CAUTIOUSLY OPTIMISTIC: UNDERSTANDING THE AUSTRALIAN PUBLIC'S RESPONSE TO THE HYDROGEN OPPORTUNITY.

Ashworth, P.[1], and Lambert, V.[2]
[1] School of Chemical Engineering, The University of Queensland, St Lucia, QLD, 4072, Australia, p.ashworth@uq.edu.au
[2] School of Chemical Engineering, The University of Queensland, St Lucia, QLD, 4072, Australia, v.lambert@uq.edu.au

ABSTRACT

The increased activity across the technical world for developing hydrogen has not gone unnoticed at the political level. However, there remains a gap in understanding of how the general public will respond to the development of such an emergent industry. Recognising this gap, we undertook ten focus groups (N=92) and a nationally representative online survey (N=2785) with the Australian public to better understand their response to hydrogen and the opportunities it presents for export and domestic use. In both focus groups and the national survey, when Australians first heard the word hydrogen they were most likely to respond with a neutral response. For example in the survey 81% responded with words such as gas, energy, water; with only 13% giving negative associations (e.g. bomb, explosion, Hindenburg); and 3% positive (e.g. clean, future). Males were more likely to be supportive of hydrogen than females. Those who answered more knowledge questions correctly were also more supportive. The main benefits associated with the use of hydrogen technologies centred around the environment - reduced greenhouse gas emissions and climate change mitigation potential were key benefits. With safety, cost and environmental impacts - particularly concerns around pollution, emissions and water use - being the most frequently cited concerns about the production and use of hydrogen. This presentation focuses on Australian attitudes to the developing hydrogen export opportunity and also for domestic use. Implications for industry and policy makers will be discussed in light of these Australians responses.

Key words: public attitudes, safety, support, risks, benefits

1.0 INTRODUCTION

While the idea of using hydrogen for energy is not new, there remains a number of barriers and opportunities that have been identified as critical for a hydrogen economy to prosper. More recently we have seen the UK enticed by the opportunity for deep carbon emissions reduction, by switching from natural gas to hydrogen through the proposed H21 Leeds City Gate project [1]. Similarly, countries like Japan and South Korea - heavily dependent on imported fossil fuels to meet their energy requirements and with limited capability of producing renewables domestically - see hydrogen as the solution for decarbonising their energy system. Both countries have set aggressive targets for increasing hydrogen use, and together with commercial financing, have made significant investments into the development of their hydrogen industries.

Despite the growing focus on emergent hydrogen technologies and infrastructure, the willingness of the public to accept or tolerate an evolving hydrogen industry has been under explored. There is little evidence of research examining the socio-technical aspects of the technology, both in Australia and internationally. This research set out to fill this gap in Australia. It aimed to identify the current knowledge and understanding of hydrogen in the Australian public; ascertain the potential barriers and enablers for the development of an Australian hydrogen industry; understand how these barriers and enablers may be influenced by various demographic factors; and test hydrogen industry scenarios with the public.

This paper details the results of this research. It reports on the relevant literature around public attitudes to hydrogen, outlines the methodology for our research and details some of the top level findings from focus groups and the national survey. Finally, it makes some suggestions for policy and industry representatives to continue to move discussions forward around the potential for a hydrogen industry to gain a social licence to operate.

2.0 LITERATURE REVIEW

2.1 Earlier public perception studies

A review of the literature showed that public perception studies have been reported most commonly in Europe (33 studies across the UK, the Netherlands, Norway, Germany, Spain, France, Greece, Sweden and Slovenia); with thirteen across Asia (Korea, Japan, Malaysia, Taiwan and China); three in North America; and only one in Australia. The studies used a mix of methodologies including telephone interviews, face-to-face questionnaires, online surveys, and focus groups. Participants were asked about their knowledge of hydrogen and hydrogen technologies, perceptions of risks, and acceptance of technologies. "Willingness to pay" was also a focus of some studies [2,3,4,5,6]. Questions assessing environmental attitudes and behaviours were common [7,8,9,10,11] and trust was also addressed in a number of studies. This included trust in the media [11]. trust in science and technology [12,13], trust in the government and trust in industry [14]. Itaoka and colleagues also addressed participants' risk appetite [11] while Ono and Tsunemi examined risk acceptance, risk avoidance and risk perception [15]. Huijts and colleagues drew connections between emotions (anger, fear, joy and pride) and attitudes based on perceived outcomes, fairness, novelty and trust, in relation to hydrogen refuelling stations in a local community [16,17].

2.2 Initial perceptions of hydrogen

Many studies began by asking participants for their associations with hydrogen. Associations from a study undertaken in Perth were mostly neutral (gas, peroxide, fuel, 54%), followed by 23% reporting negative associations (hydrogen bomb, 17% and Hindenburg, 2%), while 7% reported positive associations (clean, environmental). There were fifteen percent (15%) who indicated they did not know [14,18]. It appears that neutral associations with the word "hydrogen" are the most common response. This was true in both London and Stavanger populations where the researchers were comparing knowledge and acceptance of hydrogen vehicles and refueling stations [19], and also in Germany where the research focused on the same topics [9].

Safety and risk were less of a concern for public acceptance than "green" production. Schmidt and Donsbach [20] reported that "specific dangers such as explosions or the H2 bomb were seldom mentioned" and only 3% cited safety concerns in a Canadian study [21]. An online survey in the Netherlands (n=406) found 28% associated the word hydrogen with bomb/dangerous/explosion, while only 1% related it to the Zeppelin [14].

