AUSTRALIAN ATTITUDES TOWARDS THE USE OF HYDROGEN IN THE TRANSPORT SECTOR

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

ABSTRACT

Hydrogen fuel cells power a range of vehicles including cars, buses, trucks, forklifts and even trains. As fuel cell electric vehicles emit no carbon emissions and only produce water vapor as a by-product, they present an attractive option for countries who are experiencing high pollution from transport. This paper presents the findings of ten focus groups and a subset of a national survey which focused specifically on use of hydrogen in the transport sector (N=948). When discussing hydrogen transport options, Australian focus group participants felt that rolling out hydrogen fuel cell buses as a first step for fuel cell electric vehicle deployment would be a good way to increase familiarity with the technology. Deploying hydrogen public transport vehicles before personal vehicles was thought to be a positive way to demonstrate the safe use of hydrogen and build confidence in the technology. At the same time, it was felt it would allow any issues to be ironed out before the roll out of large-scale infrastructure on a to support domestic use. Long haul trucks were also perceived to be a good idea however, safety issues were raised in the focus groups when discussing these vehicles. Survey respondents also expressed positive support for the use of hydrogen fuel cell buses and long-haul trucks. They reported being happy to be a passenger in a fuel cell bus. Safety and environmental benefits remained paramount with cost considerations being the third most important issue. Respondents supportive of hydrogen technologies were most likely to report purchasing a hydrogen vehicle over other options.

1.0 INTRODUCTION

There are a number of barriers and opportunities identified for an emerging hydrogen economy with public understanding and acceptance being critical to this, particularly in relation to hydrogen transport. To date there has been limited research examining the public's attitude and likely acceptance of an emerging hydrogen transport economy, particularly in Australia. A web of science literature search revealed 49 articles directly related to public perception and/or acceptance of hydrogen technologies since 1998. Of these, 26 were focused on hydrogen use in the transport sector, and only one included an Australian trial [1]. In contrast, journal articles related to hydrogen and safety numbered in the thousands (N=3754).

According to the international literature, associations with hydrogen were mostly neutral [2, 3]. Knowledge was often found to influence acceptance [1, 3, 4, 5, 6, 7], and support was contingent on environmental attitudes [3, 4, 8]. Males were often found to be more accepting than females [3, 9, 10]. Lack of convenient refueling was identified as a barrier [11, 12, 13]. Performance, range, and refueling time were key considerations [12, 14, 15], and competition with battery electric vehicles was also perceived as likely to be another barrier [13, 16]. The source of hydrogen was important, particularly in Germany [2]. Trust was critical [2, 17, 18, 19, 20] and willingness to pay for the use of hydrogen vehicles varied [4, 21, 22].

2.0 METHODOLOGY

Our study aimed to investigate the Australian public's perception of hydrogen energy, including transport, through a series of focus groups and a national survey. Ten focus groups of two and a half hours in length were held in June, 2018. Focus groups were undertaken in Adelaide (3) and Whyalla (2) in South Australia, and Melbourne (3) and Traralgon (2) in Victoria. 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 from Hydrogen Mobility Australia [26]. In total, 92 participants (55 female; 37 male) of mixed ages (range 20 to 76 years; mean=44) and employment status attended.

To investigate the qualitative findings of the focus groups in more detail, a national online survey was conducted during October 2018 (N=2785). One third of respondents completed questions related to transport (N=948) and these results are detailed below.

3.0 RESULTS

3.1 Knowledge

Initial knowledge of hydrogen as an energy carrier was generally low. Focus group participants were surprised at the number and variety of applications for hydrogen energy. Almost 60% had heard of fuel cell vehicles or could describe it to a friend, but a similar percentage had not heard of hydrogen refueling stations (Fig. 1). Participants were also asked a series of questions to objectively test their knowledge with 44% of the transport tranche answering 3 or more of the 5 questions correctly. The mean score was 2.24 out of 5 (45%).

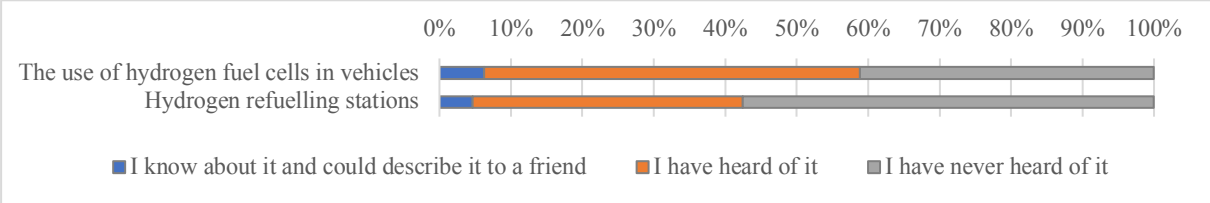

Figure 1. Self-rated knowledge about hydrogen for transport applications

3.2 Private Vehicles

Survey respondents were generally supportive of hydrogen fuel cell vehicles, with 61% stating they would be happy to buy a hydrogen fuel cell vehicle if the cost was the same as their current vehicle. Support was even stronger for early adopters of technology, t people living in metropolitan areas, those aged under 35 or with a degree.

3.2.1 Safety

Safety was the number one priority for those surveyed (Fig. 2), with over 80% considering it very or extremely important when determining whether or not to purchase a fuel cell vehicle. During focus groups discussions, immediate questions arose around safety for transport, particularly related to accidents and collisions: *"Bottom line, if you are in a catastrophic accident in a car, that's [hydrogen] as opposed to [petrol], what's your survivability?" [FG1 Adelaide]*. Concerns included leaks, ruptures, fires, and explosions. It was important to know that hydrogen was no more or less safe than conventional fuels, and that extensive safety testing was conducted (e.g. bullet tests). Comparisons with conventional fuel flammability was usually also raised: *"...petrol's flammable, gas is flammable, we use that every day."[FG2 Adelaide]*.

