are there specific barriers that may limit hydrogen uptake in each of these sectors?

One of the major barriers that will limit hydrogen uptake is the market to consume the hydrogen produced. Generation of hydrogen can only be impactful if we have thriving industries to consume some of this production domestically. Production and demand must be promoted and invested in conjointly. The existing emphasis on investment in hydrogen supply and upstream assets, predominantly geared for bulk export and spurred on by financial incentives for hydrogen production and supply costs, needs to be matched by an equivalent level of incentivisation to boost hydrogen demand.

The review should address economic instruments to enable greater levels of fuel switching, for example from diesel electric propulsion to fuel cell electric vehicles and subsidies for hydrogen refuelling infrastructure.

An obstacle to any business is the return on investment in capital costs. Until green hydrogen is competitive with the alternatives, businesses will need to rely on government funding to alleviate both upfront capital costs and limited market availability in both supply and demand. Until the industry reaches a critical point in the scale of production and established supply chains, business will have a hard time convincing their shareholders to make a decision to decarbonise without an incentive to switch fuels.

A supportive set of policies aimed at market capitalisation will encourage the development of a robust ecosystem. Government backed demonstrator projects are a good way to convince businesses to invest. Examples of large-scale green hydrogen projects will demonstrate the potential.

Access to water resources for electrolysis could be another barrier – see Q21 below. There are a range of hydro storage locations across Australia that could be integrated into both hydro storage and hydrogen production.

5. What are the actions required to overcome those barriers and realise the opportunities? For instance, what supply chain risks need to be addressed and overcome?

Australia is fortunate to have great renewable resources, but we are heavily reliant on international supply chains, including hydrogen production equipment (electrolysers, fuel cells) and auxiliary components. Supporting Australian green hydrogen supply chain companies, such as electrolyser manufacturers and enabling their Tier 1, 2 and 3 suppliers to establish facilities in Australia, will reduce the cost of implementing green hydrogen projects. If Australia grows as a world-leading hydrogen exporter and generator but relies entirely on imported equipment and skills, it is a lost opportunity.

There are still technical challenges in the storage and handling of hydrogen. It has low energy density unless liquefied, and liquefaction requires energy creating further inefficiencies. This challenge may be overcome by converting hydrogen to ammonia. However, the production of ammonia will need to be competitive with the production of carbon-neutral hydrocarbons, such as methanol produced by extracting carbon from the atmosphere. Supporting pilot plants and research and development activities will help to overcome these challenges.

Government should develop a set of enabling policies to support hydrogen production through long-term incentives that address the entire value chain rather than a small portion or phase of a few projects. Currently, there are no benchmarking studies on existing green hydrogen installations where the income, cost and productivity drivers can be identified and understood to guide the future expansion of the industry.

Industry groups and technical associations such as the Australian Hydrogen Council (AHC) and Smart Energy Council's Zero Carbon Hydrogen Australia should promote collaboration between the various industry players to help reduce the overall cost of projects.

The review and approval process of the new projects must be improved to avoid delays, particularly as other countries speed up their development and investment.

Industry activation

6. Should Australian governments adopt a more sector driven approach to hydrogen industry development?

In general, Engineers Australia supports a sector-driven approach to hydrogen industry development. It can be an effective way to kickstart the industry and drive targeted developments in key sectors to provide quick and sustainable wins. However, it should be accompanied by a comprehensive systems approach that considers broader applications and potential risks to get the technology established and create a net zero output. Industrial symbiosis/ecology are excellent examples of optimising a sector-based approach. The Hydrogen Hub ecosystem provides a good example of this, where industrial synergies are considered for developing common use infrastructure (See Q10, and Q27 to Q31 below).

Governments should focus on de-risking the current hydrogen user industries first, then leverage the infrastructure and associated learnings.

A sector-driven approach to hydrogen industry development should focus on the following:

- focus on lowest economic gap sectors that will have a pathway to longer term viability
- sectors that cannot otherwise be electrified such as high temperature heat
- value add exports such as green steel
- value adding local industry
- emission reduction such as heavy industry and transportation.

The energy ecosystem is a vast and complex system. Optimising such a system with numerous variables is a challenging task. From the outset, breaking up this system may help simplify the task at hand. However, breaking up the system can result in blind spots and a lack of efficiencies, which may result in inefficiencies.

All sectors should have equal access to government support. This will not only encourage existing sectors already in Australia to invest in hydrogen, but will also allow new Australian sectors to develop, such as electrolyser manufacturing.

In lieu of a more broadly applied carbon price, hydrogen consuming sectors such as oil refining and ammonia production, where there is no alternative to green hydrogen for decarbonisation, could be targeted. Initially, the focus could be on areas where the commercial gap is the smallest, such as displacing liquid fuels (likely diesel). For example, requiring renewable fuel targets in liquid fuel consumption, or making liquid fuel consumption more exposed to carbon pricing.

