11 November 2022

Submission: Renewable Hydrogen Target for electricity generation in the South West Interconnected System in Western Australia

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 contribute to the Western Australian Governments' consultation on a proposed Renewable Hydrogen Target for electricity generation in the South Western Interconnected System (SWIS). APGA commends the Western Australian Government for demonstrating national leadership through proposing a renewable hydrogen target, and advises the expansion of the generation-specific, hydrogen specific target to cover all gas users and all renewable gases.

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, 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 in Western Australia and nationally.

Western Australia's decarbonisation challenge is not the same as faced elsewhere in the country. As identified in the consultation paper, pumped hydro for mass energy storage is geographically unfeasible in the SWIS. It is likely the SWIS will need to rely on natural gas

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[1] APGA Climate Statement, available at https://www.apga.org.au/apga-climate-statement

[2] APGA, 2020, *Gas Vision 2050: Delivering a clean energy future*, available at https://www.apga.org.au/sites/default/files/uploaded-content/website-content/gasinnovation_04.pdf

power generation to provide dispatchable power for years to come, plus offsets to deliver affordable and reliable net zero electricity.

Hydrogen power generation, supplied through hydrogen pipelines, can initially supplement and may ultimately supplant natural gas power generation in a net zero energy future. Storage of hydrogen in pipelines also offers a realistic and cost-effective storage option for variable renewable energy, especially when compared to battery energy storage systems.

Introducing renewable hydrogen into the energy mix for Western Australia may appear to suffer from low electricity supply chain efficiency. Energy is 'lost' from the point of renewable generation through hydrogen electrolysis, and then through transforming that hydrogen back to electricity. However energy efficiency is only one factor in economic efficiency. When energy storage is taken into consideration, the economic efficiency of the electricity-hydrogen-electricity supply chain markedly improves. Pipelines offer both a realistic and cost-effective storage mechanism for energy in the form of hydrogen, while also providing a cost-effective means of energy transport.

APGA believes that renewable electricity infrastructure and renewable gas infrastructure together can combine to support the least cost, most rapid energy decarbonisation pathway for Western Australia. APGA observes that gas use decarbonisation could cost less through 100% green hydrogen replacement compared to 100% electrification.[3]

APGA supports a 10% Renewable Hydrogen Target for energy generation.

A Renewable Hydrogen Target for energy generation would be a powerful catalyst in developing a broader hydrogen industry in Western Australia. A local hydrogen industry represents a valuable opportunity in assisting Western Australia achieve least-cost decarbonisation of its electricity grid, as well as providing other benefits, such as the potential to catalyse a hydrogen export market.

The proposed renewable hydrogen electricity generation certificate-based scheme would address some of the challenges of connecting the cost of renewable hydrogen to the value of net zero emissions energy for users. APGA believes it is appropriate that the scheme as proposed by Energy Policy WA levies liability for purchasing renewable electricity on electricity retailers and large consumers, but that greater outcomes would be achievable if the Western Australian Government committed to some level of annual certificate purchasing. Alongside a 10% generation target, the certificate scheme would provide considerable support for the investment necessary to achieve broader development of the hydrogen industry and decarbonisation of the SWIS.

[3] Ibid.

APGA supports broadening the Target to consider all renewable gases.

Renewable gases include renewable forms of methane such as biomethane alongside hydrogen. Biomethane is a mature technology and can deliver carbon-neutral gas today at modelled costs in line with projected 2030 hydrogen costs.[4]

APGA considers that such a scheme could have an even greater positive impact on Western Australia's net zero energy transition if it supports all renewable gases equally. APGA proposes that the proposed Renewable Hydrogen Target be built upon to include all renewable gases. This would provide market incentives for biomethane alongside hydrogen, where both can be considered carbon neutral when produced and used, potentially at overall lower cost to energy customers.

APGA supports expanding the Target beyond energy generation.

Renewable gases have the potential to be a source of energy, heat, or chemical feedstock for many industries in the future, beyond energy generation alone. Expanding the proposed scheme to a generic target across all gas use sectors, rather than just electricity generation, would provide additional market incentives towards renewable gas uptake. This itself would deliver least cost emissions reduction through a broader range of market mechanisms than just electricity generation and help reduce the decarbonisation burden of the net zero electricity sector.