Several focus groups mentioned that people often have a fear of the unknown, and don't like change, but this tends to diminish with familiarity. The demonstrated uptake in other countries, as shown in the Hydrogen Mobility handout [26], was reassuring for most focus group participants: *"I look at this map and I see Japan, Germany, US and all those leading nations are obviously taking the lead and going for it and adopting the method, so I don't see why we wouldn't do it." [FG3 Adelaide]*.

While safety is the number one concern, if a hydrogen economy was to be developed in Australia, 77% of survey respondents trust that there will be adequate safety precautions to keep the risks under control. Similarly, in the literature, a UK study [20] found that "The dominant presumption was that hydrogen energy technologies will have been thoroughly tested and systems 'engineered' before their widespread introduction".

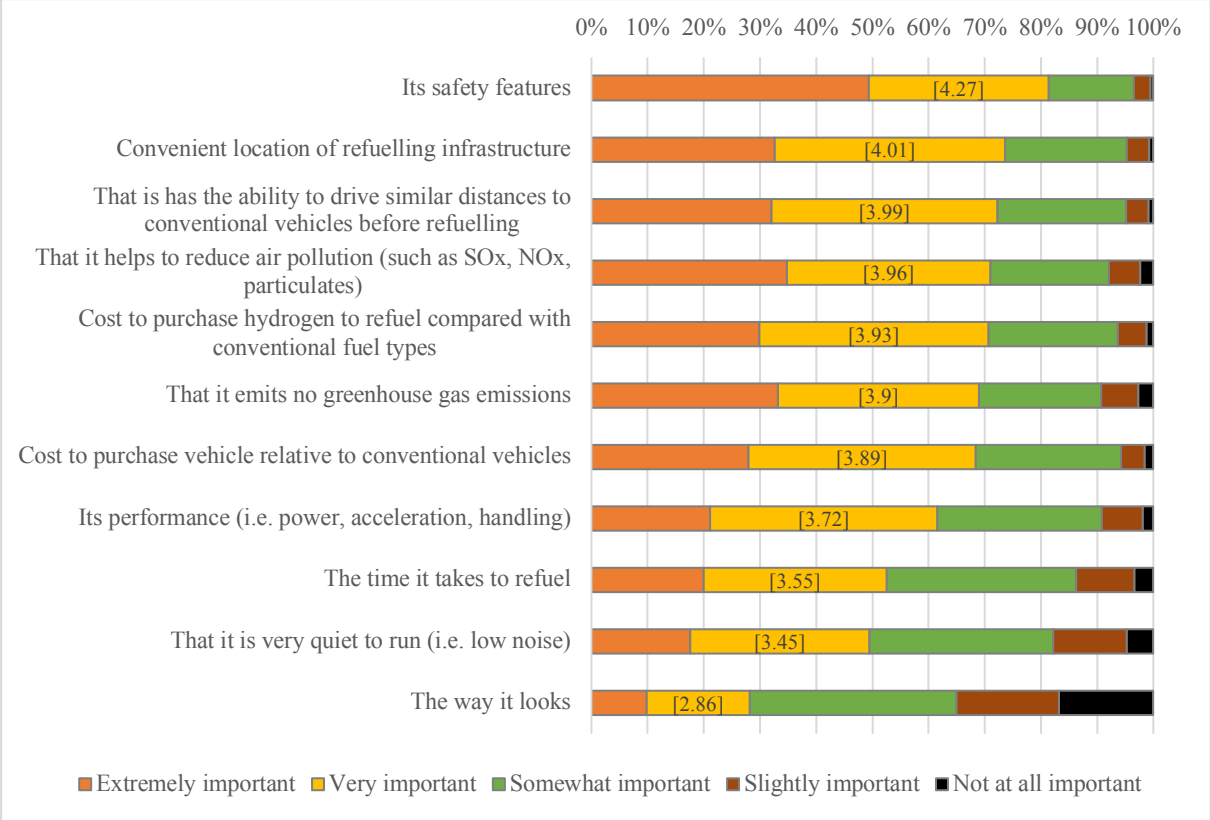

Figure 2. Relative importance of factors determining purchase of a fuel cell vehicle
(1 = Not at all important, 5 = Extremely important; [mean])

3.2.2 Refueling

Convenience of refueling infrastructure was considered to be very or extremely important to 72% of survey respondents, second only to safety (Fig. 2). *"It's got to be convenient and easy as well…even if some things are on parity as far as cost and everything, if it's not an easy process then people don't always want to take it up." [FG8 Melbourne]*. This reflects concerns discovered in the literature. A lack of refueling infrastructure and cost were identified in a UK study [13] as barriers to adoption of fuel cell vehicles. In a Spanish paper [12], forty three percent (43%) were accepting of local hydrogen refueling stations, with a further 54% supportive if they were located away from residential areas. Fifteen percent (15%) said they would not purchase a hydrogen fuel cell vehicle until better infrastructure was available, while 63% would await mass market penetration. Another Spanish study [11] found that refueling stations close to home (less than 10 minutes away) and the number of stations available (10 to 20% of conventional stations) were very important considerations in the decision to switch to alternative fuels.

Support for refueling stations in the national survey was strong (Fig. 3), as 72% of survey respondents would not mind if a local petrol station introduced hydrogen refueling bowsers. Two-thirds support the construction of nationwide hydrogen refueling stations in Australia. 57% would support a hydrogen refueling station being built near them.

