A social licence and acceptance of future fuels

Final report

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Research Provider	The University of Queensland
Project Leader and Team	A/Professor Katherine Witt Dr. Amrita Kambo
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Summary of Report

This report brings together findings from the portfolio of research projects commissioned by the Future Fuels CRC within the **RP 2.1-02 Enhancing acceptance and a social licence to operate of future fuel infrastructure through community engagement and deliberative processes** work package. This research was undertaken by The University of Queensland (UQ) from 2019 until late 2023.
This report synthesises and summarises research findings relating to:

- The state of community sentiment towards future fuels such as hydrogen and biogas, and towards the options for their use to fulfil a variety of energy needs
- Methods for effective engagement with the community and strategies for building knowledge of, support for and trust in a new energy source
- Testing the effectiveness of participatory methods in respect of the above
- Investigating the information of the differing information and engagement needs of specific community sectors and specialist stakeholder groups.

The pace of change in future fuels development (and energy transition generally) means that the industry needs the support of the broad Australian community, along with strong local support for production facilities and distribution infrastructure. Establishing and maintaining social licence is critical to achieving this. This research found that the Australian community currently has a relatively neutral view of future fuels (specifically hydrogen and biogas) and that education and information sharing was effective in increasing support. This is a good foundation position for the industry and should be capitalised upon.

Overall, this research found there is general support for hydrogen, where hydrogen from renewable sources is preferred, strongly based on messages of zero emissions and environmental benefits.
Australians also see a role for future fuels in the future energy mix and would support the introduction of hydrogen as long as it met certain conditions. These include:

- If it was evaluated robustly and determined to be in the public good
- If it benefitted the environment
- If they had been provided with enough (“balanced”, “neutral”) information from trusted sources
- If they had been engaged respectfully in advance and had the opportunity to ask questions and have them answered
- If they had been made aware and understood that there may be additional costs involved and were either willing to take on those costs or were adequately subsided or compensated
- If it was proven to be no less safe than current domestic gases and fuels
- If it could be made available at a competitive price (compared to electricity)
- If there were clear economic benefits, especially to local communities but also to the nation

Policy stakeholders identified challenges in meeting community expectations; representatives of relevant trade organisations and emergency services identified relevant foundation knowledge and skills and had clear suggestions regarding necessary regulatory change and training needs. All of these groups highlighted the extent of work needed in their respective areas, and the lengthy timeframes required to build robust and trusted systems and expertise.

Recommendations from this research aim to build on the neutrality of public attitudes, address community expectations for science-based information, and highlight the extent of work required to establish a robust and effective regulatory framework. In brief, it is recommended that:

- Lessons from pilot projects and trials be shared with the community and key stakeholder groups
- Balanced science-based information should form the basis of all community information and education
- Industry and government should share knowledge about changes in technology as it moves up the readiness levels
- Deliberative processes should be trialled to deepen and expand interactions between industry and Local Government Authorities (LGAs)
- Action to develop appropriate industry standards, regulatory systems and trainings should commence as soon as possible – these arrangements should be nationally consistent where possible.

1. Introduction

This report brings together findings from the portfolio of research projects undertaken by UQ within the **RP 2.1-02 Enhancing acceptance and a social licence to operate of future fuel infrastructure through community engagement and deliberative processes** work package undertaken from 2019 until late 2023. This includes 11 separate research-based deliverables and two PhD projects. Additionally, we note relevant findings from five additional citizens' panels (see RP2.1-07) and the development of an online training package (RP2.1-09) that were led by the same research team. Although FFCRC views the citizens panels as separate (RP2.1-07) this report draws on the other concurrent work led by the same research team where it is relevant.