APGA proposal: a combined approach

Combining the above two proposals, APGA suggests exploring the following options in order of preference for achieving least cost gas use decarbonisation in Western Australia:

1. A 'generic' Renewable Gas Target for all gas users, plus a Renewable Gas Target for electricity generation
2. Generic Renewable Gas Target just for all gas users
3. Renewable Gas Target just for electricity generation

A generic Renewable Gas Target would considerably broaden the base of the scheme. This may help reduce the impact of any necessary exemption or partial exemptions to the scheme, as well as providing additional market incentives for investment.

Case study: hydrogen pipelines for energy transport and storage

A study by GPA Engineering, commissioned by APGA, compared the relative energy transport and storage costs of hydrogen pipelines, high voltage AC (HVAC) or high voltage DC (HVDC) powerlines, and electricity energy storage technologies.[5] This study concluded

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[4] Research undertaken by the Future Fuels CRC indicates a biomethane cost range of $15 to $29 per gigajoule, close to $2 to $4 per kilogram hydrogen ($14.08 to $28.17 per gigajoule). Please contact Future Fuels CRC for access to this research.

[5] GPA Engineering, 2022, *Pipelines vs Powerlines*, commissioned by APGA.
Pipelines vs Powerlines: a summary
https://www.apga.org.au/sites/default/files/uploaded-content/field_f_content_file/pipelines_vs_powerlines_-_a_summary.pdf
Pipelines vs Powerlines: A Technoeconomic Analysis in the Australian Context

that hydrogen pipelines were a cheaper form of energy transport and storage across all modelled scenarios. To determine the cost effectiveness of full renewable energy supply chains however, a broader view of the supply chain is required.

Figure 1 compares rough levelised cost of electricity outcomes for a range of HVAC and hydrogen pipeline scenarios based on data from the GPA Engineering report and simplified energy supply chains. Hydrogen pipelines begin to deliver a lower levelised cost of electricity downstream of hydrogen gas power generation in cases where at least 60% of the energy needed must be stored prior to dispatch to customers [6]. This is due to the low cost of hydrogen storage and not needing to transport and store energy consumed through electrolysis.

Where 100% of energy needs to be stored, all cases considered within the Pipelines vs Powerlines report show hydrogen pipeline transport and storage deliver lower cost outcomes. This scenario would be relevant when considering 100% utility scale solar PV as the VRE supply for electrolysis, in particular where hydrogen power generation is used to cover morning and evening demand peaks. Full expansion of this analysis is available in Attachment A of this submission.

