26 July 2024

Submission: Transport and Infrastructure Consultation Roadmap

The Australian Pipelines and Gas Association (APGA) represents the owners, operators, designers, constructors and service providers of Australia's pipeline infrastructure, connecting natural and renewable gas production to demand centres in cities and other locations across Australia. Offering a wide range of services to gas users, retailers and producers, APGA members ensure the safe and reliable delivery of 28 per cent of the end-use energy consumed in Australia and are at the forefront of Australia's renewable gas industry, helping achieve net-zero as quickly and affordably as possible.

APGA welcomes the opportunity to provide comments to the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (the Department) consultation on the Transport and Infrastructure Consultation Roadmap (the Roadmap).

APGA supports a net zero emission future for Australia by 2050[1]. Renewable gases represent a real, technically viable approach to lowest-cost energy decarbonisation in Australia. As set out in Gas Vision 2050[2], APGA sees renewable gases such as hydrogen and biomethane playing a critical role in decarbonising gas use for both wholesale and retail customers. APGA is the largest industry contributor to the Future Fuels CRC[3], which has over 80 research projects dedicated to leveraging the value of Australia's gas infrastructure to deliver decarbonised energy to homes, businesses, and industry throughout Australia.

The Roadmap identifies a variety of pathways to decarbonising Australia's transport and freight task. This is a complex and challenging task for which there is no one-size-fits-all solution. Multiple decarbonisation options must be pursued simultaneously. APGA is pleased to see a variety of renewable alternatives being proposed in the consultation, demonstrating that the Department has evolved beyond an attempt to "electrify everything".

Australia's pipeline infrastructure industry can support several identified transport and infrastructure decarbonisation pathways. Pipelines already transport energy in the form of gas and liquid fuel today. Gas pipelines do so cheaper, safer, and more efficiently than equivalent electricity infrastructure, as do liquid fuel pipelines in comparison to fuel transport by truck. Pipelines are also able to be designed to transport and store pure hydrogen at a lower cost than equivalent electricity options.

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[1] APGA, *Climate Statement*, available at: https://www.apga.org.au/apga-climate-statement
[2] APGA, 2020, *Gas Vision 2050*, https://apga.org.au/gas-vision-2050
[3] Future Fuels CRC: https://www.futurefuelscrc.com/

The Roadmap and Action Plan should take a holistic approach to decarbonising Australia’s transport task. APGA recommends:

- **Taking advantage of the full range of transport decarbonisation options.** Supporting multiple decarbonisation pathways, including technologies fuelled by decarbonising electricity, gas, hydrogen and liquid fuel supply chains, will help avoid putting all of Australia’s transport decarbonisation eggs in one basket.
- **Leave energy supply decarbonisation to the Electricity and Energy Sector Plan.** It is important that the Transport and Infrastructure Roadmap not try and solve electricity, gas, hydrogen or liquid fuel decarbonisation itself, instead trusting the Energy Sector Plan will decarbonise each energy supply chain required to decarbonise transport.
- **Leverage the value of gas, hydrogen and liquid fuel pipeline infrastructure.** A holistic approach to decarbonising transport infrastructure should consider hydrogen and renewable liquid fuel pipelines to support refuelling across freight routes and aviation.
- **A strong renewable gas sector supports decarbonisation of transport infrastructure.** Much of the Roadmap’s consideration for transport infrastructure decarbonisation can be supported through utilisation of a strong renewable gas sector via the Industry, Resources and Built Environment sector plans.

Australia’s pipeline industry is here to support the future of decarbonised transport in Australia. APGA provides an example of an integrated hydrogen pipeline refuelling solution for long-distance freight transport in the Appendix.

To discuss any of the above feedback further, please contact me on +61 422 057 856 or jmccollum@apga.org.au.

Yours sincerely,

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Taking advantage of the full range of transport decarbonisation options

The Roadmap identifies multiple opportunities for green hydrogen to contribute to transport decarbonisation. This includes hydrogen fuel cell electric vehicles (HFCEV), which can particularly play a valuable role in heavy vehicles for the long-distance haulage sector, as well as in aviation, rail and maritime. It is worth noting that major brands such as Toyota are also investigating hydrogen internal combustion engines (HICE).[4]

While not considered in the Roadmap, it is also worth considering hydrogen for private light vehicles alongside battery electric vehicles (BEVs). Similarly to diesel supply chains, logistics and supply chains developed for heavy hydrogen vehicles can also be used to support light vehicles. Hydrogen light vehicles may be beneficial for circumstances where BEVs are problematic and there is proximity to hydrogen refuelling infrastructure, including:

- Rural areas in proximity to major hydrogen fuelled freight routes.
- Urban areas in which high density residential circumstances make BEV charging impractical, including insufficient infrastructure or garages fire rating to permit charging.

Be they HFCEV of HICE, hydrogen vehicles have several advantages over BEVs. Hydrogen vehicles are considerably lighter in weight, have greater range and faster refuelling capabilities (depending on type of battery electric vehicle). Hydrogen vehicles can support transport decarbonisation where these points matter.

The major hurdle to hydrogen vehicle uptake today is the lack of access to hydrogen refuelling. To be viable, hydrogen refuelling will require hydrogen which is affordable, reliable, and renewable. This will require efficient hydrogen supply chains.

Efficient hydrogen supply chains leveraging pipeline infrastructure

Hydrogen refuelling will require hydrogen that is affordable, reliable, and renewable. Traditional assumptions[5] place green hydrogen production at “hubs” largely based at ports, however this model has two major implications:

- First, that hydrogen is largely intended for export markets.
- Second, that electricity will be transported to the electrolyser via powerlines.

This analysis reflects an electricity industry view of a future renewable gas market. Alongside the past decades of research by the renewable electricity sector, the gas infrastructure sector has also been researching how to best support the renewable energy transition. It has found the following in contradiction to the port-hub model of hydrogen production:

- Hydrogen is cheapest to produce at scale.[6]

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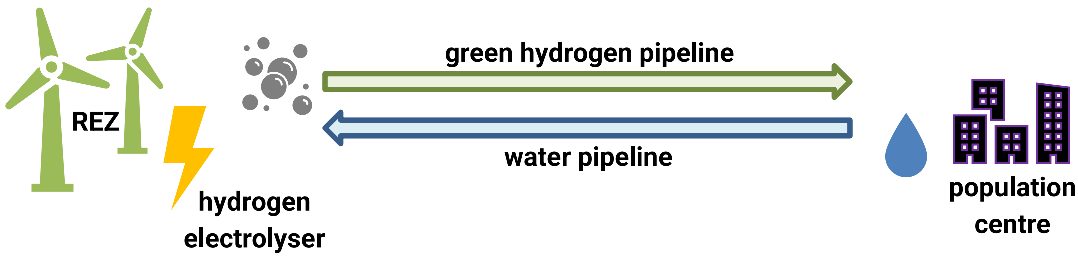
[4] Toyota Australia, 2023, *Toyota Unveils Hydrogen Powertrain Technology for Pilot Program in Australia,* https://www.toyota.com.au/news/toyota-unveils-hydrogen-powertrain-technology-for-pilot-program-in-australia

