HYDROGEN MOBILITY AUSTRALIA

NATIONAL HYDROGEN STRATEGY

Request for information

Submission by Hydrogen Mobility Australia

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About Hydrogen Mobility Australia

Hydrogen is being recognised globally as having the potential to play a significant role in a future sustainable energy system as a highly versatile energy carrier. The realisation of a hydrogen society built around this clean energy represents a solution to reducing greenhouse gas emissions and the world's reliance on fossil fuels.

Hydrogen Mobility Australia (HMA) is a membership-based industry association with a mission to realise a hydrogen society for Australia. Through government advocacy, education and industry engagement, we are working to facilitate the introduction of hydrogen and fuel cell technologies to Australia, including zero emission transport solutions.

Our membership comprises vehicle and component manufacturers, energy and technology companies, and infrastructure providers with interests across the hydrogen value chain, including hydrogen production, storage, export, power-to-gas, distribution and mobility. Together we recognise the significant opportunity the economy-wide application of hydrogen presents for Australia to decarbonise, diversify the energy mix and create jobs, investment and innovation.

As a hydrogen advocate, HMA's objective is to support the growth of this new energy sector in Australia by specifically:

- Accelerating the commercialisation of new hydrogen and fuel cell technologies by engaging with governments to create a conductive policy and regulatory environment
- Providing a forum for effective communication and collaboration of all stakeholders in the hydrogen and energy community across the public and private sectors
- Progressing Australia's shift towards a future hydrogen society built upon clean and renewable energy technologies through advocacy and education exploiting the expertise, know-how and commercial drive of the HMA members

While HMA is a hydrogen ecosystem advocate, we have a strategic focus on developing a hydrogen mobility sector for Australia. We recognise however that to create a sustainable market for hydrogen-powered transport, we need to create an underpinning hydrogen energy sector through applications such as power-to-gas.

From a mobility perspective, HMA and its members are focused on the introduction of fuel cell electric vehicles (FCEVs) from passenger vehicles and forklifts to semi-trailers and trains to Australia and the establishment of nationwide hydrogen refuelling infrastructure. Our key initiatives pertaining to this are:

- Facilitating demonstration and commercial hydrogen refuelling infrastructure deployment to develop a country wide refuelling station network
- Supporting the large-scale introduction of FCEVs to Australia and measures to encourage their uptake
- Expediting the adoption of internationally recognised regulations, codes and standards for infrastructure and vehicles through harmonisation
- Delivering hydrogen education and thought leadership on Australia's opportunity to develop a domestic and export hydrogen sector

HMA's organisational structure also includes a government observer group in recognition of the importance of public-private collaboration for the development of this sector. Membership of this group includes the Department of Industry, Innovation and Science (Fed), Department of the Environment and Energy (Fed), CSIRO, ARENA, ACT Government, Northern Territory Government, NSW Government, Queensland Government, South Australian Government, Victorian Government and Western Australian Government.

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Executive Summary

Hydrogen Mobility Australia (HMA) welcomes the opportunity to provide input to the COAG Energy Council's National Hydrogen Strategy and its Request for Information - Discussion Paper. We appreciate COAG's commitment to develop an Australian hydrogen sector and look forward to working with federal, state and territory governments on this important piece of work throughout 2019.

Australia is in a unique position to take advantage of the global shift to a clean energy future and become a major supplier of hydrogen to the world. The development of a new export market presents significant opportunities for jobs, investment and innovation nationwide. However, while there is a clear role for governments to play in acting upon this opportunity, government focus should equally be directed towards the development of a domestic hydrogen sector. A domestic focus will ensure Australia maximises the advantages that will be realised through the trade of hydrogen while enjoying the decarbonisation and energy security benefits that it provides.

The global hydrogen sector has seen significant developments in recent years and is on a pathway from niche applications towards mass market commerciality. The opportunity for Australia to capitalise on these developments is immense, however in the absence of a national government action plan including targets across the value chain, and supply and demand side incentives to create a viable domestic marketplace for hydrogen and its applications, the full benefits of these international developments will not be realised.

Our submission makes several recommendations for governments at all levels to develop a sustainable domestic and export Australian hydrogen sector. Of particular importance is the establishment of a clear national vision, objectives and accompanying targets for the Australian hydrogen sector to provide clarity of government and industry priorities. This should be accompanied by targets across the hydrogen value chain for areas including hydrogen production, hydrogen injection into natural gas networks, FCEVs and hydrogen refuelling stations to provide an impetus for industry to respond through investment in the sector.