This research program was designed in 2019 when public discussion of a potential hydrogen industry was in its infancy. The Australian government had commenced funding various technology development and feasibility studies through a dedicated research funding program in 2017 and the first *Australia's National Hydrogen Strategy* had been released (COAG Energy Council, 2019). Hydrogen industry development has proceeded at a fast pace since that time. Now, approximately five years later, we are at a point where seven hydrogen hubs, across five states, have been announced (as at February 2024) with funding from the Australian government, state governments and major industry partners. The emerging Australian hydrogen industry has attracted major international funding, and similarly, Australian companies are investing overseas. We have quickly moved from a period where the community had limited awareness of a potential hydrogen industry to a time when environmental impact assessment processes are commencing for actual hub developments. While stakeholder engagement processes around these projects may create more detailed understanding in those communities, knowledge across the broader Australian public is expected to continue to be limited. The overall aim of the RP2.1-02 work package was to understand community sentiment around and responses to the prospect of using future fuels such as hydrogen and biomethane in various forms (as blends with natural gas or as substitutes) and various applications, with a focus on distributed gas networks and domestic and household end-use. In recognition that large-scale production and widespread distribution of future fuels can only be possible with the support of the broader Australian community, this understanding was sought out for the following reasons: (i) to inform stakeholders, including gas producers and distributors, regulators and policy-makers, industry peak bodies, about how they can engage and communicate effectively about future fuels; and (ii) to build trust and acceptance and address community concerns. Early research into public attitudes towards hydrogen revealed that both in Australia and internationally, most individuals had a relatively neutral response to hydrogen, which was associated with low levels of awareness and knowledge about the technologies involved (Ashworth et al., 2019). Since then, there has been increasing public demand and policy impetus to decarbonise Australia's (and the global) energy sector with growing attention to the role that hydrogen and future fuels may play in energy transition. Many of the projects in the RP2.1-02 work package have used participatory methods of data collection that involve the provision of factual information to participants as well as a range of expert presentations and have thus contributed to the growing discourse and public understanding of future fuels and the role they might play in the future energy mix.

An initial scoping study was conducted to clarify expectations and identify priority outcomes for the RP2.1-02 work package. In the interviews conducted with key stakeholders in the Future Fuels CRC interviewees continually raised the need to grow an industry-wide understanding of **what is meant by the concept of a social licence to operate** and **how it can be translated into everyday decisions and operations**. These two key questions form the basis of this report, which consolidates the findings of the total body of work completed by UQ for FFCRC.

Our research has shown that Australians are generally optimistic about the role of future fuels as a cleaner source of energy and would like to see all Australians, and more specifically, regional communities, benefit from its development and use.

In this final report we will explain public perceptions and knowledge about future fuels and the factors that influence changes in perception. We will outline the information and conditions required to build broadscale public acceptance of future fuels as described by various stakeholder groups. A number of recommendations relating to strategies for sharing information, building public trust in the technology and a future industry, and establishing regulatory requirements are also made.

We begin with an outline of the research findings that were focussed on building understanding of social licence as a theory and its practical application.

2. Social licence and social acceptance – what are they and what do they mean for future fuels?

A social licence to operate (SLO) refers to the level of acceptance or approval by local communities and stakeholders for a company's operations or projects. To 'have' a social licence to operate generally means that the company (project) is seen as a legitimate endeavour, has earned the trust and support of the community through building relationships and good conduct, who then allow it to conduct its activities with minimal resistance or opposition. The concept of SLO recognizes that the legitimacy of a project does not only come from government approvals, permits or regulations but importantly, from its ongoing engagement and positive relationships with the surrounding society. Several academics have attempted to develop theoretical models that explain the conditions required to earn a social licence and to quantify these in order to gauge levels of support or social risk. SLO is mostly considered in relation to a specific company or project.

Social acceptance, on the other hand, is a broader term that encompasses the general approval or tolerance of a company's activities or products within society. While social acceptance is a key component of a social licence to operate, it doesn't necessarily imply the same level of engagement and relationship-building with local communities and stakeholders as an SLO does. Social acceptance of a project, technology or company can be influenced by various factors such as cultural norms, public opinion, media representation, and perceived benefits or drawbacks.

In summary, the key difference lies in the depth of engagement and relationship-building with local communities and stakeholders. A social licence to operate involves proactive efforts by the project proponents/operators to earn trust and support with its stakeholders and local communities, while social acceptance refers more broadly to the level of approval or tolerance of the project (and other such projects) within society.