[5] Particularly AEMO, 2023, *2023 Inputs, Assumptions and Scenarios Report*, https://aemo.com.au/-/media/files/major-publications/isp/2023/2023-inputs-assumptions-and-scenarios-report.pdf

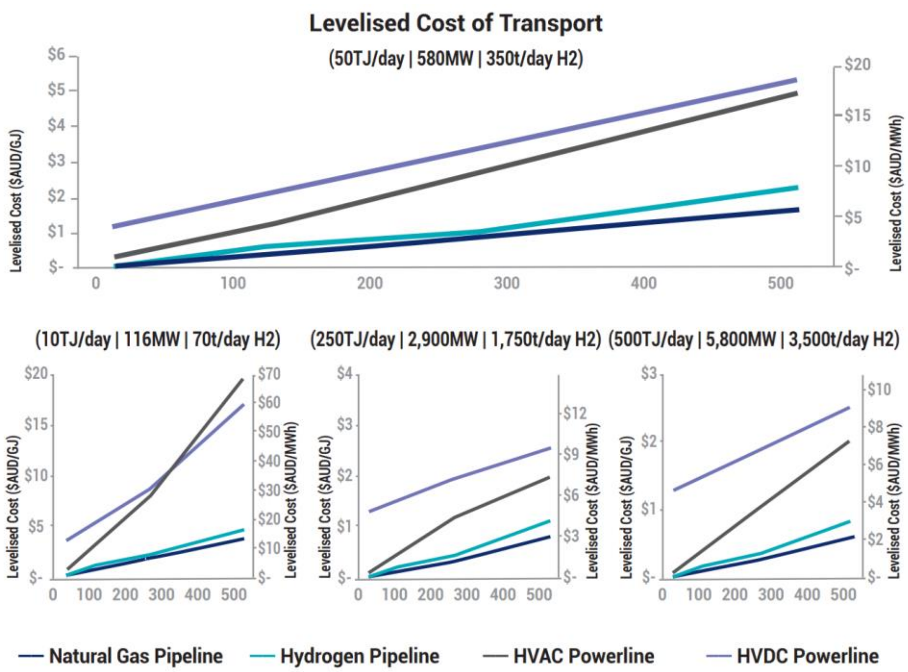
[6] Nous Group, 2023, *Net Zero Australia Final Modelling Results*, https://www.netzeroaustralia.net.au/wp-content/uploads/2023/04/Net-Zero-Australia-final-results-launch-event-presentation-19-April-23.pdf

- Hydrogen is cheaper to transport by pipeline than electricity is to transport by powerline.[7]
- Hydrogen is cheaper to store in pipelines than electricity is to store in batteries.[8]
- Transportation of desalinated sea water to an inland electrolyser comes at a fraction of the overall cost of hydrogen production.[9]

This all points towards producing hydrogen in proximity to renewable electricity production. Co-locating hydrogen electrolysers at the site of renewable energy generation would support lower hydrogen costs for domestic consumers by providing access to least cost large scale hydrogen production, transport and storage.



Gas and hydrogen transmission pipelines consistently cost less to deliver the same quantity of energy across the same distance in comparison to electricity transmission powerlines. Energy transport via hydrogen pipeline is 2-to-4 times cheaper than energy transport via aboveground powerlines,[10] and in the order of 6-to-24 times cheaper to build than underground powerlines.



[7] GPA Engineering, 2022, *Pipelines vs Powerlines: A Technoeconomic Analysis in the Australian Context*, https://apga.org.au/research-and-other-reports/pipelines-vs-powerlines-a-technoeconomic-analysis-in-the-australian-context
[8] Ibid
[9] Nous Group, 2023, *Net Zero Australia Final Modelling Results*
[10] GPA Engineering, 2022, *Pipelines vs Powerlines*

Beyond energy transmission, gas and hydrogen pipelines have additional benefits in providing low-cost energy storage. GPA Engineering's research also found that energy storage in pipelines can be hundreds of times cheaper than energy storage in utility scale batteries or pumped hydro, and 2-to-36 times cheaper in hydrogen pipelines.

All of this is important in the context of economics of hydrogen production, and of moving energy large distances from renewable energy zones to population centres. As noted above, hydrogen vehicles are a viable decarbonisation option for heavy vehicles and other transport sectors, including rail, if the necessary transport infrastructure and supply chains are invested in at the same time. The transmission pipeline industry can provide this support through the construction of cost-effective and efficient hydrogen transmission pipelines, co-located along major freight routes to supply HFCEV refuelling. This would also support hydrogen supply for other gas decarbonisation activities.

APGA has advocated – particularly regarding blending of renewable gases into networks for residential use – for governments to take an 'abundance' rather than a 'scarcity' mindset to renewable gases. A scarcity mindset considers that renewable gases will be a scarce resource that should be reserved for the highest-value uses. This reduces the case for broad-scale investment as the potential market and growth opportunities will necessarily be limited. An abundance mindset will instead provide strong signals for investment and growth by enabling producers to access the biggest possible market.

Transport and Infrastructure Action Plan can coordinate corridor development

As regional centres develop along major road corridors and cities expand out beyond previously industrial areas, it is critical that corridors for fuel pipelines, including hydrogen pipelines, be identified and reserved early.

Grant funding programs have provided some initial development to this industry. The Hume Hydrogen Highway initiative is a joint initiative between the Victorian and NSW state governments to support the growth of both renewable hydrogen and the decarbonisation of heavy transport.[11] The program provides grants towards the development of refuelling stations along the Hume Highway, and the procurement of HFCEV long-haul heavy freight vehicles, the successful industry partner is expected to be announced in the near term.[12]

Alongside this and broader hydrogen industry development programs such as Hydrogen Headstart and the Hydrogen Production Tax Incentive, a holistic view is required. This is where the Transport and Infrastructure Action Plan can provide a tangible and coordinated plan for the transition of this industry, across both state and Federal Governments.

APGA recommends developing a roadmap for hydrogen pipeline corridors alongside major Australian freight routes, such as the Hume and Pacific Highways. An example of this is explored in APGA's submission to the 2022 National Electric Vehicle Strategy consultation (Appendix 1).

[11] DEECA, 2024, *Hume Hydrogen Highway*, https://www.energy.vic.gov.au/grants/hume-hydrogen-highway

[12] DCCEEW, 2024, *Hume Hydrogen Highway*, https://www.energy.nsw.gov.au/business-and-industry/programs-grants-and-schemes/hydrogen-refuelling-network-funding

Electrification is not always the default pathway

The consultation Roadmap makes some assumptions about the decarbonisation of electricity and energy, stating that "electrification is the clear decarbonisation pathway for much of the transport sector. However, this outcome relies on the decarbonisation of the electricity grid."