Targets and mandates

7. Should Australian governments adopt national hydrogen production, use and/or export targets for hydrogen?

Engineers Australia does not support targets and mandates for hydrogen production. The government would be better placed to prepare a roadmap where transition industries are linked to the domestic hydrogen supply. Enabling general support for the supply chain will result in the greatest increase in production.

Instead, targets should focus on decarbonisation. We should be open-minded about the technologies and their relative contributions to decarbonisation. Developing new technologies and ecosystems is not a linear path and depends on numerous factors. Support should be oriented toward winning technologies to avoid investing in low-efficiency solutions.

8. If targets are adopted, what type of activities and/or sectors should this target be tailored towards? For example, production and demand targets for sectors such as transport or renewable gas target. Please describe how such targets would attract investment.

Ammonia production should be targeted as it is a process that is already integrated into the use and production of hydrogen. Sectors such as transport will follow later and require the establishment of refuelling infrastructure across highway links.

Any proposed target should be aligned with the financial and investment supports. The hydrogen ecosystem is international. Targets must align with technology development and policy support and should take a whole-of-system approach, recognising there is no single solution to decarbonisation, and pulling other levers in other parts of the ecosystem may help or hamper the hydrogen part of the overall energy ecosystem.

9. Should Australian governments use regulatory mandates to drive demand for hydrogen? If mandates were adopted, what type of activities and/or sectors could mandates be directed towards? Please describe how such mandates would attract investment.

Australian governments should promote innovation programs, grants and funding to stimulate capital growth, rather than regulatory mandates. Positive support for the market will work better than mandates. Supporting the means of delivering supply and demand will create the best result for Australia.

The Safeguard Mechanism means the biggest emitters will need to find a solution. The other side of that coin needs to be activated: researchers, entrepreneurs and other innovative players will need to be supported to offer hydrogen-based solutions. This should also attract investment organically as government support will bring more certainty in this area.

Maintaining a balanced approach is of the essence. In an environment where hydrogen production is still not meeting the investment requirements, forcing mandates can be counter-productive and hamper progress. The focus should be on decarbonisation. Mandates could force specific solutions, which may not be the most efficient ones, but creating a supportive policy environment will be most effective.

Supply chain risks

10. What are the most significant supply chain barriers being faced by Australia's hydrogen industry? Where should Australian governments focus efforts on securing elements of supply chains needed to enable the accelerated growth of the hydrogen sector?

Government support should be neutral and help all companies in the supply chain that are based in Australia (or want to create a base in Australia). Examples of supply chain issues are numerous, from base materials in an electrolyser through to skills from design engineering to operations and maintenance. For example:

- Metals such as nickel are vital to the electrolyser sector. Australia is a world leader in nickel mining and refining, yet most value-adding for the electrolyser sector is done offshore. Supporting sustainable nickel mining and processing (which in itself uses hydrogen and can adopt green hydrogen) can strengthen our sovereign capability and supply chain resilience.
- Silicon carbide is likely to play an important role in both electrification of the motor industry as well as green hydrogen and presents an opportunity for processing in Australia.
- Skills are an important part of the supply chain, and government needs to support this through its existing channels and enable companies in the green hydrogen supply chain to take on as many government supported apprenticeships and cadetships as possible.

11. Should Australia develop and support local manufacturing capabilities to secure the hydrogen supply chain? What are the specific areas of opportunity (e.g. fuel cell or electrolyser manufacturing or hydrogen transportation related manufacturing)?

Engineers Australia supports the development and backing of local manufacturing. Australia is well placed to be a global green hydrogen supplier, in both exporting hydrogen (as ammonia or any energy carrier) and also to be an equipment supplier. Australia has the expertise and primary resources to move up the manufacturing value chain. Supply chain support is required across the value chain, including instrumentation, pressure equipment and valves.

Australia can develop domestic capabilities to generate hydrogen but also convert it to energy. A 2022 meta-study, *Building the green hydrogen market – Current state and outlook on green hydrogen demand and electrolyser manufacturing*, found that an, "Increase in electrolyser manufacturing capacities of up to 200% needed till 2030."[1] Significant opportunities for Australian industry include the development and manufacture of:

- next generation solar PV panels and wind turbines, and other renewable energy technologies that generate renewable electricity
- concentrated solar thermal photocatalytic water splitting technologies
- high efficiency electrolysers such as the capillary-fed electrolysis cells, and fuel cells such as solid-oxide, ammonia and methanol fuel cells.
- technologies for transforming hydrogen to ammonia and methanol
- niche balance of plant and other products utilised across the hydrogen supply and distribution chain such as hydrogen compressors, valves, meters, sensors and process automation and control software
- transportation manufacturing – see Q3 above and Q14 below.