In addition, the availability of national co-investment support is critical while a robust hydrogen marketplace does not yet exist. Insufficient co-investment support will restrict the sector's ability to scale given that the current phase of hydrogen industry development means government support is necessary to secure the business case for many projects.

Targeted co-investment support should be directed towards projects that show a clear pathway to commercialisation and where possible, enable multiple hydrogen applications to accelerate the scale up of the overall sector, for instance hydrogen mobility and power-to-gas projects leveraging a single hydrogen production facility, thereby taking advantage of sector coupling opportunities.

We also recommend governments examine approaches to ensure environmental and community impacts are effectively managed. While many of the environmental and safety aspects associated with the production, distribution and use of hydrogen can be effectively managed through existing regulations, codes and standards, it is of upmost importance that communities are aware of this fact. As an industry association with a focus on hydrogen safety and community engagement, we would welcome the opportunity to work with governments to develop effective education programs in this space.

1. What do you think are the two or three most significant recent developments in hydrogen?

The most significant recent developments in hydrogen have been evident in the breakthroughs in economic, technical and safety challenges which the sector previously faced and have enabled the advent of an emerging, global commercial marketplace for hydrogen and fuel cell applications. A growing market for hydrogen will require additional incremental improvements in technology, however falling costs and increased efficiencies mean the economics of hydrogen are becoming increasingly attractive, thereby positioning the sector to be a major part of the future energy mix.

Given these developments, hydrogen stakeholders globally are focused on realising a significant step-up across the value chain to achieve competitive costs and mass market acceptance. Hydrogen Council analysis shows that annual investments of US$20 to 25 billion (totalling approximately US$280 billion by 2030) are required to build the scale needed to enable an international hydrogen economy.[1] These investments represent a relatively small but important part of a much larger shift in investments from fossil fuels to clean energy alternatives.

While industry has a significant role in driving this investment, governments equally have an important part to play in setting frameworks that encompass long-term, stable coordination and incentive policies – to attract these investments and scale the technology. For Australia to attract this investment, national action plans which set clear targets across the hydrogen value chain, specific deployment initiatives and associated funding support are required, and must be underpinned by a long-term regulatory framework.

As a consequence of the economic fundamentals of hydrogen becoming increasingly positive, hydrogen applications such as fuel cell electric vehicles or FCEVs are becoming a viable option for zero emission transport on a mass scale. For instance, in the CSIRO National Hydrogen Roadmap passenger vehicles and buses were identified as potentially reaching price parity in or around 2025, however government support is needed in the short to medium term through specific incentives to support initial up-take.[2]

The requirement for government support equally applies to other important hydrogen applications including power-to-gas whereby hydrogen production at scale is needed to realise the full benefits of sector wide decarbonisation and mass energy storage opportunities. Clear policy directives for displacement of natural gas, coupled with co-investment in hydrogen production equipment will be essential to act upon this development in a coordinated and effective manner.

Key point: The global hydrogen sector has progressed from niche applications to mass market commerciality due to fundamental developments in areas including technical research, economics and safety. These breakthroughs have brought about important opportunities such as the sector wide decarbonisation of transport and natural gas while enabling beneficial sector coupling advantages. However, in the absence of a national government action plan consisting of targets across the value chain, and supply and demand side incentives to create a viable market for hydrogen and its applications, the full benefits of these developments in Australia will not be realised.

2. What are the most important safety issues to consider in producing, handling and using hydrogen in Australia?

While hydrogen has been produced and transported in large quantities as a chemical and industrial gas in Australia for many decades, public understanding and exposure to hydrogen is still relatively low. The most

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[1] Hydrogen Council. 2017. *Hydrogen Scaling Up*. Available at: http://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf [Accessed 20 March 2019]

[2] CSIRO. 2018. National Hydrogen Roadmap. Available at: https://www.csiro.au/en/Dobusiness/Futures/Reports/Hydrogen-Roadmap [Accessed 20 March 2019]

effective way of addressing public concern is through the development of appropriate regulatory settings that instil community confidence.

In recognition of the need to start the process of regulatory setting for Australia, HMA successfully lobbied Standards Australia in 2018 to upgrade Australia's participation on ISO Technical Committee 197 – Hydrogen Technologies. The focus of TC-197 includes systems and devices for the production, storage, transport, measurement and use of hydrogen. Through the establishment of Standards Australia committee ME-09, the process of mirroring existing ISO standards into Australian standards will take place over the coming years.