This is not a fiat accompli, as can be seen in the decarbonisation options that do not rely on the electricity grid. Hydrogen fuel cells, biodiesel and sustainable aviation fuel are all real decarbonisation options for transport and its infrastructure, which can provide a separate decarbonisation pathway that is not reliant on decarbonisation of the electricity grid.

These options can be supported by pipeline infrastructure, which delivers more energy at lower cost than electricity today. Even new hydrogen pipelines can transport and store energy for a lower cost than electricity powerlines or electricity storage. Where the final Roadmap considers transport energy decarbonisation, it should also consider leveraging the economic efficiency of gas and pipeline infrastructure.

Sustainable Aviation Fuel key to aviation decarbonisation

Australia needs air transport. Whether for tourism of commerce, there is no getting away from the need to decarbonise the aviation sector. And of all the sectors requiring the energy density of liquid fuels, aviation tops the list. While hydrogen and electric-powered aircraft are under development, it is likely that aircraft will need to be fuelled with hydrocarbons for the foreseeable future.

Hence, much like the aviation fuel sector of today, a decarbonised aviation sector will need safe, reliable and affordable delivery of sustainable aviation fuel (SAF) and its feedstocks. Also like the aviation fuel sector of today, the SAF sector can leverage fuel pipelines to ensure safe, reliable and affordable transport of SAF.

Transporting SAF and feedstocks through safe, affordable and reliable pipelines

SAF can be made with renewable gas. Hence, developing a cost-effective SAF industry could rely on production which is connected to a blended or pure renewable gas grid. This approach could be lower cost, more technologically ready and more sustainable on feedstock supplies than alternative SAF pathways that exist today.

This requires a fuel- and user-agnostic certification scheme and recognition through NGER. Assuming these are achieved, this can lead to the most optimal mix of infrastructure and low-carbon energy for transport through pipelines.

The concept of using dedicated open-access fuel pipelines to support refuelling of aircraft is long-established in the domestic and international aviation markets. Dedicated fuel pipelines are a common feature of established airports, with fuel trucking typically reserved for smaller airports or during early stages of operation. For airports, fuel that is transported via road is less efficient resulting in higher fuel costs and emissions, both of which the Transport Sector Plan should be conscious of avoiding.

Today, Melbourne, Sydney and Brisbane Airports are supplied through a combination of jet fuel pipelines and road tankers. Adelaide Airport currently solely on road tankers to supply daily fuel needs, but is investigating the use of a nearby existing multi-fuel pipeline for aviation fuel purposes.[13]

Case Study: Western Sydney International Airport

The Western Sydney International Airport (WSI) is a new international airport currently under construction in Sydney's outer south western suburbs, due to open for operation in 2026. When WSI first opens its fuel supply will initially be delivered by road. Work has been underway to identify a fuel transport pipeline corridor since 2017, ideally in road reserves and using either new pipelines or a combination of new and existing pipelines.[14]

Some of this delay is due to the fact that a fuel pipeline is outside the legal boundaries of the airport itself. A 2023 review of fuel options noted WSI's owner could enhance the airport's long-term value to future investors by investing itself in an aviation fuel supply pipeline, or incentivise a potential investor[15] - however development of the pipeline must involve government.

This review recommended that the NSW Government should prioritise the immediate facilitation of an open-access pipeline corridor from potential ports to WSI *before* the optimal routes are compromised by competing development activity. The NSW Government and the WSI are progressing development of a fuel pipeline to WSI and surrounding precinct.[16]

Key to these fuel and feedstock pipelines is that they directly connect producers to their airport customers. But they can also supply other customers via open access pipelines. It is this access to a broad customer base which will provide additional economic incentives to invest in both the fuel and the infrastructure.

Leave energy decarbonisation to the Electricity and Energy Sector Plan

The Transport and Infrastructure Consultation Roadmap (the Roadmap) covers both the decarbonisation pathways of transport sectors and uses, and the decarbonisation of enabling infrastructure and transport energy use. Consideration of which forms of energy to utilise should be founded upon the fact that the Electricity and Energy Sector Plan (EESP) sets out to decarbonise the production of each form of energy.

The five sectoral plans which sit alongside the EESP risk making conflicting decisions if they make electricity and energy decarbonisation recommendations without the context of the EESP. Bringing assurance that electricity, gas, hydrogen, or liquid fuel production is

[13] Adelaide Airport, 2020, *Adelaide Airport Master Plan*, https://corporate.adelaideairport.com.au/wp-content/uploads/2020/05/Master-Plan-Chapter-8-Aviation-Development.pdf
[14] Deloitte, 2017, *Western Sydney Airport Aviation Fuel Supply Corridor Options Report*, https://www.westernsydneyairport.gov.au/sites/default/files/Fuel_Supply_Corridor_Options_Report_Feb2018.pdf
[15] Western Sydney Airport, 2023, *Western Sydney International Airport Review of Aviation Fuel Supply Options – May 2023*, https://westernsydney.com.au/sites/default/files/2023-05/WSI%20Review%20of%20Aviation%20Fuel%20Supply%20Options%202023.pdf
[16] NSW Government, 2024, *Western Sydney fuel pipeline*, https://www.transport.nsw.gov.au/projects/current-projects/western-sydney-fuel-pipeline

decarbonised into the transport (or any other) sector plan risks misalignment with approaches taken in the EESP.

The EESP sets out an all-options approach to decarbonisation, considering pathways for electricity generation and fuel production alike. The decarbonisation of fuel production, including gas, hydrogen, and liquid fuels, is set out in the Low Carbon Fuels section of the EESP consultation. This leads to four decarbonised energy options for the transport sector plan to consider:

- Decarbonised electricity supply for use in BEVs.
- Decarbonised gas supply, for use in CNG vehicles.
- Decarbonised hydrogen supply, for use in Fuel Cell Electric Vehicles or Hydrogen Internal Combustion Engine vehicles.
- Decarbonised liquid fuel supply, for use in conventional fuelled vehicles and aviation.

To avoid conflict, decarbonisation of energy production is best addressed in the EESP and assumed to be addressed within this plan by other plans. The consultation Roadmap does largely leave energy decarbonisation appropriately to the EESP. However, there is risk of sector plan conflict which must be kept front of mind as the final Transport and Infrastructure Roadmap and Action Plan is developed.