The Hydrogen Hub model would be another way to support the hydrogen supply chain, although efforts should be directed to ensure they do not introduce unnecessary complexity in project ownership, control and compliance.

Due to the fact that Australia is a high-labour-cost market, manufacturing should be targeted toward the high-tech and challenging parts of the ecosystem with higher margins.

12. What are the barriers to developing and supporting local manufacturing capabilities?

For new manufacturing industries and even revitalising the manufacturing sector in general, government support is required to avert:

- high capital costs
- high regulatory compliance costs
- lack of ancillary infrastructure
- competition with established suppliers
- access to financing
- lack of market demand
- export challenges
- skilled workforce shortages.

The source of energy used in local manufacturing needs to be verifiably "green", or it will be an impediment to exports as other nations account for embodied carbon in their imports, such as the European Carbon Border Adjustment Mechanism (CBAM). An internationally aligned Guarantee of Origin scheme will ensure access to Australian products and can provide a competitive advantage.

The government should support development of industry zones like the Hydrogen Hubs and take the lead in long-term planning to ensure smaller parts of the ecosystem can link together in the long -term and create efficiencies. For example, it is important to be cognisant of the relative location of solar farms, hydrogen production units and water resources.

See Q11 above.

13. What is the role of industry and governments to ensure the hydrogen industry has access to an appropriately sized and skilled workforce?

A thriving hydrogen industry has the potential to disrupt the Australian workforce at a time of competing priorities. Both the industry and the government must work together in a coordinated manner to ensure that the hydrogen industry has access to a skilled and appropriately sized workforce. By doing so, they can foster a sustainable and competitive hydrogen sector that contributes to Australia's energy transition and

[1] Building the green hydrogen market – Current state and outlook on green hydrogen demand and electrolyzer manufacturing, https://doi./10.1016/j.ijhydene.2022.07.253

economic growth. The promotion of STEM is a shared responsibility of industry (through employment) and government (through education, VET and Higher Education). The entire engineering team, that is, Technologists, Associates and Professional Engineers, will be required to support this emerging industry.

Australian Government's role includes:

- developing a national roadmap to reduce the timeline of new courses and degree development
- developing supportive policies and regulatory frameworks that encourage investment in the hydrogen sector
- providing financial support through funding and grants for research and development in hydrogen technologies and workforce development initiatives that can accelerate the growth of the industry
- calling on engineering expertise to ensure it is getting the best technical advice
- raising public awareness about the importance of the hydrogen industry and the potential career opportunities it offers, encouraging more individuals to consider pursuing careers in the sector
- increasing investments in the education system, and improve equity of access to quality education, from primary through to tertiary, including support for vocational training institutes
- promoting the positive difference that people with STEM qualifications can and are making to attaining the UN's sustainable development goals.

Industry role includes:

- workforce planning and skill development to assess its current and future needs in terms of skilled labour, technicians, engineers, researchers, and other professionals related to hydrogen production, storage and transportation
- investing in training and upskilling programs to ensure that the existing workforce is equipped with the necessary practical skills and knowledge to work in the hydrogen sector
- collaborating with education institutions where industry can help shape the curriculum to align it with the specific requirements of the hydrogen sector, ensuring graduates are job-ready and have internship opportunities.

As well as government and industry, professional organisations have a remit to provide continuing professional development (CPD) for their members to upskill them in the hydrogen space. For example, Engineers Australia is developing a Hydrogen Engineering Area of Practice to ensure technical competency. Engineers Australia is also collaborating with the Australian Institute of Energy (AIE), the Hydrogen Society of Australia (HSA) and many stakeholders from industry and government to deliver a National Hydrogen Industry Technical Series.

Micro-credentials can bridge the gap for trained/skilled people, such as tradespeople, to apply their skills in the hydrogen sector.

There are good initiatives happening, but much more is needed.

The engineering workforce

Australia is experiencing perhaps its greatest-ever engineering skills crisis, with more than 50,000 additional engineers estimated to be needed over the next few years. The majority of disciplines and nearly all sectors of the economy require more engineers, including the emerging hydrogen industry. Australia needs to graduate 60,000 more engineers by 2030 to have the engineering workforce needed in the future.

Australia's engineering workforce has two main supply channels – Australians who choose engineering for their tertiary education and skilled migrant engineers. Supply from both channels is decreasing at a time when demand is increasing. Australia has relied on skilled migrant engineers for its engineering workforce for many years now, with around 60 per cent of the engineering workforce in Australia having been born overseas. However, only about 40 per cent of skilled migrant engineers in Australia are employed in an engineering role. Compounding the problem is the number of young Australians choosing to study engineering has been declining since 2014, along with a decrease in the number of school students choosing to study intermediate and higher-level mathematics. Our analysis of 2021 census data

has shown that over 70 per cent of the additional engineers added to Australia's labour force between 2016 and 2021 were born overseas.