ME-09 will also provide an avenue for Australian input into ISO standards currently being developed by TC-197. Federal and state governments are represented on ME-09 as well as a range of industry associations with interests in hydrogen, including HMA. We urge governments to play an active role in this committee as well as its sub-committees to facilitate and accelerate the adoption of international hydrogen standards for Australia.

The existence of international standards for hydrogen production, handing and use and the process of adopting these standards in Australia needs to be communicated to local Australian communities, including decision makers at the local government level. Federal and state governments can play an important role in this through developing and delivering community education initiatives, including guidelines for approving authorities, in partnership with industry to local governments, businesses and residents on hydrogen standards and safety measures.

Initiatives such as the International Conference on Hydrogen Safety hosted by the South Australian Government in September 2019 is an opportunity to understand best practice from leading jurisdictions in this space. These learnings could culminate in a national hydrogen safety strategy or similar focused on stakeholder communication approaches to secure public acceptance as well as practices for working with local governments with an aim to comfort in approving hydrogen projects.

It should be noted that safety and technical standards for some hydrogen applications are still being explored, such as those related to power-to-gas activities. In Europe, a region pioneering this space, much of this work is being conducted at the local level. HMA therefore supports the work of the National Hydrogen Strategy – Gas injection kick-starter as a sensible approach to reviewing the current status of Australian both nationally and the state/territory level and developing recommendations as appropriate.

In addition to the above, we also support the work of the Future Fuels Cooperative Research Centre which is enabling the Australian gas and pipeline industry to provide a competitive, low carbon energy alternative for residential, commercial, industrial and transport sectors, including hydrogen. Their work is also considering approaches for securing social licence for hydrogen production, transportation and storage infrastructure, through research projects and engagement with communities.

Key point: Safety issues related to the production, handling and use of hydrogen have to a significant extent been addressed at the international level through ISO standards, of which Australia is currently in the process of adopting, and through existing frameworks relating to the use of hydrogen in chemical and industrial settings. Where gaps do exist however is in the communication of these frameworks to communities and local governments. Governments can play a role in disseminating this information, with strategic approaches informed by work of entities such as the Future Fuels CRC.

3. What environmental and community impacts should we examine?

As hydrogen is an established commodity, the environmental and community impacts associated with its production, storage and transport on land from traditional production methods, such as steam methane reforming of natural gas or coal gasification are well understood within industry and managed accordingly. However, the large-scale development of hydrogen through newer production pathways such as electrolysis will mean leveraging existing learnings in the production, handling and use of hydrogen to manage any potential environmental and community impacts.

Research into public perceptions of hydrogen for energy use indicates that the majority of Australians are supportive of hydrogen as a possible solution for energy and environmental challenges.[3] However, interviews reinforced the view that all demonstration projects will need to recognise concerns related to safety, the management of water resources, land-use change, and potential impacts on local communities. See HMA's response to each of these three aspects raised in the research below.

Safety aspects associated with the production, handling and distribution of hydrogen, as outlined in HMA's response to question 2, have to a large degree been addressed through the work of ISO TC197 – Hydrogen Technologies as well as pre-existing standards associated with hydrogen use in chemical and industrial settings. Where gaps do exist however, is in the communication of these existing frameworks to communities and how they translate into ensuring public safety. Understanding best practice approaches for raising awareness of communities should be a priority of any national approach to driving hydrogen investment in both a domestic and export setting.

Management of water resources is often highlighted as an area of concern in discussions regarding large-scale hydrogen production via electrolysis for export or domestic applications. While analysis of water usage required to enable a hydrogen export sector has been examined by ARENA as part of their analysis on hydrogen export opportunities, review of water usage for domestic purposes should also be considered, also where desalination could play a role. While we understand that water usage to support both a domestic and export sector can be managed, communication of this to allay public concerns regarding water use is an important inclusion of a national strategy on hydrogen.

Land-use changes, similar to consideration of water resources, equally requires review by governments, including particularly where the advent of dedicated solar array or wind farms to support a large-scale renewable hydrogen sector may impact upon existing land uses. Within this review, consideration of approaches to educate and inform local governments in their decision making on hydrogen-related projects is also needed to ensure that risks and opportunities are appropriately assessed.

Impacts on local communities in areas such as safety, management of water resources and land-use changes need to be effectively communicated with to ensure that are sustainably managed with minimal adverse economic or environmental impacts. In addition, communication of the positive outcomes of a hydrogen sector, the local economic impacts of job creation and investment attraction and therefore should also be quantified by governments.