The EESP and APGA's recommendations

Beyond agreeing with the all-options approach included in the EESP, APGA provided the following recommendations in its submission to Department of Climate Change, Energy, the Environment and Water (DCCEEW) consultation on the EESP:

- **Develop a NGER market-based method for gas emissions accounting**. Recognising renewable gas certificates in NGER emissions accounting is critical to providing the investment signal for renewable gas production projects reaching FID in the near term.
- **GPG support via the Capacity Investment Scheme or analogous support mechanism**. GPG is needed to support Australia's 82% renewable electricity target. Extending the CIS to include GPG or developing a similar scheme can provide the long-term investment signals necessary to support investment in GPG capacity.
- **A national Renewable Gas Target.** Around 480PJpa of renewable gas is required to deliver least cost gas use decarbonisation by 2050[17]. Targeting the least cost pathway to net zero gas sets national gas decarbonisation ambition. Strong industrial reliance on renewable gas of at least 210PJpa in 2050 makes a national RGT no-regrets policy.
- **Contracts for Difference for renewable gas supply.** Renewable gas certification and recognition in NGER is the first step in starting a renewable gas industry today. The Hydrogen Headstart program is an excellent start but more must be done to ensure availability of large volumes of renewable gas including biomethane. Renewable gas Contract for Difference schemes could be used to cap the cost of renewable gas supply.

[17] ACIL Allen, 2024, *Renewable Gas Target: Delivering lower cost decarbonisation for gas customers and the Australian economy*, report to APGA and ENA, available at https://apga.org.au/renewable-gas-target. See Attachment 1.

These recommendations, alongside the EESP support of renewable gas, hydrogen and renewable liquid fuel supply, would support the availability of renewable fuels for a future transport sector. If supply chains for the stationary use of renewable gases and liquid fuels are designed in tandem with their use in transport, the opportunity for supply chain optimisation arises as discussed elsewhere in this submission.

Renewable gas will support decarbonisation of transport infrastructure

Beyond decarbonising transport modes – road vehicles, trains, aircraft, ships – the Roadmap considers the decarbonisation of the infrastructure that supports those modes. This includes roads and road infrastructure, rail, ports and airports, all of which produce emissions in their construction and operation.

This is likely to be an area that will be covered in detail by the Resources and Built Environment Sector Plans. However, APGA notes that renewable gases and gas infrastructure also will have a large impact in the 'greening' of this sector, through supporting green metals and alloys, green concrete and other building materials and processes. APGA recently provided comments to the Department of Industry, Science and Resources consultation on green metals opportunities for Australia – noting that renewable gas will be a key input and feedstock to viable green metals production.[18]

The sustainable reuse of infrastructure also supports transport decarbonisation. While new pipelines will be required in some areas such as along freight routes, Australia's extensive gas transmission pipeline network spans some 42,000km – many of these pipelines will able to be converted for hydrogen service.[19] Australia's gas distribution network goes even further, and a large proportion of this network is already hydrogen-capable.

[18] APGA, 2024, *Submission: Unlocking green metals opportunities*, https://apga.org.au/submissions/unlocking-green-metals-opportunities

[19] APA Group, 2024, *Parmelia Gas Pipeline – Hydrogen Conversion Technical Feasibility Study*, https://www.apa.com.au/globalassets/our-services/gas-transmission/west-coast-grid/parmelia-gas-pipeline/3419_apa_public-pipeline-conversion_v6.pdf

Consultation Questions

Guiding principles 1. Do you agree with the proposed guiding principles? 2. Do you support the use of the avoid-shift-improve framework as a tool to identify opportunities for abatement?	APGA agrees with the proposed principles where they are technologically agnostic. The development of the Action Plan should pursue all decarbonisation pathways where they result in actual emissions reduction while maximising the economic opportunity. APGA also supports the avoid-shift-improve framework, as long as the 'improve' metric is technologically agnostic and does not rely on a single pathway (electrification). This is important particularly in the short term, where electrification may result in short term intensification of emissions through increased reliance on coal generation.
Promoting active and public transport 3. Do you agree the development of a national policy framework for active and public transport will support emissions reduction? 4. What should be included in a national policy framework for active and public transport and how should it be developed? 5. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure the movement of people contributes to transport emissions reduction?	APGA has no opinion on this.
Decarbonising freight and supply chains 6. The Australian Government has already engaged in consultation on the 2023 review of the National Freight and Supply Chain Strategy	Australia has a range of options to decarbonise freight and supply chains. As detailed in our substantive submission, renewable gases and new and existing gas infrastructure can contribute to the decarbonisation of this sub-sector. Hydrogen fuel cell electric

and those consultations will also inform the final Roadmap and Action Plan. 6.1. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure that the movement of goods contributes to transport emissions reduction? 6.2. How would these actions address the identified challenges and opportunities for emissions reduction in the movement of goods?	vehicles (HFCEVs) are a realistic option for many transport modes, including heavy vehicles, rail and possibly aircraft as well. Governments need to take a holistic and technologically agnostic approach to considering decarbonisation options, while also considering where these options can contribute to the broader economy. For example, to be viable HFCEVs would require access to abundant renewable hydrogen supplies at reasonable cost, and efficient supply chains. This would provide a strong signal for investment in renewable hydrogen generation, supported by new and existing gas pipeline infrastructure. This would in turn increase the supply of hydrogen for other purposes, including green metals. Hence, a mutualistic approach should be taken when considering decarbonisation options.
Net zero pathway for light vehicles 7. Do you agree with the proposed net zero pathway for light road vehicles? Please add details to your response. 8. The Australian Government is currently developing an Australian New Vehicle Efficiency Standard and has already begun to implement actions in the National Electric Vehicle Strategy. 8.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce light vehicle emissions? 8.2. How would these actions address the identified challenges and opportunities to reduce light vehicle emissions?	APGA notes that the same supply chains that would support heavy HFCEVs would also support hydrogen light vehicles. While hydrogen light vehicles (both directly fuelled and using fuel cells) are currently a niche market they are available, as are refuelling stations. These could be expanded relatively easily assuming the supply chains for heavy vehicles are in place. There are some advantages to pursuing another decarbonisation pathway for light vehicles, notably that the challenges of EVs cannot always be overcome for every consumer.
Net zero pathway for heavy vehicles	See also answer to Question 6. APGA considers the proposed pathway to be sensible and appropriately technologically agnostic.

9. Do you agree with the proposed net zero pathway for heavy road vehicles? 10. The proposed pathway for heavy road vehicles relies on a mix of battery electric, hydrogen fuel cell and low carbon liquid fuels. Rank from 1 to 3 the order in which these should be prioritised for emissions reduction. Why did you rank them in that order? 11. What role should low carbon liquid fuels play in heavy vehicle decarbonisation? 12. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce heavy vehicle emissions? 12.1. How would these actions address the identified challenges and opportunities to reduce heavy vehicle emissions?	It may be inappropriate, however to rank pathways for heavy vehicles. As noted in the consultation Roadmap, different options may be suitable for different purposes. Heavy HFCEVs may be much more practical for long distance/intercity haulage, where EVs may meet the need for intracity and last mile haulage. LCLFs in heavy vehicles similarly have a part to play. APGA has been consistent advocating for all decarbonisation pathways to be explored. Governments should consider the costs and benefits of all options when developing decarbonisation strategies. If some of these industries – particularly hydrogen for use in transport – are to be viable, strong signals are required from governments beyond subsidies. Governments should also take an 'abundance' approach – assume all options are on the table, and assume that decarbonised fuels such as hydrogen and LCLFs are as abundant as renewable electricity is assumed to be. In terms of renewable hydrogen, the production of which is only limited by the production of renewable electricity, greater the demand for hydrogen will lead to greater production of hydrogen to meet this demand. APGA therefore supports all hydrogen options for decarbonising transport.
Net zero pathway for rail 13. Do you agree with the proposed net zero pathway for rail? 14. The proposed pathway for rail relies on a mix of battery electric, hydrogen fuel cell and low carbon liquid fuels. Rank from 1 to 3 the order in which these should be prioritised for emissions reduction. Why did you rank them in that order? 15. What role should low carbon liquid fuels play in rail decarbonisation?	See answers to Questions 9-12.

16. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce rail emissions? 16.1. How would these actions address the identified challenges and opportunities to reduce rail emissions?	
Net zero pathway for maritime 17. Do you agree with the proposed net zero pathway for maritime? 18. The Australian Government is engaging in consultation as part of the development of the Maritime Emissions Reduction National Action Plan and those consultations will also inform the final Roadmap and Action Plan. 18.1. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce maritime emissions? 18.2. How would these actions address the identified challenges and opportunities to reduce maritime emissions?	See answers to Questions 9-12. APGA notes that any potential decarbonisation requirements on international ships may put Australian ports at a comparative disadvantage. This will need to be accounted for in cost-benefit analysis of decarbonisation of ports.
Net zero pathway for aviation 19. Do you agree with the proposed net zero pathway for aviation? 20. The Australian Government has already engaged in consultation on aviation decarbonisation through the development of the Aviation White Paper and those consultations will also inform final Roadmap and Action Plan. 20.1. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce aviation emissions?	See answers to Questions 9-12. APGA notes that SAF is likely to be the most realistic option for decarbonising aviation given the limitations of battery and HFC technologies. Fuel pipelines which currently deliver aviation gasoline can also deliver SAF, which makes the supply challenge less complex that it otherwise would be.

20.2. How would these actions address the identified challenges and opportunities to reduce aviation emissions?	
Net zero pathway for transport infrastructure 21. Do you agree with the proposed net zero pathway for transport infrastructure? 22. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce transport infrastructure emissions and ensure that transport infrastructure is ready for and enables low-emission transport modes? 22.1. How would these actions address the identified challenges and opportunities to reduce transport infrastructure emissions?	APGA concurs with the proposed pathway for decarbonising transport infrastructure, noting that renewable gases in the form of green hydrogen and biomethane will be a critical feedstock to green metals concrete as a source of both heat and carbon. Hence, these products are reliant on the abundance of renewable gases.
Transport energy use 23. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure the energy mix is ready to support transport emissions reduction? 24. How should the use of low carbon liquid fuels be prioritised across different transport modes over time to achieve maximum abatement?	APGA cautions that decarbonisation of energy use should be left to the Electricity and Energy Sector Plan.
Travelling in partnership 25. What are the best ways for the Australian Government to work collaboratively with industry, business, governments and communities to implement the proposed pathways? 25.1. What are good domestic or international examples of partnership and collaboration on transport and transport	A collaborative partnership is one that involves all possible stakeholders, including those not traditionally associated with the specific sector or decarbonisation pathway. APGA appreciates the opportunity to comment on the consultation Roadmap and provide perspectives that may not otherwise have been considered.

infrastructure emissions reduction that could inform the final Roadmap and Action Plan? 25.2. What opportunities can the government leverage to show leadership in Australia and internationally?	
Measuring success 26. What measures and metrics should be used to evaluate the final Transport and Infrastructure Net Zero Roadmap and Action Plan? 26.1. What other data and evidence could governments use and how could this offer further insights on the pace, scale and location of transport emissions reduction pathways? 27. Do you have any feedback on the proposed review process? 28. Do you have any further feedback on the Consultation Roadmap and proposed pathways? 28.1. Is there anything missing? Are the sections appropriately integrated? Is the Roadmap appropriately ambitious? 29. Is there any further information or documentation that you wish to be considered with your submission?	APGA has no views on this, other than to approve of the agnostic approach to decarbonisation taken in the consultation Roadmap.

Appendix 1 – APGA submission to National Electric Vehicle Strategy Consultation

10 October 2022

Submission: National Electric Vehicle Strategy Consultation

APGA welcomes the opportunity to contribute to the Department of Climate Change, Energy, the Environment and Water (**DCCEEW**) consultation on the National Electric Vehicle Strategy (the **Strategy**). APGA supports the inclusion of hydrogen electric vehicles within the Strategy and highlights the role which hydrogen pipelines can play in securing least cost refuelling infrastructure for Australia's network of major highways.

Hydrogen electric vehicles are anticipated to play a valuable role in the long-distance haulage and rural private vehicle sectors. Compared to BEVs, hydrogen electric vehicles are lighter in weight, have greater range and faster refuelling capabilities, and can address some of the uptake challenges for electric vehicles in these settings. Key to the rise of Australia's hydrogen electric vehicle fleet will be the availability of reliable, cost-effective hydrogen refuelling, and APGA appreciates the focus which the Strategy applies to this challenge.

APGA is confident that hydrogen refuelling networks supplied by hydrogen pipelines can provide a high availability, cost effective supply chain model for hydrogen refuelling. This opportunity is predicated on the following four concepts:

- Predominant hydrogen refuelling supply chain models;
- Advantages of the hydrogen pipeline transport and storage model;
- Case Studies focused on Australia's two busiest highways; and
- No-regrets hydrogen infrastructure.

APGA hopes that the National Electric Vehicle Strategy will consider hydrogen pipeline supply chain economics within its hydrogen refuelling station strategy on this basis.

Predominant hydrogen refuelling supply chain models

Development of hydrogen refuelling stations will need to consider five macro energy supply chain aspects: renewable energy production, renewable energy transport, and renewable energy storage, renewable energy conversion, and refuelling. While there is little variability in renewable energy production, conversion (electrolysis) and refuelling options, there are a number of different approaches to renewable energy transport and storage (aka supply chain) which are likely to determine the relative reliability and cost effectiveness of a hydrogen refuelling network.

Hydrogen refuelling supply chain models considered in the Australian context to date have relied upon one of three models:

- **Model 1:** Transmission of renewable electricity via the NEM to an electrolyser and hydrogen storage located at a refuelling station;
- **Model 2:** All-in-one renewable electricity generation, electrolysis, storage and refuelling in locations without energy transmission; or
- **Model 3:** A hub and spoke model utilising lower cost bulk hydrogen production at a centralised location, which is stored at refuelling stations once delivered by hydrogen tube trailer.

Each of these models solves one of three problems which occur in the other two models:

- Model 1 avoids the land requirements and variability of generation of Model 2 and the high cost of tube trailer energy transmission of Model 3[20];
- Model 2 avoids the energy transmission costs of either Model 1 or Model 2;
- Model 3 avoids the higher cost per unit hydrogen of small electrolyser deployment capacity in Model 1 & Model 2 and the land requirements of Model 3[21].