With demand for engineering skills expected to continue to increase, our research shows that Australia needs to address five areas to build an engineering workforce that can meet our current and future needs. Government, industry and education institutions need to work together to:

- Encourage more young Australians to choose to study engineering. Research shows one of the many required actions here is to raise awareness of what engineering 'is' and what engineers 'do.' This is particularly the case to improve gender diversity in the profession.
- Improve engineering study completion rates. Only ~25 per cent of four-year engineering qualification students complete their degree in the minimum time of four years, and only between 50-65 per cent of commencing engineering students graduate with an engineering degree.
- Actively retain engineers in the engineering workforce. Around 60 per cent of qualified engineers in Australia work in an engineering role. An engineering qualification is an asset for life. The engineering mindset and skillset, grounded in problem-solving, design and systems thinking, is highly versatile and valued in the broader economy.
- Re-examine our skilled migrant workforce and the systems that support it. Lifting the number of skilled migrant engineers coming to Australia is unlikely to boost Australia's engineering workforce unless we also provide better support systems to help them find engineering work. For more information on barriers to employment for migrant engineers, see the full report here.
- Explore ways of improving how the future engineering workforce is planned. Improved demand data, fed back to universities and schools, can help close the information loop and ensure that the engineers we need in the future are being trained now.

For more information on strengthening the engineering workforce, see the full report here.

Australia also needs to increase the participation and retention of women in engineering, which is one of the profession's greatest challenges. Engineering is the largest employer of the STEM professions. However, engineering has the lowest female representation of the STEM professions, with just 16 per cent of Australian engineering graduates and 14 per cent of the Australian engineering workforce being female. This is in stark contrast to other STEM fields, such as biological sciences, where gender representation tends to be far more balanced. The 2021 census data showed that the proportion of women working in engineering only rose to 14 per cent (from 12 per cent in 2016) and more than 70% of these women were born overseas. Much needs to be done to improve the proportion of women in the engineering workforce. Engineers Australia's women in engineering report provides further insight, see the full report here.

14. In addition to electrolysers, where do you see a role for domestic hydrogen related manufacturing to address supply chain risks and ensure Australia meets its decarbonisation targets such as hydrogen buses/heavy vehicles?

Electrolyser manufacturing support must also include the Tier 1 and 2 suppliers to the electrolyser companies. This includes the material suppliers such as formed nickel products, instrumentation, pipework and HV electrical systems.

Electrification of transport is fundamentally important to decarbonisation. Whether hydrogen will make a difference in this area depends in part on developments in battery technology. There is still a case for hydrogen use in heavy vehicles and long-distance transport, especially in countries such as Australia where major cities and significant infrastructure are 1000km or more apart. See Q3 on 'early adopters' above.

The role for domestic hydrogen related manufacturing in addressing supply chain risks may include:

- renewable energy equipment such as solar PV panels, wind turbines
- efficient and low emissions hydrogen generation equipment
- hydrogen and other energy storage systems that facilitate hydrogen production and renewable sources

- distribution and delivery equipment such as pipelines, tankers, connectors and pressure vessels
- energy conversion systems such as fuel cells which convert hydrogen to electricity and heat
- hydrogen fuelling infrastructure, including modular stations for remote locations
- manufacturing hydrogen buses, heavy vehicles and forklifts and other industrial machinery
- conversion kits and retrofit solutions, which enable existing vehicles and equipment to run on hydrogen
- research, testing and product certification facilities.

Attracting investment

15. What in addition to the commercial cost gap is preventing Australian hydrogen projects from progressing beyond a financial investment decision?

A lack of investors interested in long-term projects with significant risk is preventing Australian hydrogen projects from progressing beyond a financial investment decision. This needs further government investment and/or research and development incentives to attract the necessary investment from here and overseas.

Hydrogen projects require significant infrastructure to produce, store, transport, and distribute hydrogen. The lack of a mature hydrogen infrastructure network in Australia will hinder the progress of projects.

Hydrogen projects may face environmental and social concerns related to the sourcing of water and community acceptance. Addressing these issues in a sustainable and responsible manner is crucial for project progression.

Financial risk can be reduced by benchmarking existing pilot studies, effectively learning from experience and transferring knowledge to create greater certainty. Key investment questions include:

- What are the most cost-effective, efficient and reliable water-splitting technologies for any application at the GW scale?
- How can integrating renewable energy sources with hydrogen production facilities be optimised to achieve maximum energy conversion?
- What are the optimal configurations for GW-scale hydrogen production facilities regarding location, size, on-site storage and proximity to renewable energy sources?
- What strategies can ensure a reliable and sustainable water supply at the required scale?
- How can supply chain logistics and infrastructure for transporting and storing hydrogen be developed?
- What are the environmental and socio-economic impacts of hydrogen production facilities, and how can they be mitigated?
- What are the GW scale's key income, cost and productivity drivers for any given application?
- How can economies of scale be leveraged to achieve greater cost competitiveness?