At the time this research package was initiated, future fuels projects were mostly in pre-feasibility or feasibility assessment stages. Although early engagement is important, beginning the deliberate and strategic process of identifying and understanding stakeholders, building relationships, and earning trust for projects as required for a SLO was in most cases premature. SLO theory however highlights the importance of establishing legitimacy as the foundational step. In the case of future fuels, which uses new technology, establishing legitimacy means building awareness and acceptance of the technologies used, explaining the benefits and drawbacks and understanding public perceptions. In other words, the foundation step of securing a SLO is building broader social acceptance. In order to do this step, there first needs to be some understanding of baseline levels of acceptance, what drives support and resistance, and what the public requires in terms of information and engagement.

Two projects led by the UQ team directly addressed the objectives of building industry understanding of what a social licence for future fuels might look like. This includes the 'operationalising a social licence to operate' online training package developed separately in RP2.1-09; and a desktop review of the Australian and international discourse on hydrogen which identified key components of social acceptance.

2.1. BUILDING KNOWLEDGE OF SOCIAL LICENCE AMONGST GOVERNMENT AND INDUSTRY PROFESSIONALS

The online training masterclass explains the background to social licence theory and how it is an ongoing relationship between companies and different communities of locality and interest. It emphasises the need for early community engagement underpinned by a robust stakeholder analysis. The steps required to do this are laid out. There are case studies that highlight both positive and negative outcomes for projects and links to further resources for those who are interested in learning more.[1]

Over 60 industry and government participants enrolled in the training program over the course of the project. Many of these training participants had limited understanding of social licence concepts prior to training. Course

[1] See https://apga.org.au/social-licence-operate-training and https://www.futurefuelscrc.com/project/rp2-1-09-social-licence-to-operate-training-package/. This training is currently available to all members of APGA as well as Future Fuels CRC participants.

feedback suggests that they found the course very useful in building their theoretical understandings and providing practical advice regarding best practice engagement strategies. The number of government and industry personnel involved in hydrogen policy and projects is steadily increasing and an ongoing training program would be worthwhile.

2.2. BUILDING PUBLIC AWARENESS AND THE PORTRAYAL OF HYDROGEN

The desktop review of the Australian and international discourse on hydrogen was completed in 2020. It identified key components of social acceptance, including (1) how future fuels are presented to the public in documents such as state and national strategies and policies, (2) key approaches to understanding and managing social acceptance, as well as (3) general trends in perceptions and acceptance as seen from the recent discourse.

The review found that hydrogen is being presented to the Australian public as a new and innovative, clean energy technology, with prominence given to 'green' or renewable hydrogen (using water electrolysis and renewable energy) with much less attention given to other sources of hydrogen and hydrogen production technologies such as steam methane reforming of natural gas or coal, or biomass gasification. This framing of hydrogen as a zero-carbon, or 'clean, green' energy source was tested for effectiveness by the UQ project team in a subsequent national survey of public perceptions of hydrogen and found to be a very effective message for building social acceptance. However, this framing only portrays a partial and simplified version of hydrogen technology and builds a very limited public awareness of the full range of opportunities for hydrogen production and use. Of note, more recently, hydrogen production from biomass gasification is receiving increased media attention, as is the production of other future fuels such as biofuels and biomethane. Recently, exploration of natural hydrogen sources has also gained momentum, introducing the option of drilling for the resource if found to be commercially viable.

There has also been some debate about which method of hydrogen production will be most preferred by the market (which historically favours lowest price) and the financial cost vs environmental benefits. These and other trade-offs (particularly in water use) between the different methods of hydrogen production have not been communicated well and are not broadly understood. In short, hydrogen can be extracted, or made several ways, which may or may not involve carbon emissions. There are also alternatives to hydrogen in emerging future fuels technologies. Much of this diversity in choice, along with the opportunities and challenges of each option, has been overlooked in dominant communications and portrayals of hydrogen.

The framing of hydrogen as a new and innovative technology was not tested in further surveys but might be of interest in future research. Specifically, whether framing hydrogen as a 'new' energy technology (and thus deliberately distancing it from its much longer association with oil, natural gas and coal) is more effective for building acceptance than if it were framed as an established energy technology, and as a gas that is already being used and is familiar to industry and emergency services. Both light industrial users of gas and emergency services were engaged as part of this work package, to identify their information needs, perceptions of risk and other requirements for social acceptance of future fuels. Both reported being familiar with gas properties and were not fearful of using or managing hydrogen. Emergency services highlighted the need for very clear and obvious labelling to enable quick identification that hydrogen is involved in any incident they respond to. Both commercial gas users and emergency services highlighted the need for accessible training to ensure they stay updated with new technology and in turn, safety.