These differences make each supply chain model approximately competitive with the other two. APGA wishes to flag a fourth opportunity which improves upon all challenges experienced by each of the predominant three models – refuelling stations supplied by hydrogen pipeline.

Advantages of the hydrogen pipeline supply chain model for hydrogen refuelling

The hydrogen pipeline supply chain model for hydrogen refuelling is uniquely suited to hydrogen refuelling along Australia's network of major highways, each of which require in the order of 10s of terajoules (1000s of kilograms of hydrogen) per day worth of energy to facilitate long distance haulage. Hydrogen pipelines are able to provide low-cost hydrogen transport and storage within one piece of infrastructure, allowing for lower cost refuelling stations and lower cost centralised hydrogen production.

The cost of hydrogen production or refuelling apparatus is out of APGA's scope of expertise. As such, APGA is unable to provide the full energy supply chain costs for any of the above refuelling supply chain models. APGA is however well placed to comment on the advantages of using pipeline infrastructure to transport hydrogen and provides the following in the hope that this information may be added to hydrogen production and refuelling cost information by those who understand costing of these supply chain components.

The cost for transporting hydrogen with and without hydrogen storage across a distance of 500km can be seen in Table 1 below. APGA anticipates that these transport and storage costs are highly competitive in comparison to electricity transmission via the NEM, hydrogen

[20] Reddi et al 2018, Techno-economic analysis of conventional and advanced high-pressure tube trailer configurations for compressed hydrogen gas transportation and refueling, *International Journal of Hydrogen Energy* 43 (9) pp. 4428-4438 https://doi.org/10.1016/j.ijhydene.2018.01.049

[21] United Kingdom Department for Business, Energy and Industrial Strategy, 2021, *Hydrogen Production Costs 2021*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011506/Hydrogen_Production_Costs_2021.pdf

transport via tube trailer, hydrogen storage in on-site hydrogen storage vessels, or any form of electricity storage.

Table 1: Hydrogen pipeline transport and storage costs across a distance of 500km[22]

Refuelling Energy Requirement	Pipeline Transport Cost	Pipeline Storage Cost (4hrs storage)	Pipeline Storage Cost (12hrs storage)	Pipeline Storage Cost (24hrs storage)
10TJ/day or 1,420kgH2/day	$4.64 per GJ	$6.47 per GJ	$2.16 per GJ	$1.08 per GJ
	$0.66 per kgH2	$0.92 per kgH2	$0.31 per kgH2	$0.15 per kgH2
50TJ/day or 7,100kgH2/day	$2.16 per GJ	$0.00 per GJ	$1.50 per GJ	$1.54 per GJ
	$0.31 per kgH2	$0.00 per kgH2	$0.21 per kgH2	$0.22 per kgH2

Note: The referenced material also includes data for distances as short as 25km and transmission volumes as high as 500TJ per day (71t hydrogen per day), all of which demonstrate similar cost competitiveness relative to electricity transmission infrastructure.

Using a hydrogen pipeline to deliver hydrogen to refuelling stations would also minimise refuelling station cost, with refuelling stations only required to compress hydrogen out of the pipeline rather than produce or store hydrogen locally. Additionally, supplying refuelling stations via hydrogen pipelines would enable motorists to access least hydrogen supply as hydrogen would be able to occur in wholesale quantities within in any renewable energy zone (REZ) which the pipeline traversed. APGA anticipates that each of these aspects combined can provide a more reliable and cost-effective hydrogen refuelling supply chain compared to the other models identified above.

Case Studies: The Hume and Pacific Highways

The Hume and Pacific Highways are two of Australia's busiest trucking routes. Including the Pacific Motorway, these major roads span the 1700km between Melbourne and Brisbane and facilitate between 1,000 and 3,000 truck movements each day. Combining data available via the National Freight Data Hub and Victorian ARCGIS accessible databases, with a hydrogen truck fuel use estimate of 20kg hydrogen per 100km, provides the following hydrogen demand potential for average daily trucking movements on the Hume and Pacific Highways.

Table 2: Potential hydrogen demand estimate for all truck movements by highway

Highway	Hydrogen Demand (kgH2/day)	Hydrogen Demand (GJ/day)
Hume Highway (Sydney – Melbourne)	6,590	46,408
Pacific Highway (including the Pacific Motorway) (Sydney – Brisbane)	4,362	30,717

Both highways also benefit from a REZ being located approximately at the halfway point. The Wagga Wagga REZ is located halfway between Sydney and Melbourne on the Hume Highway, and the New England REZ is located around 150km west of Raleigh, the halfway

[22] GPA Engineering, 2021, *Pipelines vs Powerlines: A Technoeconomic Analysis in the Australian Context*, https://apga.org.au/research-and-other-reports/pipelines-vs-powerlines-a-technoeconomic-analysis-in-the-australian-context

mark of the Pacific Highway. Each REZ provides the opportunity for low-cost wholesale production of renewable hydrogen.

This information combined with data from the *Pipelines vs Powerlines* study can be used to undertake high level macroeconomic analysis of hydrogen transport and storage pipelines to supply refuelling stations along each highway.

Case Study 1: The Hume Highway

The Hume Highway has the opportunity to be supplied by two connected 500km hydrogen transport and storage pipelines. These pipelines can be supplied with hydrogen from the Wagga Wagga REZ, as seen in Figure 1. The maximum trucking demand for each hydrogen pipeline would be in the order of 23.2TJ/day, or 3,300kgH2/day. Note that the Hume Highway is already subject to the Hume Hydrogen Highway joint initiative between the Victorian and New South Wales Governments which seeks to support the Hume Highway becoming one of Australia’s first hydrogen transport ready freight corridors.

Pipeline development could take one of three approaches:

- Conservative initial deployment of a pipeline designed for 10TJ/day (1,420kgH2/day) throughput capacity;
- Anticipate future hydrogen demand along the highway as well as in Melbourne and Sydney, targeting 50TJ/day (7,100kgH2/day) throughput capacity; or
- Somewhere in between.

Pipeline development could also incorporate hydrogen storage for 4hrs, 12hrs or 24hrs of throughput capacity.