Resultant Cost of Electricity											
Supplychain	Throughput	Distance	60% of energy stored, 4hrs Storage	85% of energy stored, 4hrs Storage	100% of energy stored, 4hrs storage	60% of energy stored, 12hrs Storage	85% of energy stored, 12hrs Storage	100% of energy stored, 12hrs storage	60% of energy stored, 24hrs Storage	85% of energy stored, 24hrs Storage	100% of energy stored, 24hrs storage
Hydrogen Pipeline Transport and Storage	10,000 per GJ	25	$ 185.01	$ 192.33	$ 196.72	$ 184.19	$ 191.17	$ 195.35	$ 180.67	$ 186.19	$ 189.49
		100	$ 188.32	$ 194.14	$ 197.63	$ 189.69	$ 196.07	$ 199.90	$ 187.69	$ 193.24	$ 196.57
		250	$ 180.94	$ 180.94	$ 180.94	$ 189.09	$ 192.48	$ 194.52	$ 189.79	$ 193.48	$ 195.69
		500	$ 226.67	$ 238.31	$ 245.30	$ 208.03	$ 211.91	$ 214.24	$ 203.37	$ 205.31	$ 206.48
	50,000 per GJ	25	$ 178.66	$ 183.88	$ 187.01	$ 178.97	$ 184.32	$ 187.52	$ 180.31	$ 186.22	$ 189.76
		100	$ 179.38	$ 183.84	$ 186.51	$ 179.68	$ 184.26	$ 187.00	$ 179.74	$ 184.34	$ 187.10
		250	$ 177.31	$ 179.66	$ 181.07	$ 179.91	$ 183.34	$ 185.39	$ 179.86	$ 183.27	$ 185.32
		500	$ 180.85	$ 180.85	$ 180.85	$ 187.31	$ 190.00	$ 191.62	$ 187.49	$ 190.25	$ 191.91
	250,000 per GJ	25	$ 176.21	$ 180.62	$ 183.26	$ 176.94	$ 181.65	$ 184.48	$ 177.12	$ 181.91	$ 184.79
		100	$ 175.06	$ 178.48	$ 180.53	$ 177.05	$ 181.29	$ 183.84	$ 177.37	$ 181.75	$ 184.38
		250	$ 173.36	$ 175.35	$ 176.55	$ 174.54	$ 177.03	$ 178.53	$ 176.27	$ 179.49	$ 181.41
		500	$ 173.45	$ 173.45	$ 173.45	$ 177.54	$ 179.24	$ 180.27	$ 179.14	$ 181.51	$ 182.94
	500,000 per GJ	25	$ 176.35	$ 180.85	$ 183.56	$ 176.94	$ 181.68	$ 184.53	$ 176.50	$ 181.07	$ 183.80
		100	$ 174.14	$ 177.37	$ 179.30	$ 176.54	$ 180.77	$ 183.31	$ 177.02	$ 181.45	$ 184.11
		250	$ 172.27	$ 174.20	$ 175.35	$ 174.57	$ 177.45	$ 179.18	$ 175.37	$ 178.58	$ 180.51
		500	$ 174.26	$ 175.51	$ 176.26	$ 175.67	$ 177.52	$ 178.62	$ 178.09	$ 180.94	$ 182.65
HVAC Powerlines with BESS	10,000 per GJ	25	$ 148.64	$ 186.22	$ 208.77	$ 148.64	$ 186.22	$ 208.77	$ 148.64	$ 186.22	$ 208.77
		100	$ 156.64	$ 194.22	$ 216.77	$ 156.64	$ 194.22	$ 216.77	$ 156.64	$ 194.22	$ 216.77
		250	$ 174.43	$ 212.01	$ 234.56	$ 174.43	$ 212.01	$ 234.56	$ 174.43	$ 212.01	$ 234.56
		500	$ 215.46	$ 253.04	$ 275.59	$ 215.46	$ 253.04	$ 275.59	$ 215.46	$ 253.04	$ 275.59
	50,000 per GJ	25	$ 143.25	$ 179.33	$ 200.98	$ 143.25	$ 179.33	$ 200.98	$ 143.25	$ 179.33	$ 200.98
		100	$ 145.41	$ 181.49	$ 203.14	$ 145.41	$ 181.49	$ 203.14	$ 145.41	$ 181.49	$ 203.14
		250	$ 150.43	$ 186.51	$ 208.16	$ 150.43	$ 186.51	$ 208.16	$ 150.43	$ 186.51	$ 208.16
		500	$ 159.35	$ 195.44	$ 217.09	$ 159.35	$ 195.44	$ 217.09	$ 159.35	$ 195.44	$ 217.09
	250,000 per GJ	25	$ 138.89	$ 173.48	$ 194.23	$ 138.89	$ 173.48	$ 194.23	$ 138.89	$ 173.48	$ 194.23
		100	$ 140.16	$ 174.75	$ 195.50	$ 140.16	$ 174.75	$ 195.50	$ 140.16	$ 174.75	$ 195.50
		250	$ 142.71	$ 177.29	$ 198.05	$ 142.71	$ 177.29	$ 198.05	$ 142.71	$ 177.29	$ 198.05
		500	$ 145.63	$ 180.22	$ 200.97	$ 145.63	$ 180.22	$ 200.97	$ 145.63	$ 180.22	$ 200.97
	500,000 per GJ	25	$ 135.23	$ 168.32	$ 188.18	$ 135.23	$ 168.32	$ 188.18	$ 135.23	$ 168.32	$ 188.18
		100	$ 136.31	$ 169.40	$ 189.25	$ 136.31	$ 169.40	$ 189.25	$ 136.31	$ 169.40	$ 189.25
		250	$ 138.46	$ 171.55	$ 191.41	$ 138.46	$ 171.55	$ 191.41	$ 138.46	$ 171.55	$ 191.41
		500	$ 142.02	$ 175.11	$ 194.96	$ 142.02	$ 175.11	$ 194.96	$ 142.02	$ 175.11	$ 194.96

Figure 1: cost of electricity through hydrogen pipelines (including hydrogen pipeline energy storage) and HVAC (with battery energy storage) supply chains.