This work package also reviewed hydrogen-related strategic documents in Australia, which have been released since November 2019. We found that all strategic documents acknowledge the importance of the role of the broader Australian community in building a 'clean hydrogen future'. However, perhaps reflecting the still very early stages of a potential hydrogen industry[2], they highlight the need for broad public education about the technology and on building public awareness, rather than stakeholder engagement, or actually involving the public in discussions or decision making. It is expected that the environmental impact assessment processes

[2] The first detailed examination of a future hydrogen industry was the Australia's National Hydrogen Strategy (COAG Energy Council, 2019), and the first major engagement with industry and academic stakeholders led by National Energy Resources Australia in 2020.

associated with major hydrogen projects e.g. the seven hydrogen hubs receiving Australian government funding (as at 19 February 2024), will involve the full spectrum of stakeholder engagement processes associated with traditional large-scale resource development projects. It is critical that the stakeholder engagement for these initial projects is demonstrably high quality to provide a strong foundation for a future industry and valuable precedents for future projects. It cannot be assumed that communities designated to host hydrogen hubs enter engagement processes with the knowledge or understanding required to participate fully. Studies show that they are unlikely to understand what hydrogen production, storage or distribution looks like or what the impacts might be on their everyday lives.

Indeed, our review of studies on the perceptions of hydrogen in Australia confirms that knowledge of and familiarity with hydrogen technology is strongly associated with its acceptance. In other words, those who know and are familiar with hydrogen are more likely to be accepting of it. This was again reflected in the findings of the national survey of public perceptions of hydrogen conducted in 2021 (see project 7 below) which found that providing factual information about hydrogen increased support for hydrogen among the public.

This work has also identified the key role of demonstration projects (where people can see and experience the production and use of hydrogen in both industrial and domestic settings) in building initial awareness that could, over time, build confidence and trust in the technology that grows into acceptance. A desire by community members to see demonstration uses of hydrogen as a builder of trust was first identified by Ashworth et al. 2019 in a report on Community Trust in Hydrogen commissioned by the National Hydrogen Taskforce. This has been a recurrent theme in the findings over the course of the RP2.1-02 work package.

Another dominant portrayal of hydrogen in the early discourse has been as a lucrative export commodity, paralleling LNG. This framing was tested in subsequent research and found to be effective at shaping perceptions of hydrogen, with higher levels of support among the Australian population for hydrogen as an export industry than for domestic use only (Bharadwaj, Weder, et al., 2023; Lozano et al., 2022). The main reasons given for higher levels of support for an export-scale industry were for the economic and jobs benefits that an export industry is expected to bring. This was particularly so for young people and in regional communities. People also support hydrogen for being a clean energy source with national economic benefits. An environmental message about Australia's prospect of using renewable energy to produce carbon emissions free, or clean hydrogen had a significant impact in increasing social acceptance. The message tested through the national survey was: "*Australia can use its abundant renewable energy resources to produce hydrogen, which will give us 100% emissions-free "green" energy"*. This message, with an environmental values frame that positioned hydrogen as an emissions-free energy fuel, had the most impact, with support increasing by 4.5% from the baseline (Bharadwaj et al., 2024).

While there has been considerable academic literature published globally describing public perceptions and acceptance of hydrogen for transport use, especially in connection with refuelling infrastructure, hydrogen cars, and public transport, our early work highlighted a gap in the literature on social acceptance of the use of hydrogen in the home. Subsequent work under RP2.1-02 has filled this gap to a large extent.

2.3. APPROACHES TO UNDERSTANDING SOCIAL ACCEPTANCE

The desktop review of literature identified multiple approaches to understanding social acceptance and each one has implications for communication and engagement strategies that might be employed by industry and government. Two contrasting approaches were identified and can be considered:

- Those focused on psychological factors influencing perceptions and behaviour (of individuals); and
- Those which emphasise the importance of the social and political processes and institutions that create acceptance (or not).