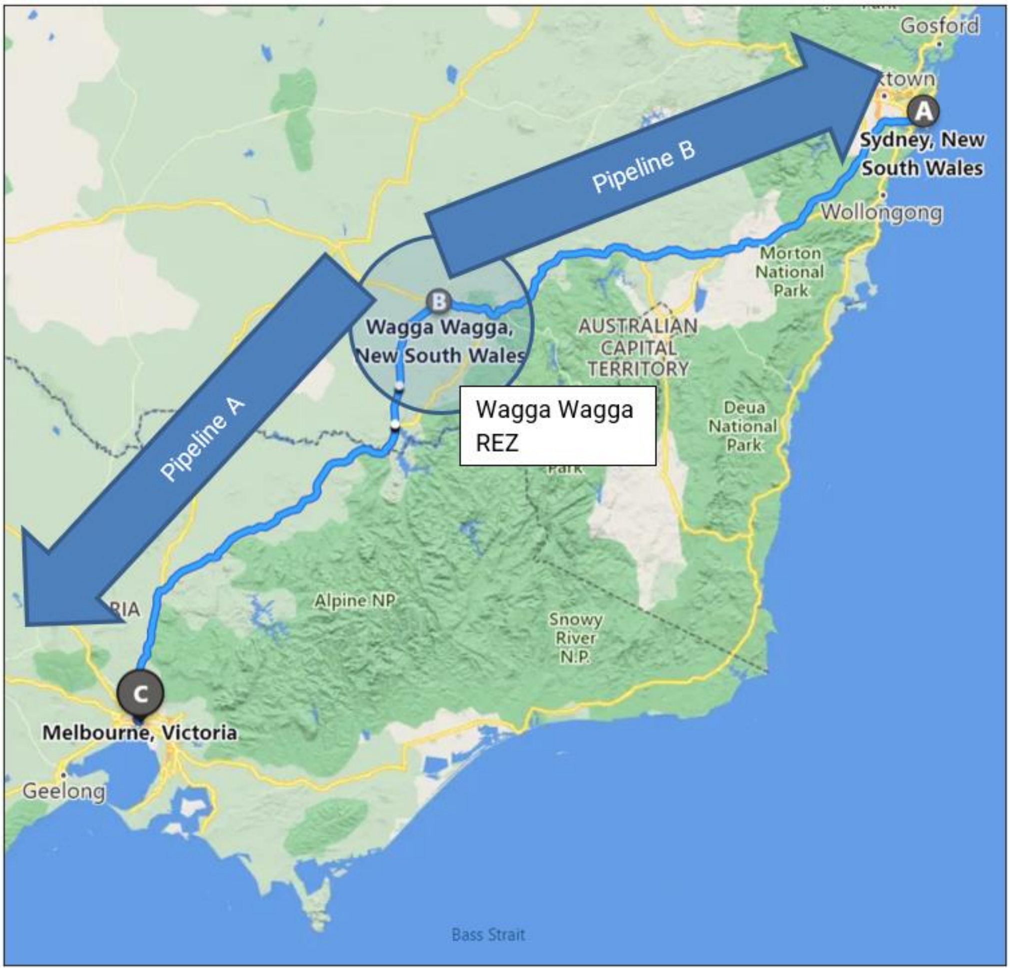
The hydrogen transport and storage costs for development of such a hydrogen refuelling supply chain would be as seen in Table 3. In comparison to tube trailer costs of $1.30 to $3.15 per kilogram of hydrogen delivered, the pipeline energy transport model becomes cost effective from a transport perspective at 9 to 22 per cent of total trucking volume for the 20TJ per day (2,840TJkgH2 per day) configuration. This percentage will reduce once a comparison between onsite hydrogen storage costs and pipeline storage costs are considered, however APGA was unable to find relevant onsite hydrogen storage cost data to undertake this comparison.

Table 3: Hydrogen transport and storage costs for Hume Highway hydrogen pipeline refuelling supply chain

Pipeline Design Case	Total Refuelling Capacity	Transport Cost	24hr Storage	Max VRE Serviceable
2x 10TJ/day 1,420kgH2/day	20TJ/day 2,840kgH2/day 43% Truck Demand	$4.64 per GJ $0.66 per kgH2	$1.08 per GJ $0.15 per kgH2	5.6GWh per day
2x 50TJ/day 7,100kgH2/day	100TJ/day 14,200kgH2/day 215% Truck Demand	$2.16 per GJ $0.31 per kgH2	$1.54 per GJ $0.22 per kgH2	27.8GWh per day

*Max VRE Serviceable: Maximum REZ Variable Renewable Electricity generation quantity to align with full hydrogen pipeline throughput capacity based on 50% electrolyser efficiency.

Figure 1: Hume Highway hydrogen pipeline refuelling supply chain



Case Study 2: The Pacific Highway

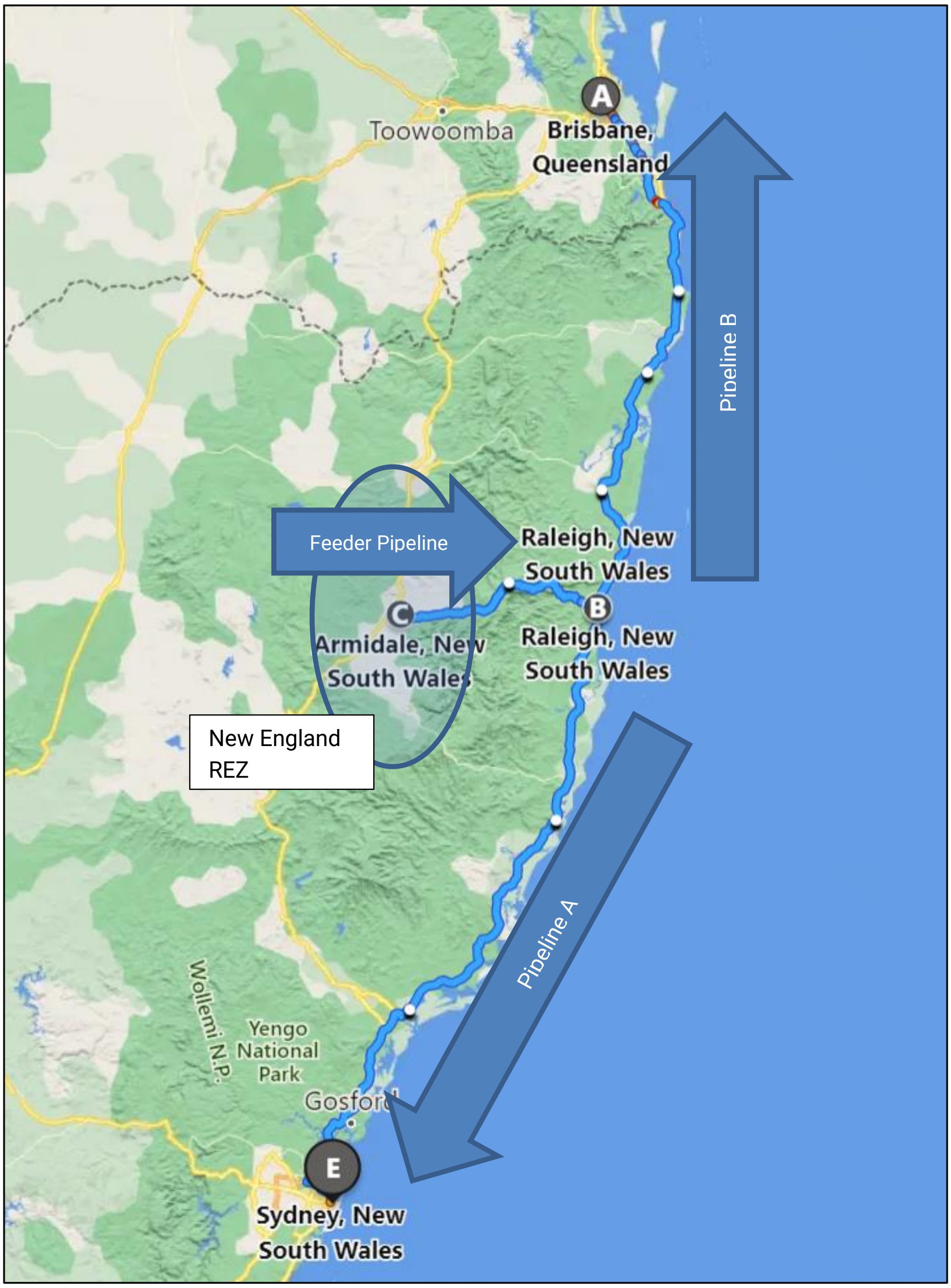
The Hume Highway has the opportunity to be supplied by two connected 500km hydrogen transport and storage pipelines supplied with hydrogen from the New England REZ via a feeder pipeline as seen in Figure 1. The maximum trucking demand for each hydrogen pipeline would be in the order of 15.4TJ/day or 2,200kgH2/day.