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https://www.apga.org.au/sites/default/files/uploaded-content/field_f_content_file/pipelines_vs_powerlines_-_a_technoeconomic_analysis_in_the_australian_context.pdf
Pipelines vs Powerlines: Appendix 3A and 3B Results Summary
https://www.apga.org.au/sites/default/files/uploaded-content/field_f_content_file/appendix_3a_and_3b_results_summary.xlsx

[6] A levelised cost of generation without fuel cost of $50 per MWh for CCGT was assumed from Lazard, 2021, *Lazard's levelized cost of energy analysis*, Version 15.0, https://www.lazard.com/media/451905/lazards-levelized-cost-of-energy-version-150-vf.pdf

APGA commits to continuing to work with the Western Australian Government to help achieve a least cost net zero energy future for all energy customers and welcomes further engagement on the potential for hydrogen and other renewable gas pipelines to support this outcome. APGA members are already investing in hydrogen infrastructure in Western Australia, and we recommend close consideration of their submissions

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

Yours sincerely,

JORDAN MCCOLLUM
National Policy Manager
Australian Pipelines and Gas Association

Attachment A: Expansion of analysis for Figure 1

Variables														
	A	B	C	D	E	F	G	H	I	J	K	L	M	Formula ($/MWh)
Supplychain	MWh	GJ	cost per GJ	Efficiency	Compression	Throughput	Distance	Transport	Cost	Cost	Cost	Generator	Generator	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	10000	25	$ 0.30	$ 4.07	$ 3.88	$ 3.06	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	10000	100	$ 1.26	$ 3.23	$ 3.55	$ 3.08	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	10000	250	$ 2.18	$ (0.00)	$ 1.89	$ 2.05	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	10000	500	$ 4.64	$ 6.47	$ 2.16	$ 1.08	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	50000	25	$ 0.12	$ 2.90	$ 2.97	$ 3.28	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	50000	100	$ 0.48	$ 2.47	$ 2.54	$ 2.56	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	50000	250	$ 0.89	$ 1.30	$ 1.90	$ 1.89	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	50000	500	$ 2.16	$ 0.00	$ 1.50	$ 1.54	50%	$ 14.00	LCoE =
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	250000	25	$ 0.05	$ 2.45	$ 2.62	$ 2.66	50%	$ 14.00	3.6*((B/D+C+E+H+I*[% energy stored])/L+M)
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	250000	100	$ 0.22	$ 1.90	$ 2.36	$ 2.43	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	250000	250	$ 0.46	$ 1.11	$ 1.38	$ 1.79	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	250000	500	$ 1.14	$ -	$ 0.95	$ 1.32	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	500000	25	$ 0.04	$ 2.50	$ 2.64	$ 2.54	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	500000	100	$ 0.16	$ 1.79	$ 2.35	$ 2.46	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	500000	250	$ 0.33	$ 1.07	$ 1.60	$ 1.78	50%	$ 14.00	
Hydrogen	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	500000	500	$ 0.83	$ 0.70	$ 1.02	$ 1.58	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	10000	25	$ 0.83	$ 29.23	$ 29.23	$ 29.23	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	10000	100	$ 3.05	$ 29.23	$ 29.23	$ 29.23	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	10000	250	$ 7.99	$ 29.23	$ 29.23	$ 29.23	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	10000	500	$ 19.39	$ 29.23	$ 29.23	$ 29.23	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	50000	25	$ 0.33	$ 28.07	$ 28.07	$ 28.07	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	50000	100	$ 0.93	$ 28.07	$ 28.07	$ 28.07	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	50000	250	$ 2.32	$ 28.07	$ 28.07	$ 28.07	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	50000	500	$ 4.80	$ 28.07	$ 28.07	$ 28.07	50%	$ 14.00	LCoE =
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	250000	25	$ 0.12	$ 26.90	$ 26.90	$ 26.90	50%	$ 14.00	3.6*(B/D+I*[% Energy Stored]/D+H+C)
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	250000	100	$ 0.47	$ 26.90	$ 26.90	$ 26.90	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	250000	250	$ 1.18	$ 26.90	$ 26.90	$ 26.90	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	250000	500	$ 1.99	$ 26.90	$ 26.90	$ 26.90	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	500000	25	$ 0.10	$ 25.74	$ 25.74	$ 25.74	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	500000	100	$ 0.40	$ 25.74	$ 25.74	$ 25.74	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	500000	250	$ 1.00	$ 25.74	$ 25.74	$ 25.74	50%	$ 14.00	
HVAC	$ 30.00	$ 8.33	$ 3.50	70%	$ 0.55	500000	500	$ 1.98	$ 25.74	$ 25.74	$ 25.74	50%	$ 14.00	