2.3 Acceptance of hydrogen

In a UK focus group study, where levels of awareness of hydrogen technologies were low, participants expressed mostly neutral views on shifting to hydrogen. They wanted "*much more detailed information about the likely benefits, costs and risks of such technologies*" [22]. Demonstrable benefits for the individual such as cost and practicality were of primary concern, whereas environmental benefits were less important [22]. In a separate Spanish study using an online survey (n=1005), Iribarren and colleagues found there were mixed responses in relation to the production of hydrogen, where 41% supported on site production of hydrogen at refueling stations while 27% preferred centralised production [2].

Itaoka et al. compared a 2015 Japanese survey to past surveys conducted in 2008 and 2009 [11]. Over that period they found that awareness and knowledge of hydrogen technology had increased due to

media coverage. However, acceptance of hydrogen energy had not changed significantly, although there were more people in the neutral camp than in the past. Support for hydrogen fuel cell buses declined from 65% to 59%, while support for gas stations remained constant. However, there were less people in the very positive category. The results found that 52% were supportive of gas stations located near to them selling hydrogen, while only 44% were supportive of a new hydrogen refueling station being built nearby. They concluded that people have become *"more cautious about the risks and benefits"* of hydrogen [11].

3.0 METHODOLOGY

Following our review of the literature, 10 focus groups were held in regional and urban South Australia and Victoria in June, 2018. Participants were guided through a discussion around the emergent opportunities for hydrogen using of a series of short videos [23, 24, 25] and an information sheet. In total, 92 participants (55 female; 37 male) of mixed ages (range 20 to 76 years; mean=44) and employment status attended. All focus groups were audio recorded and subsequently transcribed. From this a thematic analysis was undertaken to identify the key themes.

To further investigate the findings from the literature review and focus groups, a national online survey was then conducted during October, 2018 (N=2785). The respondents were split into three streams where one third completed questions related to transport (N=948) [26], another third focused on the use of hydrogen for domestic use (N= 921), and the final third responded to questions around developing a potential export industry for hydrogen in Australia (N=916). Gender and age statistics for each of the streams are detailed below in Table *1*. Results in brackets contain sub-sample means and/or p-values, where *** indicates $p<0.001$; **represents $p<0.01$; and * is used if $p<0.05$.

Table 1. Gender and age of survey participants

Demographic	Category	Stream A: Transport	Stream B: Domestic Use	Stream C: Export	Total
TOTAL		**948**	**921**	**916**	**2785**
		34.0%	**33.0%**	**33.0%**	**100.0%**
Gender	Male	463	435	487	1385
		48.8%	47.2%	53.2%	49.7%
	Female	482	484	427	1393
		50.8%	52.6%	46.6%	50.0%
	Other	3	2	2	7
		0.3%	0.2%	0.2%	0.3%
Age	18 to 34	274	266	232	772
		28.9%	28.9%	25.3%	27.7%
	35 to 54	333	333	356	1022
		35.1%	36.2%	38.9%	36.7%
	55+	341	322	328	991
		36.0%	35.0%	35.8%	35.6%

4.0 RESULTS

4.1 Initial responses and knowledge of hydrogen

Similar to the earlier international research Australians' responses to hydrogen was generally neutral. In the survey, of responses to the question *"When you hear the word hydrogen what are the first things that come to mind?"* neutral responses (e.g. gas, energy, water) were the most common (81%). Thirteen per cent (13%) were negative (e.g. bomb, explosion, Hindenburg), 3% were positive (e.g. clean, future), and 4% did not know. These responses were also reflected in the focus group findings where the majority

of participants (75%) volunteered neutral associations, 14% negative associations, 7% were positive, and 6% responded that they did not know.

To test links between knowledge and support for hydrogen, participants were asked five questions about the properties of hydrogen (Fig. 1). Only 192 (7%) participants answered all five questions correctly, 447 (16%) four correct and 615 (22%) answered three correct. In total, 1022 (37%) answered less than three correctly and there were 509 (19%) who did not answer any questions correctly. The average score was 2.24 out of 5, or 45%. Males answered more of the 5 knowledge questions correct than females (2.61 vs 1.89***) as did those with higher education degrees (2.57***).

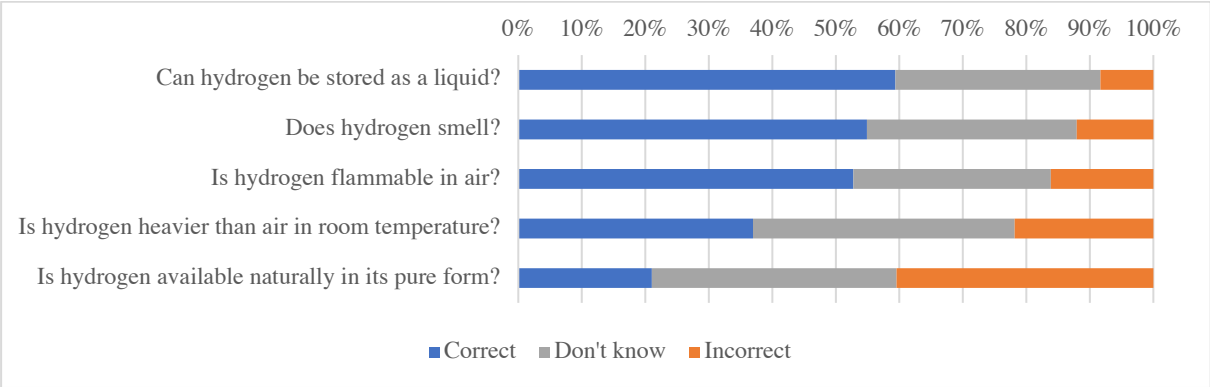

Figure 1. Objective knowledge of hydrogen properties

When asked their familiarity with hydrogen production and its uses, participants felt most confident in their knowledge of the production of hydrogen (Fig. 2). Similarly, hydrogen fuel cell vehicles was the use that most participants had heard of. Of the other uses such as refuelling stations and various domestic uses - approximately 60% of participants had never heard of any of them. Men were more likely to say they know about them and could describe it to a friend (up to 13%) with less than 5% of females answering positively to these questions.