In addition to the above, examining the carbon intensity of hydrogen production pathways to ensure a future hydrogen sector supports the proliferation of clean hydrogen will be important.

Key point: Environmental and community impacts that should be examined through the National Hydrogen Strategy include safety, the management of water resources and land-use change. To fully quantify the positive impacts on communities also, governments should consider undertaking economic analysis of local benefits of hydrogen projects, particularly in regional areas, through job creation, investment attraction and innovation spill-overs.

4. How can Australia influence and accelerate the development of a global market for hydrogen?

Australia can play an important role in supporting the world's clean energy transition through the establishment of international supply chains for clean hydrogen, however while the market pull for hydrogen from countries such as Japan and Korea have yet to be realised, government focus should be directed towards the development of a domestic hydrogen sector. A local focus on the Australian market and

[3] Lambert, V., and Ashworth, P. (2018) *The Australian public's perception of hydrogen for energy.* Retrieved from https://arena.gov.au/assets/2018/12/the-australian-publics-perception-of-hydrogen-for-energy.pdf on 1 February 2019.

investment in renewable energy and hydrogen infrastructure will build a domestic market and acquire the workforce skills needed to meet the expected future global demand for hydrogen from Australian resources.

Government efforts to support the Australian hydrogen sector to effectively transition from domestic supply in the short term to medium term to large-scale exporter in the longer term include the following:

- **National co-investment support** targeted at hydrogen projects that demonstrate a clear pathway towards industry scale-up
- **Introduction of targets for hydrogen and fuel cell technologies across the value chain** to provide certainty for industry to invest in Australia
- **Government commitments to procure hydrogen and its applications** to create initial market demand, for example FCEV integration into fleets and use of hydrogen blends in natural gas use for government buildings
- **Government support and leadership for establishment of enabling programs to support hydrogen export,** such as a hydrogen accreditation scheme (which is currently under development by HMA and CSIRO) as well as leading on a universal definition of 'green hydrogen' due to Australia's competitive advantages in renewable energy and potential role in the global supply of renewable hydrogen
- **Design of training packages** to facilitate development of hydrogen related skills and capabilities to support domestic focussed projects which are expected to be highly transferable to larger-scale efforts to support export

Together, these initiatives will not only signal Australia's commitment to hydrogen to international governments and industry, they will also create demand for hydrogen infrastructure and applications, in turn increasing supply, bringing costs down and supporting mass market adoption.

Key point: For Australia to influence and accelerate the development of a global market for hydrogen, government focus should be directed towards the development of a domestic hydrogen sector create demand for hydrogen infrastructure and applications, in turn increasing supply, bringing costs down and supporting mass market adoption. Government should therefore prioritise mechanisms such as national co-investment support, introduction of targets, public sector commitments to procure hydrogen and its applications, government support and leadership for establishment of enabling programs to support hydrogen export and design of training packages.

5. What are the top two or three factors required for a successful hydrogen export industry?

As outlined above the leading factor required for the development of a successful hydrogen export industry is short to medium term support for domestic focussed hydrogen activities. To enable the growth of a domestic sector however, two actions should be given precedence by governments (1) co-investment support for industry to scale up hydrogen infrastructure to stimulate supply and (2) support for the creation of an initial market pull for hydrogen and fuel cell applications to stimulate demand.

Government co-investment support in the form of direct financial contributions are required to facilitate a coordinated ramp up of local industry as global demand for hydrogen increases. Insufficient funding support will restrict the sector's growth prospects given that the current phase of hydrogen industry development means that co-investment is essential to secure the business case for most projects.

Targeted co-investment support should be directed towards projects that show a clear pathway to commercialisation and where possible, enable multiple hydrogen applications to accelerate the scale up of the sector, for instance hydrogen mobility and power-to-gas projects leveraging a single hydrogen production facility. Financial support for demonstration projects to improve the economic viability of a pilot, attract investment and accelerate the development of a hydrogen industry may also be required until hydrogen export pathways are demonstrated to be technically and commercially viable.

It should also be noted that while infrastructure would drive the initial uptake of current (passenger) vehicles, the same infrastructure can be used for heavy vehicles, which could support the future uptake of hydrogen trucks and buses with more ease.