Attachment 2: Submission response template

Renewable Hydrogen Target – stakeholder feedback template

Submission from Australian Pipelines and Gas Association

This template has been developed to enable stakeholders to provide feedback on the questions posed in the Renewable Hydrogen Target consultation paper.

Energy Policy WA encourage stakeholders to use this template. If you wish to provide additional feedback outside the template, wherever possible please reference the relevant question/section to which your feedback relates.

<table>
<tr><th>No.</th><th>Question</th><th>Feedback</th></tr>
<tr><td colspan="3">Renewable Hydrogen Target for electricity generation</td></tr>
<tr><td>1</td><td>What are some examples of an objective or objectives that could be used to assess the benefits, costs and impacts of a Renewable Hydrogen Target for electricity generation?</td><td rowspan="2">A broader objective of supporting renewable hydrogen uptake across all current gas sector use cases can help to ensure hydrogen uptake delivers least cost emissions reduction through a broader range of market mechanisms.

The Western Australian Government can otherwise support and/or encourage other use cases for hydrogen by introducing a more generic Renewable Hydrogen Target which facilitates uptake of renewable hydrogen for all current gas users.

APGA's order of preference for forms of Renewable Hydrogen Targets is as follows:</td></tr>
<tr><td>2</td><td>How might other uses of renewable hydrogen be accommodated under a Renewable Hydrogen Target certificate scheme? How might Government otherwise support and/or encourage other use cases for hydrogen?</td></tr>
</table>

No.	Question	Feedback
		1. Generic Renewable Hydrogen Target for all gas users plus Renewable Hydrogen Target for electricity generation 2. Generic Renewable Hydrogen Target for all gas users 3. Renewable Hydrogen Target for electricity generation. Further, as all renewable gases achieve the same net zero emissions ends, APGA also proposes the Renewable Hydrogen Target evolve into a renewable gas agnostic Renewable Gas Target. A key fact to consider relating to this point is that Future Fuels CRC Research indicates that Biomethane can be produces at costs as low as $2.09 per kilogram hydrogen equivalent today ($14.70 per GJ), where such pricing is a 2030 hydrogen price target. Please contact the Future Fuels CRC for more detail on biomethane cost research.
Considering hydrogen		
3	What role do you believe renewable hydrogen can play in the decarbonisation of electricity generation? To what extent will a Renewable Hydrogen Target for electricity generation in the SWIS assist in achieving the decarbonisation objectives of the State Government?	We know that gas power generation (GPG) supporting variable renewable electricity (VRE) generation improves the whole-of-system cost in the SWIS[7]. It follows that renewable GPG (RGPG) supplied via renewable hydrogen will likely have a similar impact in a net zero electricity future. This is because the majority of the support provided by GPG, being dispatchable, synchronous generation, is also achievable through RGPG despite a marginally higher fuel price. The decarbonisation of gas use via renewable gases further reduces the burden of decarbonisation placed upon the electricity. It is often assumed that electrification of gas demand will be the solution to gas use decarbonisation, however renewable gases provide an alternative. Direct renewable gas

[7] Frontier Economics, 2022, *The role of gas in the transition to net-zero power generation* https://www.apga.org.au/sites/default/files/uploaded-content/field_f_content_file/frontier-economics-report-stc.pdf