The initial large-scale projects need government support as a demonstration to companies that it can be done and can be profitable. Support such as the US Inflation Reduction Act (IRA)[2] is a good example. The *Hydrogen Headstart* initiative is a good first step, but further long-term support will be needed to bring projects to market. The lack of a long-term supporting policy structure puts Australia at a disadvantage compared to the other major competitors. Hydrogen is an international energy carrier and being a frontrunner is not possible without supportive policies that attract international investors to establish large-size infrastructure.

The lack of a tradeable market for hydrogen as an energy commodity and limited transport and consumption infrastructure is a barrier. Given this, financial investment decisions often require vertically integrated companies (producers and consumers) to take this step and/or a secure offtake agreements. The commercial pain of hydrogen project financial investment decisions needs to be shared across the

[2] https://www.energy.gov/lpo/inflation-reduction-act-2022

supply chain by producers and consumers, ideally supplemented by government and encouraged by effective policies such as a broadly applied carbon price or trading mechanism.

16. What signals are effective overseas and can apply to unlock greater investment?

The US Inflation Reduction Act (IRA) is a good example of effective policy enablement, which is now being followed by other countries such as Canada. We can also take lessons from Japan's incentives, which include support for overseas investment.

More broadly applied and higher carbon prices are effective signals. The EU Emissions Trading Scheme (ETS) applies across about 40% of emissions and prices (due to lower caps than in Australia) and is well over A$100 per tonne. In Australia, the Safeguard Mechanism applies to <30% of emissions and prices are $30 to $40 per tonne. Further, the European Union is introducing a Carbon Border Adjustment Mechanism (CBAM) to address carbon leakage, which the Australian government plans to explore shortly.

17. Are there any other measures needed to unlock investment in the development of the Australian hydrogen industry including from international and Australian institutional investors?

Australians have a huge stake in mitigating global warming. Their superannuation funds hold vast reserves of wealth, which in a small percentage can be diverted to green hydrogen investments aided by very generous tax concessions from the Australian Government. With the right policies in place, investment can also be very attractive to overseas superannuation funds enabling access to considerable capital.

Australian governments could be investing income from the fuel levy and coal excise into developing a local renewable energy industry, thereby naturally assisting the transition away from carbon-based fuels and laying the foundations of the future industries, and sources of tax income, that will replace them. A proportion of the latter source of government income could also be directed to university research, innovation, commercialisation, skills development and training.

Government backed loans are a way to support small and medium enterprises to get off the ground and will encourage institutional investors to also back them.

18. When would it be appropriate to take a 'tech neutral' approach to developing hydrogen, and when would a more directed approach be warranted?

We should always be technology neutral. It is risky and potentially limiting to do otherwise as different technologies may respond to different sectors' needs. Allowing a natural selection process to occur is likely to yield a better overall result. The technology will improve with increased installed plant capacity and field experience within established hydrogen markets that present low-risk opportunities to project owners and investors. The competitive advantage would drive increased technology and development into other areas/sectors for the use of hydrogen.

If the ultimate aim is to decarbonise and protect the environment, we must remain neutral and be open to any technology that helps achieve this target. However, at the moment, there is no green hydrogen without electrolysers and renewable energy generators. Support of electrolyser manufacturing and renewable energy, such as solar panels and wind turbines, is critical.

19. What further regulatory work is required as we accelerate the development of the hydrogen industry? What barriers do you currently see?

Codes of practice are useful for the enforcement of breaches but do not support and guide as well as a standard or other informative document. The baseline understanding and skill sets required of trades and workers within the hydrogen industry for successful project completion would be supported by:

- formulation of Australian Standards in concert with ISO and IEC international standards
- a product certification scheme particularly for electrolysers and fuel cell systems and corresponding balance of plant items

- a hydrogen competency framework to recognise and accredit hydrogen professionals to improve project delivery efficacy and streamline procurement processes
- a set of nationally consistent, peer reviewed hydrogen industry training modules.

Re-designing projects for different rule sets or state specific regulatory requirements adds a cost barrier that may hinder investment and project execution. These initiatives should be set in consultation with a broad range of hydrogen industry stakeholders including regulators, generators, equipment OEMs and consumers of hydrogen.

The sector is still developing in a number of areas and needs to be flexible to change and development. Instead of regulatory control being restrictive, a set of guidelines or principles documents would assist in guiding the industry.