On the demand side support to **create an initial marketplace for hydrogen and fuel cell applications** is equally important to create a market pull for hydrogen that current does not exist in Australia. Such demand is necessary to attract investment in domestic projects, which as noted above, act as a pathway towards export sector development. Measures such as the introduction of national targets for hydrogen and fuel cell technologies across the value chain, public sector commitments to procure hydrogen and its applications, and consumer incentives for hydrogen products, such as FCEVs are all essential in the short to medium term to create this demand locally and the subsequent spill over benefits for a future hydrogen export sector.

Key point: The leading factor required to develop a successful hydrogen export industry is government support on both the supply and demand side towards the creation of a domestic based hydrogen sector. Enabling the growth of a domestic sector through co-investment support for industry to scale up hydrogen infrastructure to stimulate supply in parallel with support for the creation of an initial market pull for hydrogen and fuel cell applications to stimulate demand will be essential for a coordinated and methodical pathway towards realising large-scale hydrogen export.

6. What are the top two or three opportunities for the use of clean hydrogen in Australia?

The declining costs of both hydrogen-related technology and in hydrogen itself has led to several significant developments for the global hydrogen industry, most notably witnessed in the advent of fully-commercialised hydrogen fuel cell transport and the pursuit of large-scale energy storage through power-to-gas applications leveraging existing gas network infrastructure. Given Australia's road transport usage patterns combined with our expanding renewable energy sources requiring new storage mechanisms, HMA believes the leading opportunities for the use of clean hydrogen in Australia are the development of a hydrogen transport sector as well as hydrogen injection into gas networks. Further information on both opportunities is presented below.

Development of a hydrogen transport sector

FCEVs have been commercially available in Asia, Europe and the US since 2013 and some countries have set explicit targets for vehicle and station targets to accelerate adoption (see table below). The Hydrogen Council predicts that by 2050, hydrogen will power more than 40 million cars, 15 – 20 million trucks, and around 5 million buses. This is around 20% – 25% of their respective transport segments.

2030 FCEV and station targets

Jurisdiction	Vehicles	Stations
California	1 million	1,000
China	1 million	1,000
Korea	6.2 million*	1,200*
Japan	800,000	900

*2040 targets

Over 8,000 FCEVs have been sold worldwide to date, over 200 refuelling stations are operational and automotive executives rank FCEVs as the key trend for the sector. New entrants are entering the sector in recognition of the opportunity, including Woodside Energy who recently joined the international Hydrogen Energy Network consortium planning to roll out 100 refuelling stations in Korea over three years.

In Australia, refuelling infrastructure is currently limited with two stations in operation in NSW and Victoria. Additionally, Toyota Australia (with support from ARENA) recently announced a permanent station will be built at Altona, Melbourne to complement its existing portable refuelling truck. Further, the ACT Government is in the process of acquiring 20 FCEVs and constructing a refuelling station in collaboration with various private companies. These FCEV projects provide a highly visible opportunity to showcase hydrogen and its

benefits, and we believe they will play an important role in supporting the growth of a domestic hydrogen sector by raising awareness with communities and acting as a signal of market readiness and drive investment in the sector more broadly. Toyota Australia's trial of the Mirai FCEV for instance is an example of this in practice.

FCEVs can support the decarbonisation of the Australian transport sector, increase domestic fuel security due to reduced reliance on imported petroleum and build experience and acceptance of hydrogen use as pathways to more challenging projects (including heavy industrial vehicles and export). See a summary of each of these opportunities below.

Decarbonisation of Australia's transport sector is becoming increasingly urgent. Transport is Australia's second largest emitter, making up 19% of current greenhouse emissions. Transport-related emissions continue to rise, in part due to a lack of action from governments. Australia, for instance, is now one of only a small number of OECD countries without a CO_2 emissions standard for light vehicles.

The scale of Australia's transport emissions reduction challenge is significant. Affordable, accessible transport is essential to our economy and our way of life. Australia has around 19 million registered vehicles on the road and over 1.1 million new light vehicles are sold each year. From a freight transport perspective, Australian freight vehicles moved over 200,000 million tonne-kilometres of freight across Australia's road network in 2017-18, representing a 5.0 per cent increase in tonne - kilometres (one tonne moved on road over one kilometre) since 2016.

Progress to address freight transport is being seen through initiatives such as Project Portal, a partnership between Toyota and Kenworth to produce ten fuel cell trucks for use at the Port of Los Angeles and within the Los Angeles basin as well as Hyundai's announcement it will supply 1,000 fuel cell trucks to Switzerland over a five-year period, from 2019. These projects represent a stepping stone towards global roll out of freight vehicles in the future, including to Australia.