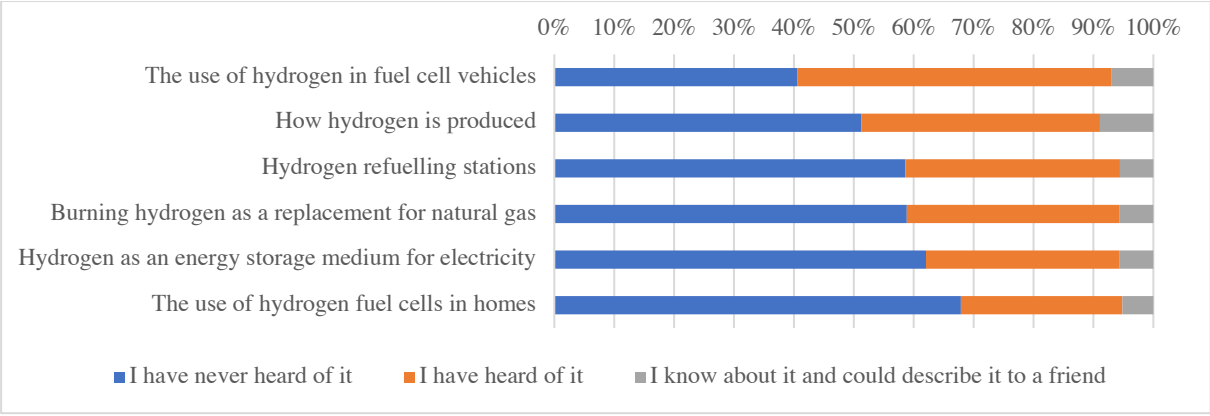

Figure 2. Knowledge of hydrogen production and its uses

In response to the question "*Overall how do you feel about hydrogen as a possible solution for energy and environmental challenges",* the majority of participants were supportive (52%) and 45% neither supportive nor unsupportive. This varied significantly by gender with 65% of males supportive or very supportive compared to only 40% of females. Those who answered more knowledge questions correctly were more supportive ($p<0.001$), while those who knew less tended to be neither supportive nor unsupportive.

4.2 Risks and benefits of hydrogen

In the focus groups, common concerns for hydrogen were around safety, *"What's the worst case scenario if things went wrong?"* [FG1]; and whether there are likely to be any negative environmental impacts*,"...I'd have some concerns about safety issues, both environmental and industrial, because it is still a highly volatile gas, and I would hate to see a spark setting off something, so I'd have concerns both about environmental production and also industrial."* [FG6]. These environmental concerns also stretched to the use and amount of water required for the process, *"You are saying renewables with water. Do we currently have a surplus of water in Australia? You ask people in NSW, the farmers, they are fighting over water. If they went down that path, where is that extra water going to come from?" [FG9].*

There was also recognition that for hydrogen to be accepted it would need to be cost competitive with other technologies. Concerns were around cost to both the consumer as well as what the cost of production might be. This also included considerations for what the energy requirements would be to produce hydrogen, *"...how much energy do you get from hydrogen, related to how much you have to put in?"* [FG10].

Similar results were also echoed in the survey when asked the open ended question "*What are your main concerns associated with the use of hydrogen technologies?"*. Safety (N=1517) was the most frequent response with terms offered including words such as safety, danger, explosions, risk, volatility, flammable, fire, unstable, and leaks. Environmental impacts (N= 426) was another major theme with common terms being environment, pollution, emissions and water. While cost (N=399) also arose with references to price and expensive.

4.3 Hydrogen for export use

From the Export stream of the survey (N=916) there were very few (5%) who opposed the idea of the export of hydrogen with most (72%) being supportive. However, only 38% were happy to have a hydrogen export facility built near them and 22% were opposed. Early adopters, males and those with a university education were more supportive of both export and hosting a facility nearby ($p \leq 0.001$). Those experiencing frequent power outages and younger people were more supportive of a plant being built near them ($p < 0.05$). The younger age group may be thinking of new opportunities for jobs which was a theme that arose in the focus groups.

Focus group participants could see the benefits of Australia developing an export market, particularly with Japan given the well-established trade agreements between the two countries. *"Certainly if we are exporting to Japan we start to get advantages of scale that makes whatever energy we use a bit cheaper for us to step into it." [FG1]*. In addition to opportunities for economies of scale, there was also enthusiasm expressed for Australia to become a leader in innovation which was recognised to bring additional economic benefits. Participants in the regional areas were even more optimistic as they felt the development of such an industry would bring them additional benefits through increased jobs and services. This was particularly the case in Traralgon who were feeling the impacts of the closure of the Hazelwood power station; *"...you could revitalise these ex-brown coal towns, and do a transition…everyone around here just cares about the jobs" [FG10].*

However, despite the enthusiasm for the suggested export opportunities, focus group participants were adamant that this should not be at any expense of domestic needs which they felt had occurred with gas exports. "*If we export this kind of energy using our renewable energy, so our solar and wind, could that possibly make energy more expensive for us?" [FG2].* Similarly, it was important that Australia was not seen to be shipping all of our water resources off shore in the form of liquid hydrogen. *"As long as it is not a strain on our natural resources, like water or anything else, it would make great economic sense." [FG2]*. Figure 3 details the survey responses to considerations for developing a hydrogen export industry. Women rated concerns for safety (4.21^{**}), environmental impacts (4.12^{*}) and water use (3.91^{*}) higher than men. Contributing to the world's emissions reductions was of higher importance for younger

people (3.98*), on par with their importance of safety (3.99*). Environmental impacts of export were also considered to be of higher importance by those born overseas (4.16*).