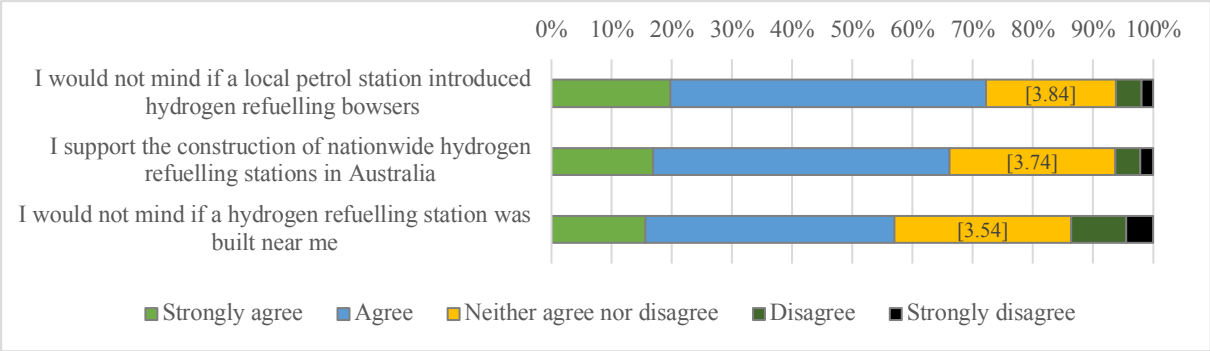

Figure 3. Support for refuelling stations and national infrastructure
(1 = Strongly disagree, 5 = Strongly agree; [mean])

Believers in global warming and those subscribing to GreenPower were more supportive of a local petrol station introducing hydrogen refueling bowsers than the general sample. As were younger people, males and those with a higher education. These groups were also more supportive of construction of nationwide hydrogen refueling stations in Australia. Conversely, climate change deniers, all electric households and older people were the least supportive of refueling station being built nearby (as well as those on lower incomes, with lower education, or not working) and any expansion of hydrogen infrastructure.

Focus group participants made comparisons to LPG vehicles for refueling. They asked about timeframes for rolling out hydrogen refueling infrastructure and whether they could be installed at existing fuel stations. Some people were interested to know how hydrogen was stored at refueling stations and thought that reduced potential for environmental damage from spills or leaks compared to petrol was a benefit. The extent and cost of building an infrastructure network in Australia was considered to be much larger compared to other smaller countries implementing either electric vehicle infrastructure (e.g. Scandinavia) or hydrogen refueling stations (e.g. Japan): "*Scandinavian countries that are doing it, they're only small countries. Australia is huge." [FG9 Traralgon]*

A Norwegian study [3] found that those living within 1km of a hydrogen refueling station were more supportive than the general sample. The project had received positive media attention as a regional success story at the scientific and environmental forefront, which was believed to have encouraged local ownership of the project and elicited high levels of support. Refueling demonstrations can also increase knowledge and acceptance of hydrogen fuels [28]. Vehicle range between refueling was considered the third most important factor when considering whether to purchase a fuel cell vehicle (Fig. 2). "*...the longer travel range, that's very appealing." [FG2 Adelaide]*

3.2.3 Emissions

With the only tail pipe emissions being water, the elimination of greenhouse gases and reduced air pollution were definite benefits, and were ranked fourth and sixth in terms of importance (Fig. 2).*"It would be obviously better than some of our other sources, as an energy source, if it's only putting out water vapor." [FG9 Traralgon]*

The HyTrust project in Germany [2] found safety and risk were less of a concern for public acceptance than "green" production. Of the 79% support for the introduction of hydrogen vehicles, 66% was contingent on the hydrogen being "green" and coming from renewable or carbon neutral sources. Global climate protection was the top reason for supporting hydrogen vehicles (85%), followed by lack of exhaust fumes - protecting health (81%). In contrast, during a UK focus group study, demonstrable benefits for the individual such as cost and practicality were of primary concern, whereas environmental benefits were less important [20]. The UK participants wanted "much more detailed information about the likely benefits, costs and risks of such technologies".

3.2.4 Cost and Incentives

Cost was also very or extremely important to around 70% of the Australian public (Fig. 2). *"It's a lovely pipe dream but they need to make it affordable" [FG7 Melbourne]*. People wanted to know how much it would cost to refill relative to conventional fuels, and whether it would help reduce reliance on fossil fuel reserves and potentially lead to more stable fuel prices. "*I think it sounds like a good thing. I think the problem will be, especially with vehicles, the price of vehicle, cost of actually purchasing at the pump. People look at cost at the end of the day." [FG1 Adelaide]*

The cost to purchase a hydrogen vehicle compared to an internal combustion engine or battery electric vehicle was discussed at length during the focus groups: "*Most people can't even afford electric cars yet." [FG1 Adelaide]*. There was recognition of economies of scale and that prices will be high in the early stages, and that incentives may help to make them more affordable: *"There would have to be sort of a government incentive and initiative to sort of upgrade your car, like a trade-in." [FG10 Traralgon]*

Survey participants were asked to rank which government incentives would likely motivate them to purchase a hydrogen fuel cell vehicle. Lower fuel costs were clearly the most popular incentive, ranked at number 1 by 58% of respondents, followed by lower registration costs (Fig. 4). Tax exemption and road toll exemptions ranked in the middle, while convenience factors, such as free parking in the city and access to priority or bus lanes, were the least important. Fuel and registration costs were even more important to older people and those in the regions, while younger people considered free parking in the city more important than the general population.