No.	Question	Feedback
		supply chains can also more energy efficient than electricity supply chains which utilise renewable gas power generation. These are just two reasons behind APGA's preference toward a generic, renewable gas agnostic Renewable Gas Target over generation only or hydrogen-only targets.
4	What role can the infrastructure associated with the production of renewable hydrogen (i.e. renewable electricity generation facilities, electrolysers, transport and storage infrastructure) play in the broader SWIS?	APGA engaged GPA Engineering to deliver the Pipelines vs Powerlines study in 2022[8]. This has demonstrated that pipelines provide a lower cost form of energy transport and storage in comparison to powerlines and other forms of electricity energy storage. Please see APGA's long form submission for commentary on which portions of the Pipelines vs Powerlines case map demonstrate economic viability of hydrogen energy transport and storage for GPG.
Technical feasibility		
5	To the extent you are able please reflect on some of the technical issues, challenges and considerations in the utilisation of hydrogen in the generation of electricity. To what extent can these technical issues and challenges be overcome? How should this impact on the consideration of a Renewable Hydrogen Target for electricity generation in Western Australia?	As will be highlighted by many, the electricity supply chain from VRE to hydrogen then back to electricity experiences energy efficiency challenges. What is not often discussed however is that in circumstances where all energy produced needs to be stored, such as for peaking power generation, the economic efficiency of renewable hydrogen supply chains can be greater than renewable electricity supply chains. This is predominantly due to the relative cost effectiveness of hydrogen pipeline energy storage in comparison to battery energy or pumped hydro energy storage. APGA explores this opportunity in its long form submission. It is also worth considering the opportunity of megawatt scale fuel cell generation alongside hydrogen turbine and reciprocating engine forms of generation. The APGA member base includes

[8] GPA Engineering, 2022, *Pipelines vs Powerlines*.

No.	Question	Feedback
		companies which specialise in 100% hydrogen turbines and reciprocating engines and would be happy to connect the Department to these members. In addition, please refer to the first megawatt scale hydrogen fuel cell generation facility developed in South Korea to consider the potential for more energy efficient fuel cell generation technologies[9].
Certificate schemes for Renewable Hydrogen Target for electricity generation in the SWIS		
6	Do you believe a renewable hydrogen electricity generation certificate-based scheme represents an efficient and effective means to deliver a Renewable Hydrogen Target for electricity generation in the SWIS? Please explain your answer.	A broader objective of supporting renewable hydrogen and biomethane uptake across all current gas sectors use cases can help to ensure hydrogen and biomethane uptake delivers least cost emissions reduction opportunities through a broader range of market mechanisms. However, in lieu of a generic Renewable Gas Target for all gas users, a renewable hydrogen electricity generation certificate-based scheme is a sound alternative. Such a scheme can address some of the challenges of connecting the cost of renewable hydrogen to the value of net zero emissions energy for users. Ideally this would happen through the National Greenhouse Emissions Reporting Scheme and the Emissions Reduction Fund, but these pathways are currently not fit for purpose for the hydrogen and biomethane industries. APGA believes that certification schemes like the one proposed by the Department can help fill the gap between the cost and the value proposition of hydrogen and other renewable gas production.
7	What are some other approaches which could be considered alongside a renewable hydrogen electricity generation certificate	A generic, certificate based Renewable Gas Target for all gas users.

[9] World largest hydrogen fuel cell power plant was built in Korea by Kospo – 78 MW, Hydrogen Central 2021 https://hydrogen-central.com/largest-hydrogen-fuel-cell-power-plant-korea-kospo/