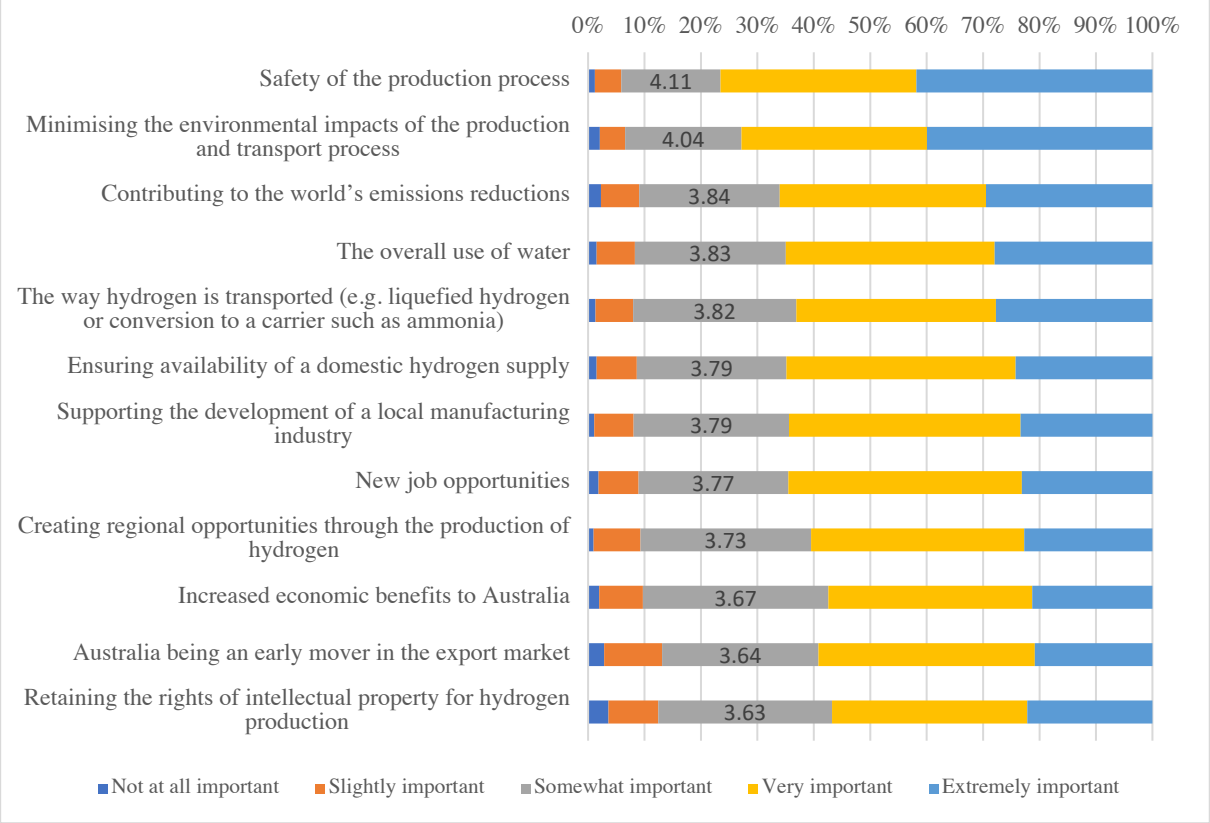

Figure 3. Important considerations for developing an Australian hydrogen export industry (1=not at all important to 5=extremely important)

4.4 Domestic use of hydrogen

Focus group participants' support for domestic hydrogen grew when they saw the video excerpt of the *Leeds City Gate h21* project in the UK [25]. While safety concerns remained, some participants recalled similar concerns being raised before the switch to town gas in Australia however they recognised its use has now become an accepted norm. Others felt that hydrogen would not be any different to natural gas but the invisible flame presented a safety concern in case of burns or being able to control cooking temperatures. Participants also thought the lack of odour could be a problem if a hydrogen appliance was accidentally left on. High flammability of hydrogen was also a worry and participants were interested to know if there were any associated health impacts that might arise from using hydrogen in the home. They were also interested to hear about the need for, and potential costs, of any appliance upgrades that might be needed in a switch to hydrogen in the home. With an expressed need that any associated costs should be subsidised by the government rather than born by the householder.

The Domestic stream of the survey (N=921) supported the findings from the focus groups with safety remaining the most important factor (Fig. 4), and the perceived need for an odour to be added to detect leaks. There was also positive support for associated health benefits of no carbon monoxide emissions from burning hydrogen.