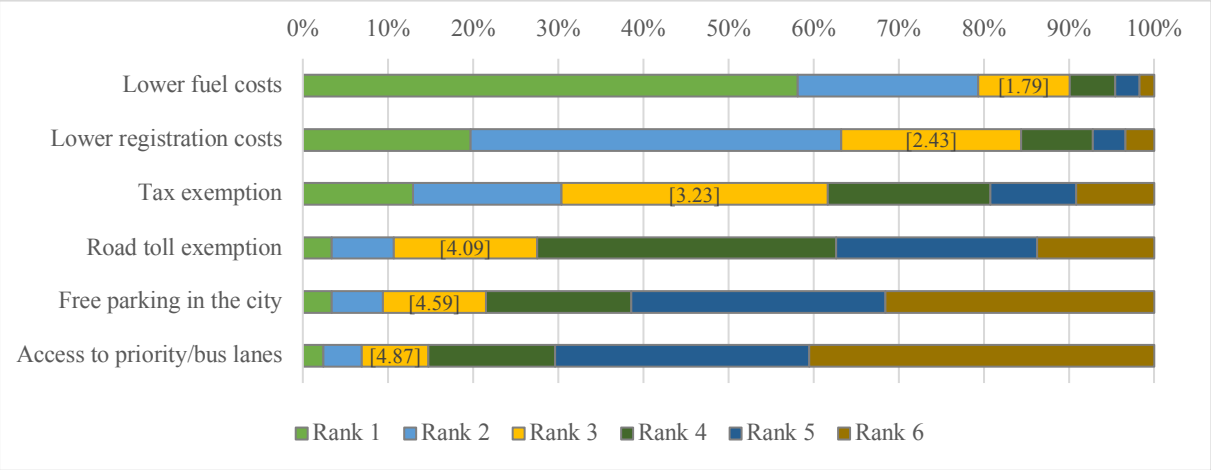

Figure 4. Ranking of government incentives to motivate purchase of fuel cell vehicle
(1 = Most important, 6 = Not important at all; [mean])

3.2.5 Performance

Performance of the vehicle (torque, efficiency, power) was important to some (Fig. 2). Some preferred internal combustion engines, and queried whether hydrogen fueled internal combustion engines were an option. Others wondered whether hydrogen could be used as a dual fuel or in a hybrid vehicle, or whether vehicles could be modified to use hydrogen instead, similar to LPG conversions.

The HyTrust project in Germany [2] found that associations with "hydrogen cars" were mainly positive and that negative associations were unrelated to risk, but were instead related to car performance (speed, power) and cost. Kang and Park [15] found that in Korea, performance, purchasing cost and running cost of fuel cell vehicles were significant factors, along with psychological motivation, that influence purchase intentions. They suggest that without addressing vehicle performance, the government program "low carbon, green growth" would not be effective at stimulating customers to purchase

hydrogen vehicles. Past studies have reported that there is a positive feedback effect from personal experience with trialing or driving a hydrogen vehicle [29].

While low noise was generally seen as a positive, some considered a silent engine to be an issue for pedestrians, particularly children. A study in the UK found similar results, where focus group participants saw this as a risk, particularly for blind people, pedestrians and cyclists, as well as children [14]. They even proposed "engineering some sort of noise into the vehicle for safety".

Aesthetics was considered the least important feature, although younger people and early adopters ranked looks slightly higher than the general population. Women rated the importance of safety features, greenhouse gas emissions and performance higher than men. Those living in regional areas felt that convenience of refueling, vehicle range, reduced air pollution, greenhouse gas emissions and vehicle performance were more important than people in cities. This was also true for those aged over 55, as well as a higher concern for safety.

3.2.6 Vehicle Preference

Competition with battery electric vehicles has been identified as one challenge facing fuel cell vehicles [13, 16]. A UK study reported results from fuel cell vehicle trials at a Low Carbon Vehicle event, which found that the vehicles were considered superior to battery electric vehicles for range and refueling time, however were similar to battery electric vehicles in performance, fuel economy, environmental impacts, image/looks and brand, and inferior for purchase price and running costs [13]. A Finnish study investigating the public acceptance of biofuels found that 60% of respondents thought the ideal fuel for their car would be electricity [30]. Twenty per cent (20%) nominated hydrogen and the remaining 20% supported hybrid vehicles. In contrast, Norwegians were more supportive of hydrogen, with 35% of respondents selecting hydrogen as the most environmentally friendly vehicle for them, with electric vehicles second at 21% [28].

During the focus groups, comparisons between hydrogen fuel cell vehicles and battery electric vehicles included cost, range, refueling, embodied energy, and lifespan: "*Certainly the charge time or fill up time sounds much better. It's not as though you can pull into a service station and charge up [a battery], not in three minutes." [FG1 Adelaide]*. A couple of people noted that battery electric vehicles were not necessarily clean, particularly while electricity for recharging was still predominantly coal-fired. A few people queried whether hydrogen vehicles would overtake battery electric vehicles.

Embodied energy and resource use were raised a number of times during the focus groups, with comparisons made to battery electric vehicle and solar panel production: *It gets down to how much it is going to cost the environment to manufacture all these, battery cars are just off the scale on what it actually costs to manufacture, with the pollution and the resources it takes. Sounds like hydrogen would be better." [FG1 Adelaide]*

Survey participants were asked how likely they would be to purchase different types of car if the price, features, design, brand etc. were the same. Hydrogen fuel cell vehicle was the vehicle of preference for those in the survey (Fig. 5). While there is likely to be some response bias in their answers, given the survey focused on hydrogen, the results reflect the focus group discussions with many individuals happy to transition for improved environmental outcomes. As one person from Adelaide expressed, *"If it was proved that you are not disadvantaged in any way, in terms of the power of the car, the longevity, the cost, all those sorts of things, then why wouldn't you do it I suppose?" [FG1 Adelaide]*

Conventional vehicles were the next most common preference, followed by hybrid vehicles and battery electric vehicles. Fully autonomous vehicles were the least preferred. Early adopters of technology, younger people, those with higher education, or working were more likely to buy alternative types of vehicles. Climate change sceptics and older people were less likely to buy non-conventional vehicles. Those who were not working or on a low income were less likely to purchase any vehicle.