Domestic fuel security is also a growing area of focus within Australia. Australia currently imports most of its crude oil from overseas (80%) to produce finished fuel products. Hydrogen presents an opportunity to localise production, decrease dependence on international supply chains, strengthen national security, improve balance of payments, and enhance the local industry/employment prospects.

Utilising transport as a pathway to more challenging projects is a sensible approach for building familiarity with the production, handling and use of hydrogen through introduction of tried and tested technologies, such as FCEV's. It also creates a market pull for hydrogen with production likely to scale in an orderly fashion over time as vehicle volumes grow and other hydrogen applications begin to proliferate. FCEVs also act as a stepping stone to the introduction of commercialisation of heavier vehicles, such as heavy haulage and freight vehicles, facilitating the development of an initial infrastructure network.

To capitalise on the opportunity presented by hydrogen-powered transport in Australia, HMA welcomes the inclusion of the transport kick-starter project under the National Hydrogen Strategy which will address the biggest challenge facing the sector; availability of refuelling infrastructure. As a partner in this exercise, we have put forward a proposal to undertake this project which includes a focus on the following areas:

- Development of an agreed industry/government vision, objectives and priorities for Australian hydrogen transport sector development over time
- Assessment of opportunity across all road transport modes with emphasis on heavy vehicles (trucks, buses and trains)
- Approaches to coordinate vehicle availability, customer demand and infrastructure roll out to ensure effective sector deployment
- Consideration of infrastructure models, including costings, technology availability, coordinated roll out opportunities, key stakeholders, operational models etc.
- Geographic mapping of priority regions across Australia for station deployment (at points over time based on vehicle availability/customer demand)

- Consideration of public-private business models to support coordinated and accelerated deployment (including evaluation of international examples)
- Roadmap for deployment of vehicles/infrastructure and government/industry action plan

We look forward to working closely with federal, state and territory governments on delivering this important piece of work which will provide a much-needed strategic plan for the coordinated roll out of the Australian hydrogen mobility sector.

Hydrogen injection into natural gas networks

Australia's high levels of renewables penetration has created large storage requirements. These are being partly met through grid scale batteries and traditional energy storage such as pumped hydro, however additional storage mechanisms will be needed to capture excess energy supply. Australia's gas infrastructure can store the same amount of energy as 6 billion Powerwall batteries and presents an energy efficient low-cost pathway to energy storage on a mass scale.[4]

Through injecting renewable hydrogen into gas pipelines, it can be stored underground for later use or during the colder winter months, providing reserve energy in the same way battery technology does, in a carbon-neutral, secure and cost-effective manner, while also providing interseasonal energy storage.

By taking unused energy generated by renewables and converting it to hydrogen through power-to-gas technology, a secure transformation to a net zero emissions energy system can be achieved. This opportunity is currently being actively explored by HMA members ATCO, Australian Gas Infrastructure Group and Jemena.

The South Australia Government has commenced work on a kickstart project with a scope to 'commence work to allow up to 10 per cent hydrogen in the domestic gas network, both for use in place of natural gas and to provide at-scale storage for hydrogen' and inform the development of the National Hydrogen Strategy. The project will assess the regulatory changes and technical standards that would be required to allow up to 10% hydrogen in gas networks and hence enable the gas networks to be an off taker for hydrogen production projects.

HMA looks forward to the outcomes of this kickstart project, including its identification of the role of governments in supporting the progressive scale up of the injection of hydrogen into gas networks over time.

Key point: The top two opportunities for the use of clean hydrogen in Australia include hydrogen mobility across all transport modes and hydrogen injection into natural gas networks. Both applications will assist Australian to meet its Paris climate commitments, support the growth in renewables through cost-effective large-scale energy storage and deliver fuel security benefits by localised production. They also present important opportunities to scale hydrogen production and supply, providing an underpinning hydrogen sector to build upon for future export opportunities.

7. What are the main barriers to the use of hydrogen in Australia?

The greatest challenge facing the hydrogen sector at present is cost of infrastructure combined with a lack of a viable hydrogen marketplace. While many of the required technologies are already available today – competitive costs can only be achieved with scale in parallel with a market pull for hydrogen. In recognition of this, governments and industry are increasingly shifting their focus from R&D to large-scale deployment initiatives supported by long-term policy frameworks and incentive mechanism to encourage hydrogen demand.