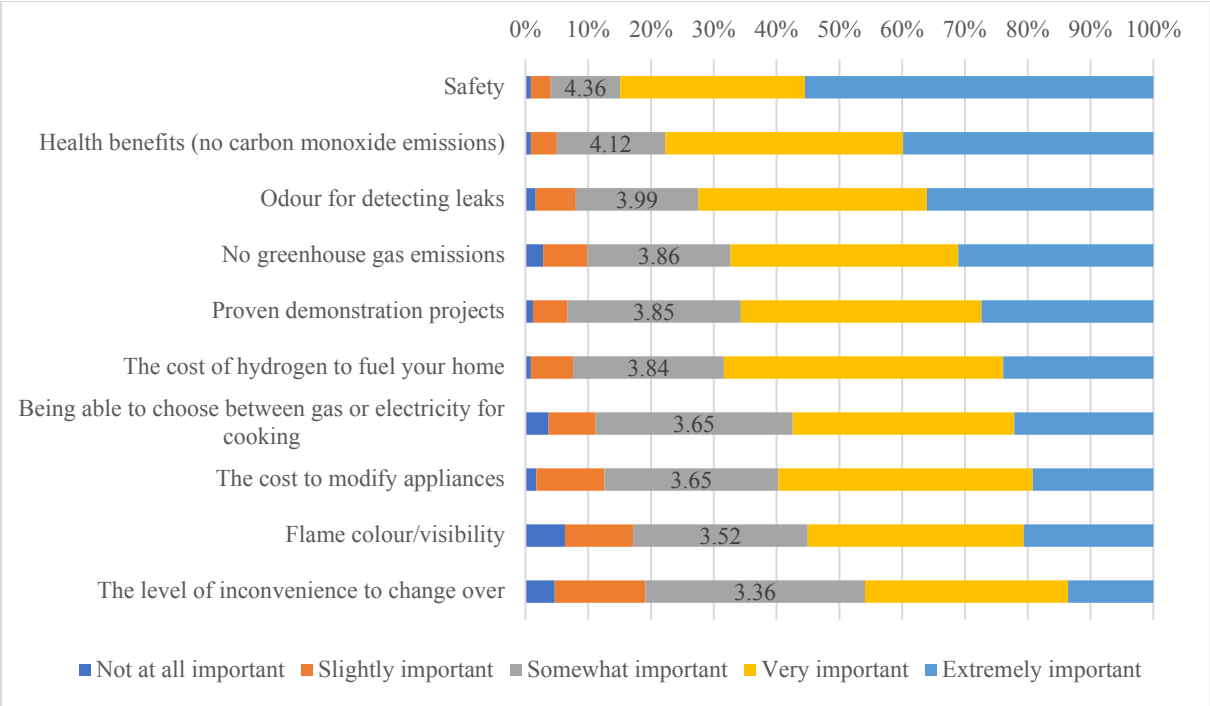

Figure 4. Considerations for living in a hydrogen home
(1=not at all important to 5=extremely important)

Figure 5 shows that survey participants were also in agreement with hydrogen being used for a range of domestic applications, particularly hot water heating and on-site electricity generation. Early adopters ($p<0.001$) and those paying for GreenPower ($p<0.05$) were on average more supportive of all domestic uses, while all electric households were less supportive of hydrogen use in the home ($p<0.05$, except hot water heating which was not significant). Those born overseas were happier to use hydrogen for space (3.70^{*}) and hot water heating (3.80^{*}) which possibly reflects their familiarity with this form of heating. Highly educated people were also more supportive of space heating (3.72^{***}), hot water heating (3.77^{**}) and cooking (3.67^{**}). Those with frequent power disruptions (3.89^{*}) or supply disturbances (3.98^{**}) were happier to use hydrogen for on-site electricity generation.

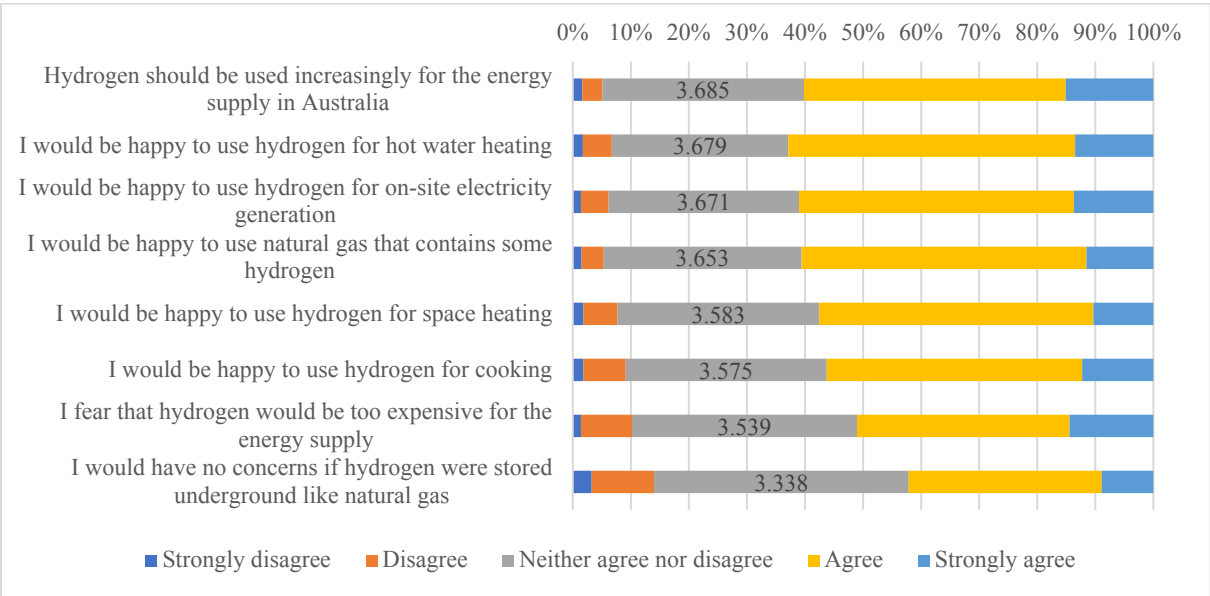

Figure 5. Levels of agreement with potential domestic uses
(1=strongly disagree to 5=strongly agree)

The opportunity to build resilience in our energy system by producing hydrogen from excess renewable energy and storing for later use to balance supply and demand was seen to offer great potential. However, this was with a caveat that it would not increase costs too much. The combined need for increased security of supply, was particularly evident in the Adelaide focus groups as participants had experienced a black out in the previous week. Their concerns were echoed in the quote:*"…they need to have a transition plan that's not going to cost us, and South Australia are a great example of expense and unreliability. I'm all for renewables, you can't argue against it, how could you? Transition properly such that you are not going to be paying the kind of pricing that we are, and the lack of reliability that we've had? If you can sort that out that's great." [FG1].*

4.5 Cautiously optimistic but renewable hydrogen preferred

In both the focus groups and survey the majority of individuals preferred hydrogen to be produced using renewable energy and electrolysis only, with 57% from the survey supporting this method. However, reflecting the quote above, some were accepting of hydrogen being produced using fossil fuels with carbon capture and storage (CCS) as an intermediate step while transitioning to renewables (38%). Although only a quarter were prepared to tolerate the production of hydrogen from using CCS indefinitely.