Pipeline development could take one of three approaches:

- Start conservatively with the deployment of a pipeline designed for 10TJ/day (1,420kg H_2/day) throughput capacity;
- Anticipate future hydrogen demand along the highway as well as in Melbourne and Sydney, targeting 50TJ/day (7,100kg H_2/day) throughput capacity; or
- Somewhere in between.

Pipeline development could also incorporate hydrogen storage for 4hrs, 12hrs or 24hrs of throughput capacity.

Figure 2: Pacific Highway hydrogen pipeline refuelling supply chain



The hydrogen transport and storage costs for development of such a hydrogen refuelling supply chain would be as seen in Table 4. In comparison to tube trailer costs of $1.30 to $3.15 per kilogram of hydrogen delivered, the pipeline energy transport model becomes cost effective from a transport perspective at 18 to 44 per cent of total trucking volume for the 20TJ per day (2,840TJ kgH_2 per day) configuration. This percentage will reduce once a comparison between on-site hydrogen storage costs and pipeline storage costs are considered, however APGA was unable to find relevant on-site hydrogen storage cost data to undertake this comparison.

Table 4: Hydrogen transport and storage costs for Hume Highway hydrogen pipeline refuelling supply chain

<table>
<tr><th>Pipeline Design Case</th><th>Total Refuelling Capacity</th><th>Transport Cost</th><th>24hr Storage</th><th>Max VRE Serviceable</th></tr>
<tr><td rowspan="2">2x 10TJ/day
1,420kgH2/day</td><td rowspan="2">20TJ/day
2,840kgH2/day
65% Tot. Truck Dem.</td><td>$6.23 per GJ</td><td>$1.08 per GJ</td><td rowspan="2">5.6GWh per day</td></tr>
<tr><td>$0.88 per kgH2</td><td>$0.15 per kgH2</td></tr>
<tr><td rowspan="2">2x 50TJ/day
7,100kgH2/day</td><td rowspan="2">100TJ/day
14,200kgH2/day
325%Tot.TruckDem.</td><td>$3.20 per GJ</td><td>$1.54 per GJ</td><td rowspan="2">27.8GWh per day</td></tr>
<tr><td>$0.45 per kgH2</td><td>$0.22 per kgH2</td></tr>
</table>

*Max VRE Serviceable: Maximum REZ Variable Renewable Electricity generation quantity to align with full hydrogen pipeline throughput capacity based on 50% electrolyser efficiency.

The additional cost for the Pacific Highway system over the Hume Highway system is due to the need to transport hydrogen to Pipeline A and Pipeline B from the New England REZ. This incurs additional pipeline costs of around $0.48 - $2.18 per GJ ($0.07 - $0.31 per kgH2). Due to pressure loss across the feeder pipeline, compression may be required at the intersection near Raleigh at an additional cost of $0.50 per GJ ($0.07 per kgH2).

No regrets hydrogen infrastructure

Hydrogen infrastructure proposed within the above case studies represents no regrets hydrogen infrastructure. Hydrogen uptake is broadly recognised as a necessary component of achieving net zero emission in Australia. If a hydrogen electric vehicle fleet does not arise despite the development of this infrastructure it can be used just as effectively to deliver the hydrogen to three of Australia’s major manufacturing and industrial hubs at equal or greater volumes than proposed within this submission.

With this potential for alternative capital city demand cases in mind, the 50TJ per Day (7,100kgH2 per day) alternative become particularly interesting in each scenario. Due to the reduced per unit cost of larger hydrogen infrastructure compared to smaller hydrogen infrastructure, it makes greater economic sense to design these pipelines to be able to supply manufacturing and industry in the three capitals as well as supplying hydrogen to refuelling stations along these major highways.

This infrastructure is also future proofed in the event that either refuelling or capital city hydrogen demand increases. If a pipeline is designed with storage capacity, this storage capacity can be repurposed for throughput capacity at a later date. For example, a 500km pipeline capable of flowing 10TJ per day (1,420kgH_2 per day) which is capable of storing full throughput capacity for 24hrs would need to be 32-inch in diameter. A pipeline of this size is capable of flowing well over 500TJ per day (71,000kgH_2 per day) when leaving no room for storage capacity, or 50TJ per day (7,100kgH_2 per day) while maintaining 4 hours’ worth of storage capacity.

If hydrogen vehicle use falters, or hydrogen vehicle and/or industrial use sores, the hydrogen pipelines proposed within these case studies are able to either be repurposed in and of themselves or up-purposed through duplication as either source of demand increases.

Supporting hub and spoke model for remote rural communities

As an amendment to hydrogen refuelling supply chain Model 3, hydrogen pipelines can support an extended hub and spoke, or corridor and spoke, model for supplying hydrogen for more remote communities. Tube trailer filling stations can be strategically located along the length of each pipeline proposed in the above case studies, greatly increasing the coverage of hydrogen refuelling without a requirement for more medium scale hydrogen production facilities. This would support greater democratisation of hydrogen access across Australian society while also avoiding the cost of smaller wholesale hydrogen production models.

Building on existing state policy

The case studies proposed within this submission also align with the joint Hume Hydrogen Highway initiative by the Victorian and New South Wales Governments. This initiative recognises the value of hydrogen trucking along the Hume Highway by facilitating the first four hydrogen refuelling stations. These are just the beginning, being sufficient to refuel the proposed fleet of 25 long haul trucks. Once this proof of concept initiative successfully demonstrates the commercial viability of hydrogen trucking along the Hume, both state governments will need to consider the most cost effective approach to allow mass expansion of hydrogen refuelling infrastructure along this route – a challenge which Case Study 1 of this submission may be able to support.