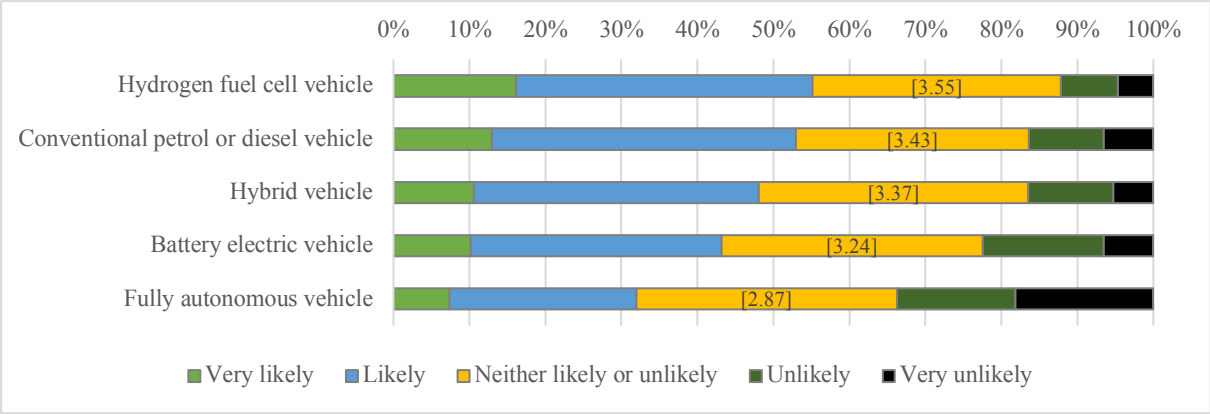

Figure 5. Likelihood of purchasing different cars if the price, features, design, brand, were the same (1 = Very unlikely, 5 = Very likely; [mean])

When asked to explain the reason for their vehicle preferences during the survey, the hydrogen fuel cell vehicle was considered the most environmentally friendly option, and was the most preferred provided it was also affordable and thoroughly tested to be safe. Conventional vehicles are familiar and considered to be proven technology, with cost, convenience, safety and reliability other reasons for this choice. Hybrid vehicles were considered to be environmentally friendly, affordable, safe and proven. Battery electric vehicles were preferred for environmental reasons, cost and safety. Those in favour of autonomous vehicles see it as the way of the future, with low cost and environmental impacts coupled with improved safety and efficiency. It is also the vehicle of preference for those who cannot or do not like to drive. Others did not trust autonomous vehicles, and preferred to retain driving control.

3.3 Buses and long-haul trucks

Rolling out hydrogen fuel cell buses or trucks as a first step was thought to be a good way to demonstrate the use of, and increase familiarity with, the technology, and iron out any teething issues before rolling out on a large scale, provided it was safe: *"I think it is a good idea for public transport to start with hydrogen before even the public do. That is probably a good transition" [FG2 Adelaide]*. 71% of those surveyed support the introduction of hydrogen fuel cell buses and 70% would be happy to be a passenger on a fuel cell bus (Fig. 6). *"I feel trucks and probably public transport is a starting point and then once that seems to be working individuals would be more likely to take it up after that" [FG8 Melbourne]* Those who used public transport daily were more supportive of hydrogen fuel cell buses but the difference was not statistically significant. Focus group participants thought it would be cleaner than current public transport options.

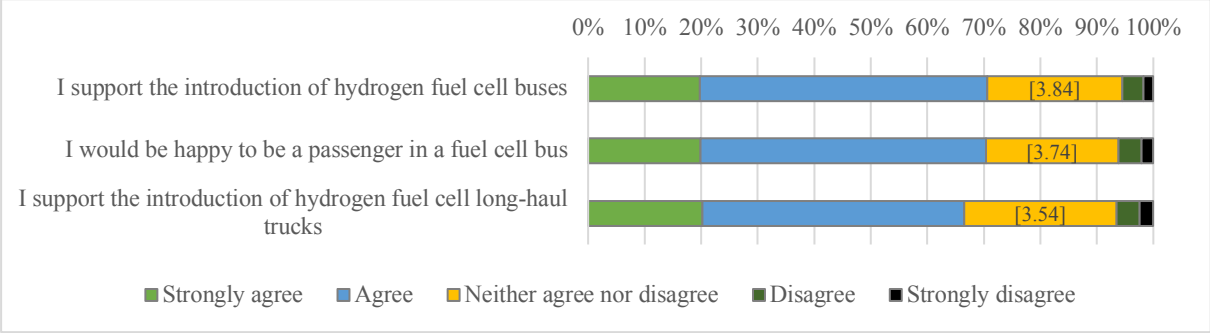

Figure 6. Support for fuel cell buses and long-haul trucks (1 = Strongly disagree, 5 = Strongly agree; [mean])

The AcceptH2 study, conducted across four different cities (Berlin, London, Luxembourg and Perth), found over 90% acceptance towards fuel cell bus trials [4]. In all cities it was found that initially 56%

of participants had heard of hydrogen vehicles, with Berlin residents being the most informed (72%) [1]. Surveys conducted after the AcceptH2 trials found average support for the introduction of hydrogen powered vehicles rose from 46% to 67%.