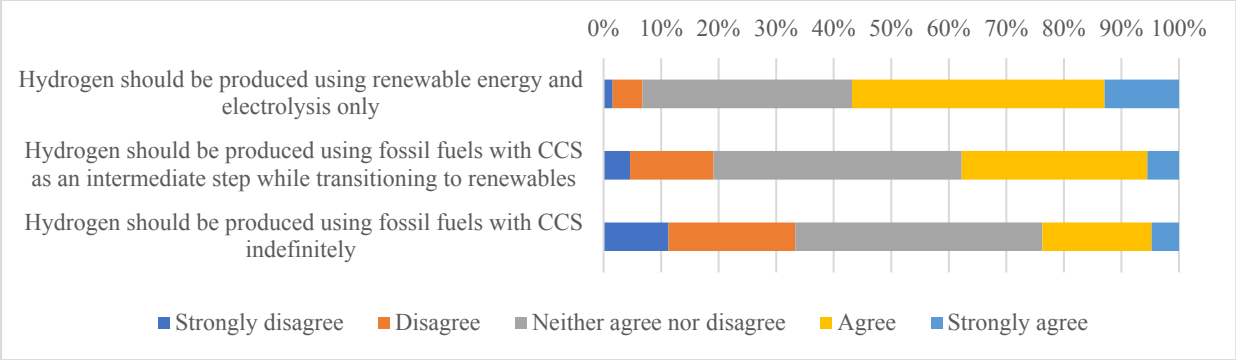

Figure 6. Levels of agreement with the different production processes
(1=strongly disagree to 5=strongly agree)

When examining these responses by state, South Australia had the highest support for renewable production, although the difference was not statistically significant (Table *2*). Queensland showed the highest support levels for transitioning using fossil fuels with CCS, which was significantly different to South Australia and Western Australia. Victorians had the highest mean for producing hydrogen using fossil fuels with CCS indefinitely, however only 27% of the state was in favour of it. The ACT had the strongest opposition with 45% against using fossil fuels indefinitely – note with the low numbers for Tasmania, NT and ACT caution in interpreting these results is needed.

Table 2. Preferences for hydrogen production by State and Territory

Hydrogen should be produced using…	**N**	**Renewable energy and electrolysis only**	**Fossil fuels with CCS as an intermediate step while transitioning to renewables**	**Fossil fuels with CCS indefinitely**
NSW	878	3.60	3.20	2.87
Victoria	704	3.63	3.23	**2.88**
Queensland	557	3.60	**3.26**	2.85
South Australia	215	**3.66**	3.10	2.80
Western Australia	289	3.65	3.10	2.72
Tasmania	70	3.61	3.09	2.79
Northern Territory	25	3.36	2.96	2.64
ACT	47	3.60	3.19	2.60

In spite of the expressed concerns about safety which occurred in both the focus groups and survey, the majority (77%) of survey participants believed there will be adequate safety precautions to keep the risks of developing a hydrogen economy under control (Figure 7). Trust in safety controls was strongest ($p<0.001$) for early adopters, older participants, and males, and also greater ($p<0.01$) for those from regional areas or with more frequent power outages. However, those who were skeptical about climate change ($p<0.001$) and university graduates ($p<0.01$) were more likely to score this question lower.

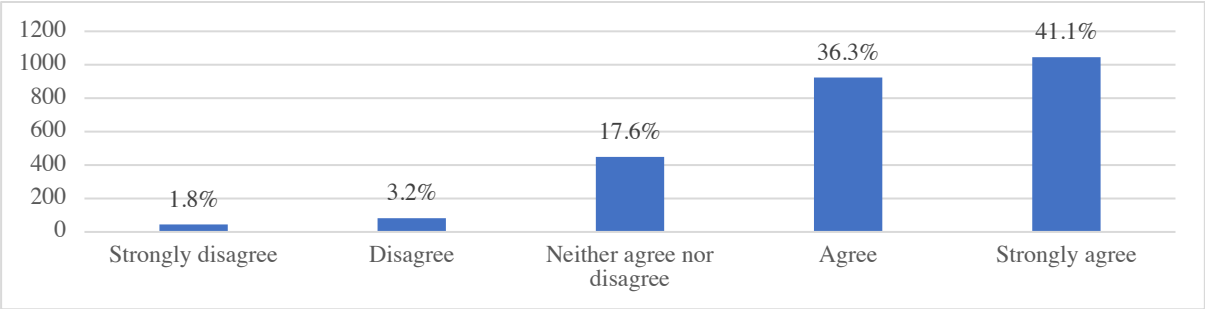

Figure 7. Trust in adequate safety precautions around the development of a hydrogen industry

5.0 DISCUSSION

While this paper does not cover all of the details of the survey and focus groups it provides enough information to show that on the whole the Australian public saw the development of a hydrogen industry as having potential. However, this was only if the potential risks could be managed appropriately. Government was seen to play a key role in this by ensuring that adequate regulations to manage the risks were in place (Figure 8). Similarly, it was felt that the government needed to develop a long-term strategy was needed to ensure all benefits of a burgeoning hydrogen industry was captured as well ensure there were funds available for research and adequate incentives for consumers to become involved.