No.	Question	Feedback
	scheme that would provide a framework to deliver on the objectives or outcomes sought?	
Liable entities		
8	Is the proposed approach of certification, deemed liability and certificate transfer an efficient and effective way to deliver on the intent of the Renewable Hydrogen Target for electricity generation? Are there alternative approaches which could better deliver on the objectives?	APGA supports the general intent of certification, liability, and certificate transfer. The consultation paper does not specify whether the proposed scheme would be similar to other schemes (such as the Federal Renewable Energy Target), with respect to the intent of the Western Australian Government to purchase some or all certificates at a certain value to support funding of renewable hydrogen through the scheme. If this is the intent of the Western Australian Government, APGA would support this approach. Government purchase of at least some volume of certificates would better facilitate uptake without burdening customers with higher energy bills.
Exemptions		
9	What are the benefits, costs and impacts of an exemptions regime for a Renewable Hydrogen Target for electricity generation?	As noted in the consultation paper, an exemption or partial-exemption scheme such as that which operates for 'Emissions Trade-Exposed Entities' in the Federal Renewable Energy Target may be appropriate to reduce the cost of the scheme to specific consumers.
Non-renewable hydrogen		
Renewable fuels		
10	Should the Renewable Hydrogen Target for electricity generation consider alternative renewable fuels as eligible for the creation of Renewable Hydrogen Electricity Generation Certificate? Why or why not?	Yes. APGA believes that a renewable gas-agnostic approach would be appropriate for both an electricity generation target, as well as a generic target for all gas users. Compared to hydrogen, biomethane offers significant early emissions-reductions opportunities, particularly where methane capture (such as from landfill or wastewater) or production (such as biodigesters)

No.	Question	Feedback
		facilities already exist and can be readily blended with natural gas in existing pipelines without technological change.[10] Biomethane produced in single facilities can $2-4/kg especially where operational costs can be offset with other product streams. Expanding the effective definition of a Renewable Hydrogen Target to include other renewable gases (such as biomethane) is appropriate to allow these existing industries to contribute.
Setting a target		
11	Please consider the benefits, costs and implications of a 1%, 5% and 10% Renewable Hydrogen Target for electricity generation in the SWIS on your business or industry, and provide commentary on how you would expect to react from a commercial and investment perspective to each target level.	As noted in the consultation paper, a 10% target would have stimulation investment more effectively than the 1% or 5% targets, and also enable participants to benefit from greater economies of scale. It is important for the future of the industry that the capital costs and technological challenges of hydrogen production be relatively quickly overcome. The gas pipeline industry is already investing in the necessary research and development to augment existing pipeline infrastructure to carry hydrogen, but this investment needs to be replicated across the entire hydrogen and renewable gas supply chain. Despite its higher gross cost, APGA's preference is for the higher (but still modest) 10% target, which will provide significant market impetus for investment to deliver the most rapid pathway to gas use decarbonisation.
12	At a whole-of-economy and / or sectoral level, what do you consider to be some of the benefits, costs and implications of a 1% target, a 5% target, and a 10% target?	
Target terms		
13	Is the suggested approach of a medium term aggregate target, with annual entity targets, an efficient and effective means to	

[10] APGA, 2022, *Gas Vision 2050: 2022 outlook*.

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	achieve the objectives of the Renewable Hydrogen Target for electricity generation in the SWIS? Why or why not?	
14	To what extent should banking and borrowing of liabilities be permitted under the scheme? What are the benefits and costs of a borrowing mechanism as described in the paragraph above?	APGA agrees with allowing for banking and borrowing of liabilities under the scheme, as long as obligations upon entities is maintained at the end of the target period. As with other certification schemes, banking and borrowing could help to address the time it will take to develop investment proposals and business cases for hydrogen facilities in the event that they delayed mandate approach proposed in APGA's answer to Question 15 below is not taken.
Scheme commencement and ramp up		
15	How soon do you believe a Renewable Hydrogen Target for electricity generation in the SWIS could be feasibly delivered from a technical perspective (i.e. if cost was not a consideration)? Please reflect on your own organisation and/or sector when providing your answer.	While commencement of the scheme should occur as soon as practical, mandated achievement of target levels will need to consider practical project delivery timelines. Such consideration would need to include reasonable timeframes for hydrogen production, pipeline and power station development. APGA notes that once a commercial proposition for energy transport and storage via pipeline has been identified, the process of commercial negotiation, development and subsequent construction of contract carriage pipeline infrastructure generally takes a significantly shorter period than equivalent powerline infrastructure which needs to pass through the Economic Regulation Authority (ERA) New Facility Investment Test (or equivalent east coast Regulatory Investment Test – Transmission). This is largely due to the contract carriage nature of pipeline infrastructure. Additional to this point, it is anticipated that the investment and deployment timeframes for hydrogen production and generation facilities would take longer than pipeline investment and deployment timeframes, hence these should form the basis of