While long haul trucks were considered in general to be a good idea (67% support in Fig. 6), safety issues were raised during the focus groups: *"If two trucks collide, what's going to happen?" [FG5 Whyalla]*. There was some distrust in trucking companies. Whilst one person thought it might raise the cost of goods due to the vehicle transition costs, others thought fuel prices might be more stable compared with fluctuations in oil and petrol prices driven by the finite nature of fossil fuel reserves. *"It has the potential, like whenever supermarkets put their prices up on things it's because of the transport costs, or so they claim, so if you can have cheaper transport, then it might keep those food prices and other prices [down]" [FG1 Adelaide]*

Those who completed the national survey were asked how important different factors were for the introduction of fuel cell buses (Fig. 7). Once again, safety was considered to be the top priority if hydrogen fuel cell buses were introduced, although the importance of safety was lower for younger people, early adopters and males. Environmental benefits and cost were also of high importance. Environmental benefits were of greater importance to those who subscribe to GreenPower, those who believe in climate change and women. Females and older people thought a cost/benefit comparison with battery electric buses was more important than the general population. Cost to passengers was more important to women and those with higher levels of education, early adopters and those with a job. Reliability, Australia being a technology leader and local council costs were considered less important factors for the introduction of hydrogen buses. Disruption to services was more important to those who suffer frequent power supply disturbances, early adopters of technology and females. Early adopters thought Australia being a technology leader was important, as did those with green power, older people and males. Cost to local council was more important to early adopters.

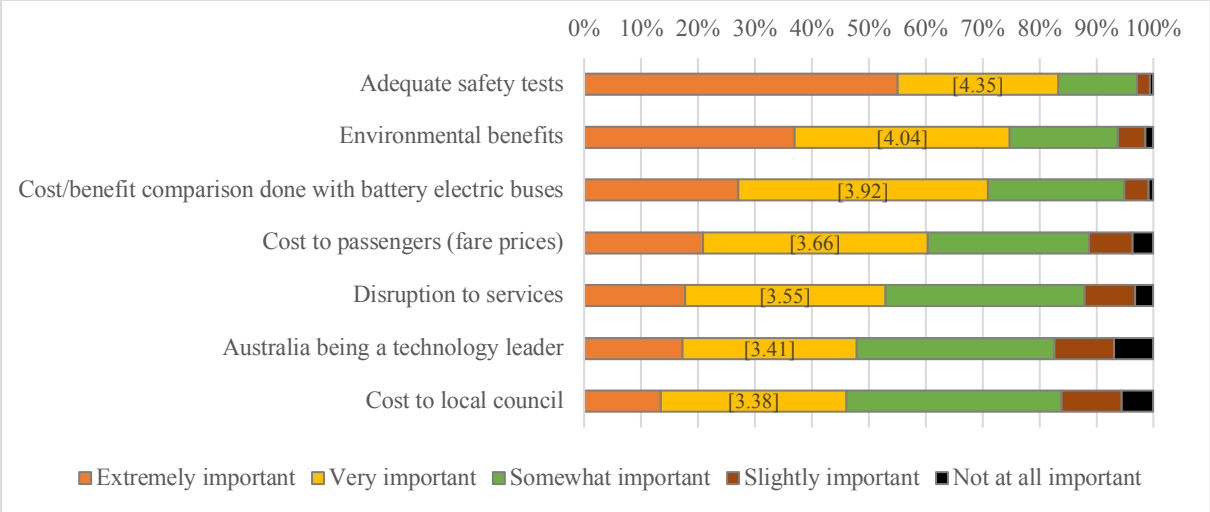

Figure 7. Importance of factors determining support for the introduction of hydrogen fuel cell buses (1 = Not at all important, 5 = Extremely important; [mean])

3.4 Travel Behavior and Willingness to Pay

3.4.1 Travel behavior

Survey respondents were asked how often they use different modes of transport (Fig. 8). Driving was the most commonly used mode of transport, with 45.4% driving their own car daily. Those living in regional areas drove more frequently. Younger people drove less and used all other modes of transport more. People born overseas were even less likely to drive their own car, and more likely to use public transport.

Walking was common regardless of age, with 40% walking daily and another 28% two or three times per week. Only 14% used public transport daily. Metropolitan use of public transport, uber/taxi, walking and car sharing was higher than in the regions. Older people used public transport, bicycle, uber/taxi, car sharing and car-pooling less than those aged under 55. Males cycled and walked more often than females and were also more likely to rent a car. Those who subscribed to GreenPower cycled more often and used car rentals and car-pooling more. Those with a higher education used all modes of transport except driving more than the general population. Uber/taxi was more popular for occasional use than renting a car, car-pooling or car sharing. Car sharing was the least popular mode of transport with 79% of respondents never using this mode.