[4] Energy Networks Australia, (2019) *Energy Networks Australia's submission to the Victorian Hydrogen Investment Program.* Retrieved from https://www.energynetworks.com.au/sites/default/files/energy_networks_australia_vic_hydrogen_submission.pdfon 27 March 2019.

The Hydrogen Council recommends current pilot activities should be used as a platform to scale their successes nationally. In the transport sector, they suggest a three-phased deployment plan at the national level, led by an overall roadmap and targeted support to ramp up the infrastructure and deploy more vehicles. In building heat and power, the Council proposes to replicate the approach taken in the UK, investigating a city-by-city transition from natural gas to hydrogen. For industrial applications, they propose support for large-scale pilots in steel manufacturing, power generation, and clean or green hydrogen feedstock for the chemicals, petrochemicals, and refining industries.

Once these technologies are proven, it is recommended that a long-term regulatory and incentive framework should then be put in place to promote uptake. This approach is consistent with HMA's responses above and we recommend the National Hydrogen Strategy reflects this.

Once investment for large-scale projects is secured, barriers such as excessive delays due to regulation or permitting processes can stall these funded projects. It is therefore important that existing regulations continue to protect the public interest and provide a framework for industry to operate in until a need for regulatory change is identified and can occur. However, it is also important to ensure that regulatory processes are commensurate with the risk/impact and do not overburden project proponents to the extent they are discouraged from further investment.

We therefore recommend the National Hydrogen Strategy consider the need for providing regulatory services that explore opportunities to fast track project permitting processes, particularly in relation to land use and water access arrangements.

Key point: HMA recommends the National Hydrogen Strategy include measures to develop and implement a long-term regulatory and incentive framework, including consideration of regulatory services for streamlined project approvals. Currently the two major challenges facing the hydrogen sector are cost of infrastructure and lack of a viable hydrogen marketplace. Regulation and permitting challenges can delay or stall sector development despite securing investment in large-scale projects and identifying supply opportunities.

8. What are some examples where a strategic national approach could lower costs and shorten timelines for developing a clean hydrogen industry?

A strategic national approach can be effective in lowering costs and shortening timelines for developing a clean hydrogen industry, however only if the measures within it are meaningful and targeted at clear industry needs. HMA believes there are four key areas where government action is required.

a. Setting a vision, objectives and accompanying targets for the Australian hydrogen sector
   - Establishment of a clear long-term vision to provide clarity of government and industry priorities, and in turn instil confidence to local and international investors
   - Introduction of targets across the hydrogen value chain, including for hydrogen production, hydrogen injection into natural gas networks, FCEVs and hydrogen refuelling stations similar to other markets, such as Japan and Korea
   - Commissioning of an economic impact analysis to quantify the employment, investment, innovation and spill over benefits that can be generated from a domestic hydrogen sector to support the business case for investment in projects

b. Co-investment support for hydrogen projects
   - Government co-investment programs entailing direct financial contributions while a robust hydrogen market does not exist. Insufficient co-investment support will restrict the sector's growth prospects given the current phase of hydrogen industry development means government grants are essential to secure the business case for most projects given a return on investment is not yet present.

c. Adoption of internationally harmonised and consistent regulations, codes and standards
   - Government support to effectively manage the harmonisation of internationally recognised regulations, codes and standards for infrastructure and vehicles

- Government to investigate and act upon areas where international standards do not yet exist for hydrogen applications

d. Government commitments to procure hydrogen fuel cell technologies, as well as federal government coordination of procurement for other states and territories where scale is required
   - Government fleet commitments to integrate FCEVs into fleets and support the creation of a viable vehicle and hydrogen marketplace
   - Centralised procurement of hydrogen applications where scale is required, such as buses where orders of approximately 100 units and above are needed to achieve economies of scale pricing benefits

Key point: A national strategic approach can be effective in lowering costs and shortening timelines for the development of a hydrogen sector, however only if it includes meaningful, action-oriented initiatives. Specifically, it must set a clear vision, objectives and accompanying targets for the Australian hydrogen sector, ensure sufficient co-investment support for hydrogen projects, facilitate the adoption of internationally harmonised and consistent regulations, codes and standards, and include government commitments to procure hydrogen fuel cell technologies.

9. What are Australia's key technology, regulatory and business strengths and weaknesses in the development of a clean hydrogen industry?