The government needs to adopt investment friendly policy in which it welcomes the new environmentally friendly investment and devise a system to streamline the approval process. Complex approval roadmaps and lengthy reviews, particularly compared to other parts of the world, will work as a barrier. The flip side of this is the time taken for stakeholder engagement for regional infrastructure projects. Good engagement simply takes time. Regional Planning scenarios that prepare communities for these type of infrastructure projects would speed up approval processes.

Benefit all Australians

20. What actions do you view as being critical to build and maintain community support for Australia's developing hydrogen industry?

The support of the general community will be key to the development of the hydrogen industry moving forward. The urgency and pace of the energy transition mean communities are often left behind. Giving communities the tools and skills to be active participants in the development of a hydrogen industry will be an enabler of a sustainable business sector. This will require:

- building local capacity to make informed decisions
- genuine iterative consultation
- taking a place-based approach.

There is currently a general lack of awareness and understanding of the hydrogen industry's existing and future role in underpinning Australia's energy decarbonisation. The government must lead public engagement with transparent and clear communication to promote the hydrogen industry. A key vehicle for this could be to develop a range of regional planning schemes that focus on renewables and green hydrogen infrastructure. Development of the planning schemes would involve in-depth engagement with a view to minimising timeframes for individual project approvals.

Engagement may include promotions at local communities and schools to demystify hydrogen. Regular updates on progress, safety measures, and potential economic and environmental advantages will be vital to maintain support. Support the local community with skills development and thus secure employment and well-paying careers. Demonstrate that green hydrogen production is safe and sustainable.

A major concern with the community about hydrogen, particularly ammonia, is the risk of explosion. While these concerns can be overstated, the negative sentiment can impede the social acceptance of hydrogen projects and cause delays in approvals and permits. Communities in close proximity to Hydrogen Hubs would be important focus areas, particularly those in regional areas.

It is essential that Australians see the benefits of any proposed hydrogen exports. These projects will have massive land and resource footprints, given the significant renewable energy and water requirements, and take up workforce and supply chain resources that could otherwise be utilised to decarbonise our own economy.

21. How should the interests of the emerging hydrogen industry with respect to water be balanced with other users?

To develop a sustainable water supply in support of a hydrogen industry, we need a national water strategy that considers all sources and uses, including environmental and agricultural, across the economy, now and well into the future. This can be one of the major challenges faced by the hydrogen industry, particularly with extended periods of drought.

While we have developed a good understanding of the water required in the creation of both green and blue hydrogen, as well as conversion to ammonia, the government must include the impact on water resources and agriculture in its long-term strategy and planning process. A formal study into the impact on water resources affected by the existing green hydrogen pilot installations may help to address this question. The potential of fresh, desalinated and recycled water should all be considered.

The quality of the water or preprocessing needed to purify the water for hydrogen generation or other uses needs to be considered. For example, water that may not be suitable for hydrogen generation without preprocessing may be suitable for irrigation.

Water security is a key issue of community concern, particularly in remote regional communities. However, there is a great example of how hydrogen can underpin an integrated drinking water and renewable energy-based power supply for remote indigenous communities. Murdoch University has conducted two projects in the Pilbara Region of Western Australia, which demonstrated that a 100% renewable energy (RE) based stand-alone micro-grid (SAM) using a hybrid hydrogen-battery energy storage system would provide a sufficient and stable power supply and quality drinking water for the local community. This positive case study could be promoted in regional areas to build and maintain community support for hydrogen. (Refer also to Q23).

22. How else can Australian governments ensure that First Nations communities are resourced to effectively participate, benefit and be empowered by the development of the hydrogen industry?

The hydrogen industry must set a very high standard concerning Indigenous communities and their cultural heritage. If hydrogen projects are located on or near Indigenous lands, engage with Indigenous communities and respect their rights and cultural heritage. Establish mutually beneficial partnerships that ensure they share in the benefits of the industry.

See the response to Q20.

23. Is there more information that the communities including First Nations communities would like to receive about the renewable energy and hydrogen sector? What information should be provided?

Community engagement and awareness training will be fundamental to building trust and acceptance of hydrogen projects moving forward (refer to the response to Q 20). A good example is the proposed community engagement process for the Pilbara Hydrogen Hub, supported by funding from the WA Department of Jobs, Tourism, Science and Innovation (JTSI). This is planned to include face-to-face awareness training (Hydrogen 101), an easily accessible knowledge portal with frequently asked questions and answers, and a regular newsletter.

Sharing accurate information in a timely manner in response to community concerns is important. Industry must work with local communities to ensure that the community benefits from the development of hydrogen projects. It is also important to ensure this information is being shared via the right channels to reach the most impacted people in the community.

24. What regulatory barriers will become more prominent as we accelerate the development of the hydrogen industry?

The differences in state legislation will become a prominent regulatory barrier. Having a single set of clear regulatory requirements for the hydrogen sector will enable projects to be designed and executed quickly and safely.