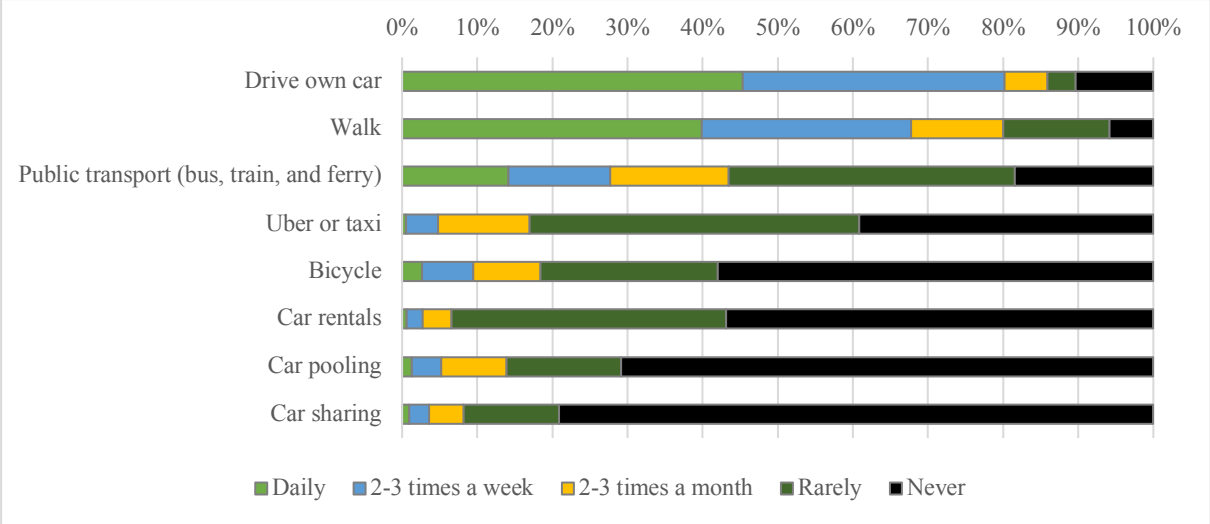

Figure 8. How often people use different modes of transport

3.4.2 Willingness to pay

The AcceptH2 study [1] found that willingness to pay (WTP) for hydrogen fuel cell bus technology to gain environmental benefits (air pollution reduction) was positive with similar values at four different locations (€0.29 – €0.35/fare). The determinants of WTP varied in different locations. Income was significant in London and Berlin only. Environmental attitudes were found to be important in London and Perth, while in Berlin and Luxembourg, environmental behavior was more significant. Older European residents were willing to pay less.

In Korea, air pollution from diesel exhaust is a growing problem and the results from 1000 interviews found that Korean households were willing to pay additional income tax to expand hydrogen stations [21]. Similarly, Bigerna and Polinori [22] found that residents of Perugia, Italy, where air pollution has damaged historic buildings, were willing to pay extra for the introduction of hydrogen buses.

While some focus group participants were willing to pay for environmental benefit, most seemed to think cost would be more important to the general population. *"I would be happy to pay extra initially but…not everyone makes that amount of money to be able to spend that much money on a car." [FG8 Melbourne]* There was a perception amongst the younger groups that there may be generational differences in willingness to pay for environmental benefit, with older people less likely to pay more for or take up new technologies. Cultural and geographic differences were also mentioned.

The national survey confirmed this, with less than half the respondents (37%) willing to pay more for the use of hydrogen technologies even if there were clear environmental benefits. The overall survey found that willingness to pay was influenced by age, attitude towards new technology, education, power reliability, climate change beliefs, income, and gender [27].

The relationship between willingness to pay and transport mode choice was also investigated (Fig. 9). Frequency of car use is highest for those only willing to pay for hydrogen if costs are comparable to conventional technologies. Those who are willing pay a lot more if there are clear environmental benefits drive the least. Those who are willing to pay a little or a lot more walk the most frequently. For the remaining modes of transport, there is a clear relationship between the amount people are willing to pay for environmental benefits and how often they use alternative forms of transport to the car. The less people are willing to pay, the less frequently they use alternative forms of transport.

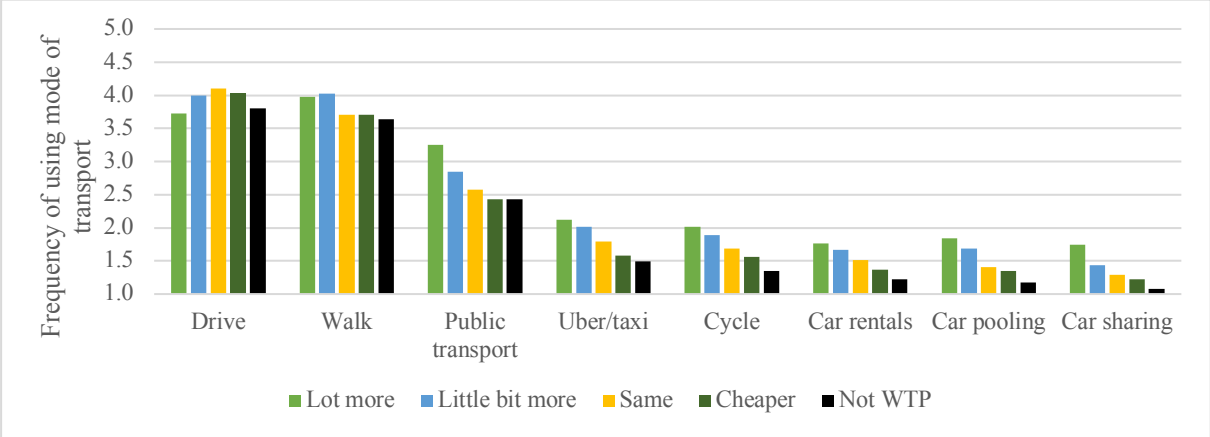

Figure 9. Transport mode choice is related to willingness to pay for environmental benefits (1 = Never, 5 = Daily)

3.6 Overall support for hydrogen

Early in the survey, respondents were asked how they felt about hydrogen as a possible solution for energy and environmental challenges. Support for hydrogen as a technology and vehicle preference appear to be related (Fig. 10). Those who are unsupportive of hydrogen technologies strongly prefer conventional petrol and diesel vehicles, and those who are *very* unsupportive are very unlikely to purchase anything else. Those who were unsure about hydrogen as a solution at the start of the survey were more likely to buy a conventional vehicle over a hydrogen fuel cell, but also more likely to buy a hydrogen or hybrid vehicle over a battery electric vehicle. Those supportive of hydrogen technology as a solution are most likely to purchase a hydrogen vehicle over other options.