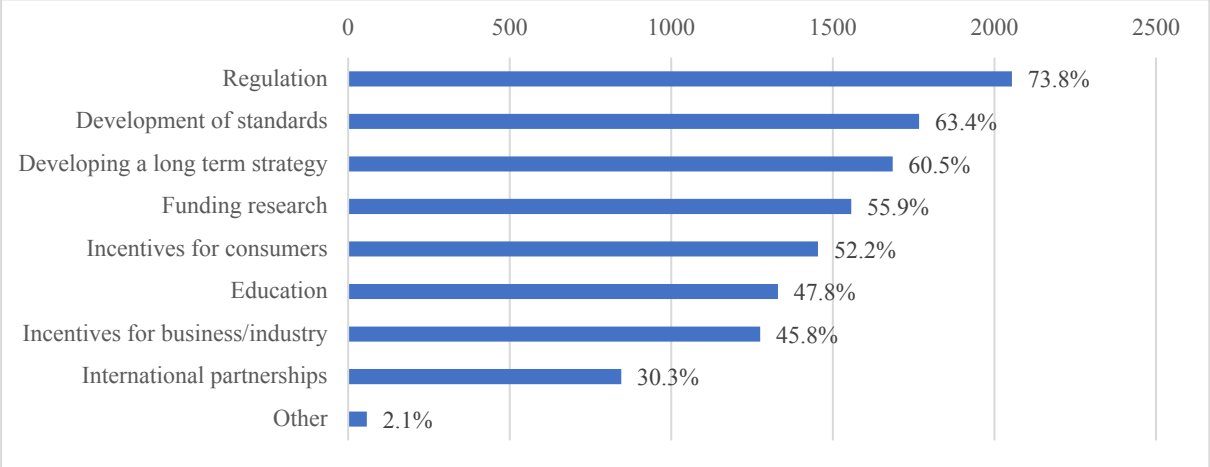

Figure 8. The role of government in developing a hydrogen economy

From the results in Figure 8 it appears that on the whole the public trusts the government to do the right thing and therefore based on these results they become an important element in the transition. Not only by implementing the appropriate regulations but also finding appropriate ways to communicate the necessary information needed for the public to understand what is involved in developing such an industry. This was highlighted in responses to the question "*If a hydrogen economy was to be developed in Australia, who should be responsible for disseminating information? (Tick all that apply)",* 67% of respondents felt the government institutions had the highest responsibility. Research institutions were seen to have the next most important role with 49% nominating them also responsible for disseminating

information. However, participants also recognised that industry (43%) has a role to disseminate information and at least one quarter of respondents felt it should be a collaborative approach.

As part of the focus groups a number of questions arose that participants felt were important to know when weighing up the pros and cons of establishing a hydrogen industry in Australia. These included:

- How far advanced is the technology?
- Where else is it happening in the world?
- Have there been catastrophic events or accidents elsewhere in the world?
- What is the cost?
- What is the embodied energy?
- What are the timeframes for making a transition to a hydrogen economy?
- What's in it for me?
- What are the health benefits?
- How is it transported?
- Would there be and environmental or other impacts from accidents at sea when transporting hydrogen?
- What might be the environmental impacts of CCS associated with a hydrogen industry?
- Could hydrogen could be misused for military purposes

What is clear from the above is that while there are some common concerns, the Australian public are interested to learn more about the opportunities arising from a potential hydrogen industry and how different parts of the country might capitalize on this.

6.0 CONCLUSIONS AND RECOMMENDATIONS

From this initial research it is clear that while overall knowledge of hydrogen in the general public is low some do recall the basic properties of hydrogen from their days at school. This knowledge appears to help them engage on the topic and consider the opportunities being presented by the burgeoning industry. While respondents tended to be cautious of the unknown, they felt that with education and project demonstrations, the public would become more accustomed and accepting of hydrogen and likened it to the switch from Town Gas in the 1960's. Another important finding is that while some were prepared to pay a little more for the environmental benefits of using hydrogen, most felt that any transition for domestic use would need to be comparable with current costs of energy. All of the modelling suggests that this is likely to take some time.

However, we have learnt from earlier examples of failed technology transfer and social license to operate literature there is a lot that can be done while the technical components of the industry are developed. Purpose built communication and engagement will be one essential component to progress the development of such an industry. Similarly, focus group participants felt that pilot demonstration projects would be an essential element of developing proof of concepts for a hydrogen industry to build confidence of the general public in such an industry. The feeling being that pilot projects would allow problems to be exposed in a much less threatening or costly way.

Therefore, it appears it will be important for government and industry to continue to engage on the topic of hydrogen and ensure any positive developments in the industry are captured and communicated accordingly - beyond just those interested stakeholders. Investment in further research and development for hydrogen is also an important requirement of both government and industry. This investment should ensure social sciences and communications experts are part of projects to document any concerns that arise from early demonstration projects as well as identify enablers. This needs to include an ongoing assessment of safety concerns and appropriate engagement to demonstrate how the risks are being handled.

With our abundant resources, the opportunity to develop a hydrogen industry in Australia is promising however it will require dedicated resources to monitor how trial projects are progressing and any lessons learned are well documented and communicated both in Australia and internationally.

7.0 ACKNOWLEDGEMENTS

The authors would like to acknowledge Charlotte Rouse from the Australian Renewable Energy Agency for her input, and also extend thanks to the participants of the focus groups and national survey. This work was funded by the Australian Renewable Energy Agency (ARENA).