The permitting and approval process is one of the most challenging phases of each project. This can be even more challenging for large-scale projects.

The export of green hydrogen and its derivatives will depend heavily on the acceptance of traded certificates from international agencies. Audits, accreditation, and compatible certificates of origin like the Australian Government "GO", and the European "CERTIFHY" schemes will be very important. Compatibility between Australian and international standards in handling and storing hydrogen-based products will also be essential.

25. What market conditions would indicate the need for a hydrogen reserve, price cap or other fuel security measures?

If we are a net producer, which we should be, we should not need a reserve. We need to ensure some degree of domestic reservation so that all production is not committed to overseas buyers via long term supply agreements.

Rather than a price cap, a competitive hydrogen supply market will drive lower prices. A cap is artificial and if not connected to production costs, will damage producers and the industry.

Commercial viability off the back of strong manufacturing of green products and infrastructure leveraging the abundance of natural resources in Australia should avoid the need for other fuel security measures.

It is crucial that if subsidies are provided there is a viable pathway to commercialisation in the long run. Once subsidies stop, these projects need to be able to demonstrate they will generate profit and that "backfill" developments (new production) will be economically viable in future without subsidy.

26. How can Government/s ensure that the early strong investment in the sector transitions to government revenue as the sector matures?

The first step is to ensure that the hydrogen industry becomes a profit-making part of the ecosystem. Once the capital expenditure has been recovered, royalties become a viable income stream for government. Reviews of the Minerals Resource Rent Tax may expedite this revenue stream if this tax applies to hydrogen production. Otherwise, the government may look to introduce something similar for a mature hydrogen industry.

Infrastructure to support the hydrogen industry

27. How can the National Hydrogen Infrastructure Assessment be delivered to maximise the value to governments and industry?

The existing approach could be repeated, or alternatively, specific infrastructure issues such as water supply and treatment, storage and hydrogen pipelines could be given particular attention.

The hydrogen industry is a young sector that needs support to stand independently. For such an industry, optimisation is a critical component. Government must help the industry to reduce the overall cost of production and handling by long-term planning and establishing (or encouraging the industry players to establish) common infrastructure where possible to spread the cost.

Careful consideration of project development applications, prioritising those that repurpose existing infrastructure and utilise common infrastructure with other related projects, should be a key focus.

28. How can Australian governments ensure the efficient use of existing infrastructure, and delivery of new infrastructure, including common user infrastructure?

The planning and development of Hydrogen Hubs will optimise the efficient use of existing infrastructure and prioritise the development of common user infrastructure by fostering industrial collaboration and

knowledge sharing amongst major industries. Building on existing synergies and industrial symbiosis will reduce cost, minimise waste, and facilitate approvals and permitting.

Infrastructure to support an export industry, including upstream power generation, is critical but should be secondary to domestic needs. Some form of domestic reservation system should be established to prevent the export of essential resources for our own decarbonisation and economic development.

29. How should the infrastructure needs of the hydrogen industry be balanced with other infrastructure users, e.g. electricity generation?

The economics of hydrogen production will vary from one location to another depending on available renewable resources and proximity to demand. A grid connection that might be under heavy load during the day and idle at night can transfer electricity for electrolysers at night. See Q34 below

The use of built energy and embodied carbon for the system should be considered. It should also be noted that electrical infrastructure requires materials such as steel, which creates demand for green steel.

30. What are the trade-offs (or synergies) of developing a hydrogen industry with other government goals?

Significant synergies are required to be leveraged to mutually support other government goals, including electrical infrastructure, solar, batteries, transmission, transportation, water infrastructure and so forth. All of these systems need to fit within the overall system.

The best approach is to see the role of hydrogen as being a part of a much larger ecosystem and plan to address decarbonisation of the ecosystem rather than focusing on the sub-systems. In other words, determine the role of hydrogen in reaching our net zero goals. As Australia experiences deep decarbonisation, this will require an entirely new level of sector coupling with other parts of Australia's energy system. For example, infrastructure upgrades might become sunk costs if they cannot cater for the 'winning' formula. Collaboratively navigating this complexity requires appropriate 'system of systems' level governance structures.

Existing gas infrastructure

31. How can existing gas infrastructure be repurposed to address priority use cases for hydrogen?

The nature of energy export may change, and the timelines and details can vary widely based on Australian and destination countries' policies and approaches. However, whatever the ultimate condition will be, it's critical to understand that the existing gas infrastructure has a role in this transition.

Hydrogen is best used in hard to decarbonise sectors. Existing gas infrastructure for domestic use is possibly best electrified rather than modified for hydrogen. Gas infrastructure for industrial uses is a different scenario, and it may not be feasible to replace commercial gas systems with electrical. Hydrogen blending, storage (underground) and blending of renewable methane are all potential uses of existing gas infrastructure.