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		the window before which any mandated target would come into effect. The scheme should go live as soon as practical such that any project able to deliver sooner than the projected timeline could commence generation of certificates under the scheme, hence providing a competitive advantage for early project delivery.
16	Similar to the above, how soon do you believe a Renewable Hydrogen Target for electricity generation in the SWIS could be feasibly delivered from a commercial or economic perspective (i.e. if cost was a consideration)? Please reflect on your own organisation and/or sector when providing your answer.	
17	Over what period of time do you believe is an appropriate ramp up period for the Renewable Hydrogen Target for electricity generation in the SWIS? In providing your answer reflect on the actions your organisation and / or sector would need to take to participate in the scheme.	
Hydrogen cost outlook		
18	In the short (<5 years), medium (5-15 years) and long (15+ years) term, where do you expect the cost of production of renewable hydrogen to move from the estimated levels of today? What do you expect to be the drivers of this change?	There are many factors influencing the potential pathway costs for hydrogen production, depending on the nature of the pathway component (in this case, is hydrogen being used directly for energy generation, or is it also being used as energy storage in pipelines). The CSIRO's 2018 *National Hydrogen Roadmap* has considered this in detail[11], and the story has already changed in the four years since its publication (especially in the context of high international energy prices). At the time of publication, the levelised cost of hydrogen from electrolysis was modelled as approximately $2.29-2.79/kg by 2025, and as focus has shifted away from thermochemical to electrochemical hydrogen

[11] CSIRO, 2018, National Hydrogen Roadmap, https://www.csiro.au/-/media/Do-Business/Files/Futures/18-00314_EN_NationalHydrogenRoadmap_WEB_180823.pdf

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		production this has considerably altered the value proposition where there are additional benefits. Over the medium to long term, assuming a market is established and made viable such as via this scheme, investment and associated cost of production of green hydrogen is expected to continue to decrease. For Western Australia, scale is likely the single most influential factor (which is where a higher % target becomes important), alongside a coordinated and collaborative approach to setting the regulatory frameworks around the target scheme. Scale also provides the opportunity for large scale advanced manufacturing of hydrogen electrolysers to be developed within Western Australia. Large scale advanced manufacturing is anticipated to substantially reduce hydrogen production costs. Further, the Australian pipeline industry has been working on a Hydrogen Pipeline Code of Practice which seeks to optimise the design of, and hence cost of, hydrogen pipelines in Australia. Hydrogen pipelines designed under existing standards as considered within GPA Engineering's Pipelines vs Powerlines study already deliver lower cost energy transport and storage compared to powerlines and electricity storage technologies. The hydrogen pipeline value proposition is only expected to improve once design is undertaken under the soon to be delivered hydrogen pipeline code of practice.
Hydrogen demand and electrolyser capacity		
19	To what extent to you believe the above scenarios are reasonable and achievable? Please explain your answer with reference to your previous answers regarding the objectives of the scheme.	These scenarios are all achievable in the event that the Western Australian Government invests in the correct supports in policy and regulation. This is especially true where government undertakes annual purchase of some or all certificates within the scheme.

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		This opportunity can be enhanced if the Western Australian Government were to support domestic advanced manufacture of hydrogen electrolysers to mitigate electrolyser cost and medium-term supply chain challenges.
20	How would you expect the levels of hydrogen demand for electricity generation in the SWIS to be met at various points in the supply chain? Would you expect a single generator would emerge and provide all certificates?	The event that a single generator emerges to provide all certificates would indicate that the target is too small to facilitate a diverse and competitive hydrogen gas power generation market.
21	Would you expect one very large renewable hydrogen producer, a number of very small renewable hydrogen producers, or some other combination, to emerge in the State as a result of the scheme? Alternatively, would a domestic-focused producer have sufficient scale to operate in a domestic market only?	APGA can envisage a realistic scenario as a result of this scheme where one or a few large scale, hydrogen producers supplied via behind-the-meter VRE could utilise hydrogen pipeline(s) with linepack storage to deliver least cost hydrogen to generators or other customers. This would be more economically advantageous than a number of small producers, however a number of small hydrogen producers may arise if supply chain issues curtail access to necessary componentry.