8.0 REFERENCES

1. Northern Gas Networks. H21 Leeds CityGate. 2016. Accessed from: https://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/H21-Report-Interactive-PDF-July-2016.compressed.pdf
2. Iribarren, D., Martin-Gamboa, M., Manzano, J. & Dufour, J., Assessing the social acceptance of hydrogen for transportation in Spain: An unintentional focus on target population for a potential hydrogen economy. *International Journal of Hydrogen Energy,* **41,** 2016, pp. 5203-5208.
3. O'Garra, T., Mourato, S., Garrity, L., Schmidt, P., Beerenwinkel, A., Altmann, M., Hart, D., Graesel, C. & Whitehouse, S., Is the public willing to pay for hydrogen buses? A comparative study of preferences in four cities, *Energy Policy,* **35,** 2007, pp. 3630-3642.
4. Garrity, L., Public Perception and Economic Preferences towards the use of H2FC buses in Perth. Hydrogen and Fuel Cell Futures Conference, 12-15 September, 2004.
5. Yang, H. J., Cho, Y. & Yoo, S. H., Public willingness to pay for hydrogen stations expansion policy in Korea: Results of a contingent valuation survey. *International Journal of Hydrogen Energy,* **42,** 2017, pp. 10739-10746.
6. Bigerna, S. & Polinori, P., Willingness to Pay and Public Acceptance for Hydrogen Buses: A Case Study of Perugia. *Sustainability,* **7,** 2015, pp. 13270-13289.
7. Xenias, D. & Whitmarsh, L., Dimensions and determinants of expert and public attitudes to sustainable transport policies and technologies. *Transportation Research Part a-Policy and Practice,* **48,** 2013, pp. 75-85.
8. Tarigan, A. K. M., Bayer, S. B., Langhelle, O. & Thesen, G., Estimating determinants of public acceptance of hydrogen vehicles and refuelling stations in greater Stavanger. *International Journal of Hydrogen Energy,* **37,** 2012, pp. 6063-6073.
9. Zimmer, R. & Welke, J., Let's go green with hydrogen! The general public's perspective. *International Journal of Hydrogen Energy,* **37,** 2012, pp. 17502-17508
10. Heinz, B. & Erdmann, G. Dynamic effects on the acceptance of hydrogen technologies - an international comparison. *International Journal of Hydrogen Energy,* **33,** 2008, pp. 3004-3008.
11. Itaoka, K., Saito, A. & Sasaki, K., Public perception on hydrogen infrastructure in Japan: Influence of rollout of commercial fuel cell vehicles. *International Journal of Hydrogen Energy,* **42,** 2017, 7290-7296.
12. Achterberg, P., The changing face of public support for hydrogen technology explaining declining support among the Dutch (2008-2013). *International Journal of Hydrogen Energy,* **39,** 2014, pp. 18711-18717.
13. Achterberg, P., Houtman, D., Van Bohemen, S. & Maneveska, K. Unknowing but supportive? Predispositions, knowledge, and support for hydrogen technology in the Netherlands. *International Journal of Hydrogen Energy,* **35,** 2010, 6075-6083.
14. Montijn-Dorgelo, F. N. H. & Midden, C. J. H. The role of negative associations and trust in risk perception of new hydrogen systems. *Journal of Risk Research,* **11,** 2008, pp. 659-671
15. Ono, K. & Tsunemi, K.. Identification of public acceptance factors with risk perception scales on hydrogen fueling stations in Japan. *International Journal of Hydrogen Energy,* **42,** 2017, pp. 10697-10707.

16. Huijts, N. M. A., De Groot, J. I. M., Molin, E. J. E. & Van Wee, B., Intention to act towards a local hydrogen refueling facility: Moral considerations versus self-interest. *Transportation Research Part a-Policy and Practice,* **48,** 2013, pp. 63-74.
17. Huijts, N. M. A., The emotional dimensions of energy projects: Anger, fear, joy and pride about the first hydrogen fuel station in the Netherlands. *Energy Research and Social Science,* **44,** 2018, pp. 138-145.
18. O'Garra, T., AcceptH2 Full Analysis Report: Comparative Analysis of the Impact of the Hydrogen Bus Trials on Public Awareness, Attitudes and Preferences: a Comparative Study of Four Cities, Imperial College, London, 2005.
19. Thesen, G. & Langhelle, O., Awareness, acceptability and attitudes towards hydrogen vehicles and filling stations: A Greater Stavanger case study and comparisons with London. *International Journal of Hydrogen Energy,* **33,** 2008, pp. 5859-5867
20. Schmidt, A. & Donsback, W. Acceptance factors of hydrogen and their use by relevant stakeholders and the media. *International Journal of Hydrogen Energy,* **41,** . 2016, pp. 4509-4520.
21. Hickson, A., Phillips, A. & Morales, G., Public perception related to a hydrogen hybrid internal combustion engine transit bus demonstration and hydrogen fuel. *Energy Policy,* **35,** 2007, pp. 2249-2255.
22. Flynn, R., Bellaby, P. & Ricci, M., Environmental citizenship and public attitudes to hydrogen energy technologies. *Environmental Politics,* **17,** 2008, pp. 766-783.
23. Student energy group, Hydrogen 101, Video https://www.youtube.com/watch?v=Kv8WT3-7ZHE
24. CSIRO, Hydrogen – fuel of the future, Video https://www.youtube.com/watch?v=GPW5pRHPLTk
25. Northern Gas Networks, H21 Leeds CityGate, Video excerpt (from 50sec – 4min 30 secs), https://www.northerngasnetworks.co.uk/2016/07/12/watch-our-h21-leeds-city-gate-film/
26. Lambert, V. & Ashworth, P. Australians' considerations for the use of hydrogen in the transport sector. Proceedings of the International Conference on Hydrogen Safety, 24-26 September 2019.