	Strengths	Weaknesses
Technology	• Presence of local hydrogen R&D expertise, through bodies such as CSIRO's Hydrogen Future Science Platform • Australian automotive R&D expertise through GMH, Ford and Toyota engineering facilities	• Limited government support to incentivise establishment of a hydrogen manufacturing and technology sector in Australia
Regulatory	• Stable and well-developed regulatory frameworks • Hydrogen accreditation scheme under development providing guarantee of origin to domestic and export hydrogen customers	• Existence of regulatory gaps across aspects of the hydrogen value chain • Lack of a centralised authority or streamlined process for approval of hydrogen related activities • Lack of a light or heavy vehicle CO2 emissions standards • Uncertain energy policy environment
Business	• Major national and multi-national companies already investing in hydrogen projects in Australia	• Understanding of hydrogen and its applications relatively low across Australian business community

10. What workforce skills will need to be developed to support a growing clean hydrogen industry?

The Hydrogen Council estimates the hydrogen economy will create 30 million jobs globally by 2050.[5] This estimate includes approximately 12 jobs created directly and indirectly per million dollars of revenues in advanced industries. Of these, roughly 15 million additional jobs would be associated with the value added around fuel cells, such as production of vehicles based on the fuel cell powertrain. Investments in the ramp-up of infrastructure and manufacturing would create additional revenues and jobs, mostly in construction and machinery.

[5] Hydrogen Council. 2017. *Hydrogen Scaling Up*. Available at: http://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf [Accessed 20 March 2019]

CSIRO's National Hydrogen Roadmap identifies that Australia has a technically skilled workforce with strong expertise across the energy sector as well as in high value or advanced manufacturing production processes that can be leveraged to develop a hydrogen sector. Australia is therefore well placed to take advantage of this potentially significant job creation opportunity as identified by the Hydrogen Council, however there will be specific areas that will require government to support the transition of the workforce to this new sector.

One area for example identified by HMA in its preliminary assessment of skill requirements for an emerging hydrogen sector will be the need for a certification system for gas fitters (or similar) to be validated for working on hydrogen in a residential, commercial and industrial context. This could be delivered through the TAFE system similar to current gas fitter certification which provides accreditation for work on gas systems. In addition, creating a pipeline of students with interests in the hydrogen economy will also be important to ensure sufficient skills to meet potential future demand.

Integrating hydrogen-related topics into STEM programs in schools as well as facilitating deeper partnerships between universities and industry for collaboration on hydrogen projects are some examples of how Australian governments can encourage interest and participation in the sector as it develops.

HMA recommends a mapping exercise of current Australian curriculums be undertaken by the Australian Government to identify gaps in the development of hydrogen related skills followed by the creation of hydrogen curriculums as appropriate to support the creation of skills required for a future domestic and export hydrogen sector.

Key point: Australia is well placed to take advantage of the potentially significant job creation opportunity created through a domestic and export hydrogen sector, however there will be specific areas that will require government to support the transition of the workforce to this new sector.

11. What areas in hydrogen research, development and deployment need attention in Australia? Where are the gaps in our knowledge?

As outlined above, cost of infrastructure and of hydrogen itself is the biggest impediment to hydrogen sector growth worldwide. It is therefore HMA's recommendation that any research, development and deployment opportunities considered by Australian governments should be based on achieving cost reductions in production of hydrogen itself and related equipment or efficiencies of hydrogen-related processes.

CSIRO for instance acknowledges the hydrogen sector value chain currently consists of a series of relatively mature technologies with a high Technological Readiness Level but low Commercial Readiness Index. This conclusion is drawn in recognition of the number of international pilot projects demonstrating use of hydrogen across multiple applications. CSIRO does identify that there is considerable scope for further R&D, however global focus has shifted from technology development to market activation. We note that CSIRO also recently commenced a study into early development R&D needs of the sector, and we look forward to its findings.

With previous funding commitments to, including ARENA's has recently allocated $22 million to 16 research teams to accelerate the development of a potential renewable energy export supply chain, centred around hydrogen and related carrier materials. Given the strong research focus through the program and the recognised need to shift the hydrogen conversation to building scale, there is a clear need for dedicated funding programs for demonstration and commercial stage infrastructure projects. HMA therefore recommends Australian governments prioritise support initiatives for hydrogen production, storage and transport applications that focus on proof of concept and ultimately achieving scale.

Key point: Any research, development and deployment opportunities considered by Australian governments should be based on achieving cost reductions in production of hydrogen itself and related equipment or efficiencies of hydrogen-related processes. Support initiatives for hydrogen production, storage and transport applications that focus on proof of concept and ultimately achieving scale.