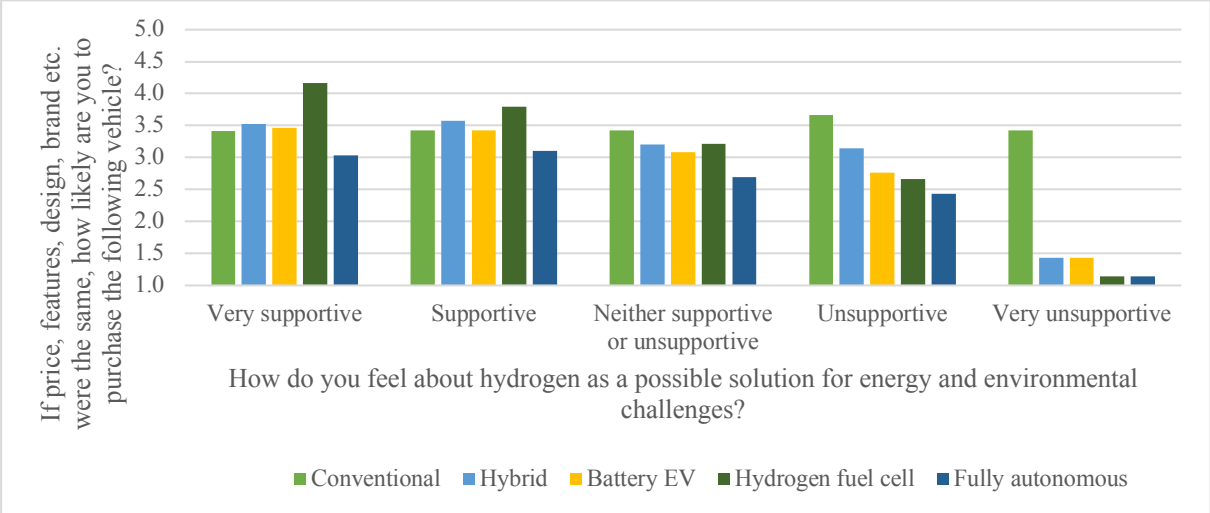

Figure 10. Level of support for hydrogen impacts vehicle preference (1 = Very unlikely, 5 = Very likely)

4.0 CONCLUSION

The Australian public was generally supportive of hydrogen for transport applications. Public transport and long-haul hydrogen vehicles could help build confidence in the early stages, and once costs are comparable, fuel cell cars would be preferred over other vehicle types. Safety is of utmost importance, and convenient refueling is paramount. In the words of one focus group participant: "*It certainly shows all the hallmarks of something that is worthwhile investigating and investing in, as long as the groundwork is put in to implement it across the board evenly and fairly, and safely, it's definitely worth looking at." [FG10 Traralgon]*

5.0 ACKNOWLEDGEMENTS

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REFERENCES

1. 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.
2. 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
3. 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
4. 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.
5. Alanne, K., A survey of Finnish energy engineering students' knowledge and perception of hydrogen technology. *International Journal of Hydrogen Energy,* **43,** 2018, pp. 10205-10214.
6. 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.
7. 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.
8. 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.
9. 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.
10. 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.
11. Brey, J. J., Brey, R. & Carazo, A. F., Eliciting preferences on the design of hydrogen refueling infrastructure. *International Journal of Hydrogen Energy,* **42,** 2017, pp. 13382-13388.
12. 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.
13. Hardman, S., Chandan, A., Shiu, E. & Steinberger-Wilckens, R., Consumer attitudes to fuel cell vehicles post trial in the United Kingdom. *International Journal of Hydrogen Energy,* **41,** 2016, pp. 6171-6179.

14. Bellaby, P., Upham, P., Flynn, R. & Ricci, M., Unfamiliar fuel: How the UK public views the infrastructure required to supply hydrogen for road transport. *International Journal of Hydrogen Energy,* **41,** 2016, pp. 6534-6543.
15. Kang, M. J. & Park, H., Impact of experience on government policy toward acceptance of hydrogen fuel cell vehicles in Korea. *Energy Policy,* **39,** 2011, pp. 3465-3475.
16. Hanley, E. S., Deane, J. P. & Gallachoir, B. P. O., The role of hydrogen in low carbon energy futures-A review of existing perspectives. *Renewable & Sustainable Energy Reviews,* **82,** 2018, pp. 3027-3045.
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. 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.
19. 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.
20. Flynn, R., Bellaby, P. & Ricci, M., Environmental citizenship and public attitudes to hydrogen energy technologies. *Environmental Politics,* **17,** 2008, pp. 766-783.
21. 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.
22. Bigerna, S. & Polinori, P., Willingness to Pay and Public Acceptance for Hydrogen Buses: A Case Study of Perugia. *Sustainability,* **7,** 2015, pp. 13270-13289.
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. Hydrogen Mobility, Accelerating the realisation of a hydrogen economy in Australia, 2018 Infographic April 2018.
27. Ashworth, P., Lambert, V., Cautiously Optimistic: Understanding the Australian public's response to the Hydrogen opportunity. Proceedings of the International Conference on Hydrogen Safety, 24-26 September 2019.
28. 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.
29. Martin, E., Shaheen, S. A., Lipman, T. E. & Lidicker, J. R., Behavioral response to hydrogen fuel cell vehicles and refueling: Results of California drive clinics. *International Journal of Hydrogen Energy,* **34,** 2009, pp. 8670-8680.
30. Moula, M. M. E., Public acceptance of biofuels in the transport sector in Finland. *International Journal of Sustainable Built Environment,* **6,** 2017, pp. 434-441.