Enabling the export industry

32. How can agreements with other nations best support rapid growth to Australia's hydrogen industry?

Given the move toward green hydrogen, a robust Guarantee of Origin scheme for both hydrogen and the renewable energy used to create it, will be critical and a facilitator of trade that potentially creates a competitive advantage for Australia.

Free trade agreements are crucial in supporting hydrogen. Electrolyser manufacturers will need to import some components regardless of the support given to local manufacturers. Difficulty in importing components will increase costs and lead times.

Offtake agreements, with sufficient term and pricing to enable financial investment decisions, are critical. Perhaps the production and consumption governments could share the contract for difference subsidy requirements. The Fortescue Future Industries memorandum of understanding with the German company E.ON to produce up to five million tonnes of green hydrogen by 2030 is a demonstration of the

potential opportunities that come with the push to move away from Russian gas as quickly as possible. This would require around 60-70GW of wind and solar and could initially be shipped as green ammonia. Fortescue has also signed technology deals, including the construction of the world's biggest electrolyser factory in Gladstone, Queensland.

33. How should Australia ensure that the necessary foreign investment in hydrogen industry, and export projects leads to lasting benefits for all Australians?

A simple, consistent and long-term approach to stimulus and policy will enable a stable environment for investment decision making. We should ensure foreign investment does not create monopolies, supply chain issues or profits exiting the country that are out of balance with the benefits achieved by the technology.

Government support for the full supply chain will lead to sustainable foreign investment through multinational companies building offices and factories in Australia, creating long-term benefits for Australian society.

To reach the critical mass production rate which guarantees a positive business case, a large production rate must be achieved. This is impossible by relying only on domestic consumption, at least in the foreseeable future. Reaching that milestone is practically impossible without attracting foreign investment. That investment can be targeted to both domestic consumption and export markets.

The responsible and sustainable development of hydrogen projects in Australia will need to be accompanied by close monitoring of country level plans in Asia and beyond to understand their decarbonisation plans and clean energy requirements on an ongoing basis.

Other feedback

34. What other issues should Australian governments consider in relation to revising the National Hydrogen Strategy?

Soaking up excess solar

There is a significant misconception that the production of hydrogen will easily soak up excess solar. There are two concerns. Firstly, there are significant inefficiencies employing these devices intermittently. The hydrogen device would need to be capable of consuming all of the "spare" power and would only operate at full capacity from about 10am to 3pm if there was solar available, approximately 21% of the time on any given day. The production rates would be a lot lower in the shoulder periods as well. The CAPEX to establish a hydrogen plant is expensive and as a result, you want it to be operating at nameplate capacity to enable your return on investment.

With a battery or a hydrogen plant, if these are in different locations you need to transfer this "spare" solar to the place that it is consumed. The cost of the power lines to battery or hydrogen plant is part of the CAPEX that needs to be invested as well as the plant itself. Where possible, these should be co-located. Building a hydrogen plant where the solar is also necessitates a requirement for water.

Secondly, there is also an issue around the 'quality' of power being fed into electrolysers, which is impacted by the concentration of inverter based solar PV in a particular region. Invertors change DC voltage and current into AC waveforms. They do this with power electronics. The power electronics are switches that turn on an off. The invertor tries to simulate a wave form through a process of the switch being on and off. The produced output is not a perfect sinewave, but it is generally reasonable. The problem is the switches are not perfect and cannot instantly change the power. When you apply this to an inverter that switches all the time, and for different lengths of time, you get a large number of voltage spikes and your process plant may be affected by harmonics.

This is important because a circuit breaker is designed to operate at the zero point to allow it to operate safely. 'Noise' can make it hard to tell where the zero point is. Frequency can affect sensitive devices. Other impacts are that this frequency can affect computer devices, telecommunications equipment and

other sensitive devices. If you are running a process, poor frequency control can impact on production. Control devices try and match the frequency that they produce to the network it is connected to. Network protection devices also utilise a zero crossing detector to determine when to turn feeders on and off. If they cannot tell the zero crossing point, they find it hard to synchronise correctly, which impacts system safety.

Hydrogen Leakage

To ensure a sustainable industry, more work needs to be done to ensure hydrogen leakage does not undermine our greenhouse gas goals through chemical reactions with methane, ozone, water vapour and aerosols. While hydrogen only lasts in the atmosphere for a couple of decades, it can have potent effects.

Natural Hydrogen

Further research into the potential of natural hydrogen produced by geological processes underground could be worthwhile. Natural hydrogen is accessible and offers environmental advantages. It has the potential to provide a cleaner source of hydrogen for various applications, making it an attractive option for commercialising the hydrogen industry.


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