An overall finding from the complete body of work undertaken in RP2.1-02 is that all the identified approaches are applicable in relation to future fuels. This is explained briefly in the following paragraphs.

The first approach is an understanding of social acceptance as a set of psychological factors (values, beliefs, constructs) which determine the preferences and behaviours of individuals. Individuals are the focus of attention as they are influential in their roles as a voting citizen, a potential activist, a social media content author and/or a consumer. The logic here is that individual behaviour is rational and based on knowledge and conscious decisions about costs and benefits trade-offs. Communication strategies aligned with this approach include the

provision of factual, neutral information to inform rational action and decision making. Our work under RP2.1-02 (including RP2.1-07 and RP2.1-09) has shown that the Australian public is indeed wanting trusted, factual information about future fuels technologies in order to inform their choices around energy technologies and their use. We have also identified the most trusted organisations to provide this information as being universities, CSIRO, and non-government (non-political) organisations. In relation to hydrogen, we found that the provision of information does generally increase levels of support, but the size of the increase can depend on multiple factors. For example, as published by the project team in Lozano et al. (2022, p. 28816) "*respondents who think safety is an important consideration are less supportive of a hydrogen facility being built near them. However, their trust in the safety of the technology is positively associated with support for hydrogen facilities being built near them"* This finding aligns with the findings in the project report on 'Social theories and practical applications for hydrogen deployment', which showed that provision of factual information alone does not necessarily translate to increased public acceptance. Our work suggests that underlying personal and environmental values (that in turn influence risk perceptions) were seen to be more influential than rational self-interest when making decisions about energy use behaviour and technology acceptance. Messages that appeal to these underlying values can be effective in building social acceptance (Bharadwaj et al., 2024; Bharadwaj, Weder, et al., 2023). Similar results were found in the case of biogas, where it was observed that information on biogas (an image plus a short message) had a positive and significant effect on the Australian public's support for biogas. However, respondents were slightly more supportive towards messages that framed biogas as a 'local, reliable and renewable' energy source compared to messages that framed benefits in economic terms (Bharadwaj, Kambo, et al., 2023).

These results show that when social acceptance is approached in terms of appealing to individual preferences (including constructs, values, and beliefs) there are many and nuanced ways in which people respond to information and that an individual's support for a technology is built over time (with information, familiarity and trust) and is strongly aligned with personally held beliefs and values. We have also shown that at an individual level, it seems that many Australians are in the process of 'making their mind up' about future fuel technologies as new information emerges. This is a critical time to provide balanced information and to answer questions that people may have. We have also shown that individual support is not static but can be increased (or decreased) based on multiple, interdependent, contextual factors. For example, in the case of hydrogen it was shown how support differed in relation to respondents' socio-economic characteristics and geographic locations (Bharadwaj, Weder, et al., 2023) and heterogenous effects are observed (Bharadwaj et al., 2024). These findings stress the need to provide a range of communication materials and messages about future fuels that can appeal to a variety of underlying individual values and priorities (that typically do not change quickly) as some messages will be more effective for different people. In this work we have 'tried and tested' some key messages and framings (see reports and papers arising from the RP 2.1-02 work package) alongside new enquiries and experiments that elicit the state of social acceptance of future fuels from an aggregated individual perspective.

A second approach to understanding social acceptance is less focussed on the knowledge, behaviours, and attitudes of individuals and more about the social and political processes and institutions that create acceptance (or not). When understood as a process rather than an outcome, social acceptance is a much more dynamic concept which is continuously being reconsidered and redefined (this version is often referred to as a social licence to operate). This approach also considers the conditions under which social acceptance is formed and takes into consideration the role of moral issues such as fairness and equity, the role of institutions (and specifically regulations) and the role of shared social and environmental values in decisions and policy making.

A key finding from this research was that while understanding social acceptance from the individual perspective is important for designing effective information provision, social acceptance (or social licence) is best gained through involving communities in deliberative processes where they can participate in discussions that lead to planning and decision-making, learn from others, share their experiences and concerns and build trust and confidence in the technology, the regulatory environment as well as the project proponents. This finding informed the design of subsequent research methodologies, the findings of which will be summarised and discussed below.

2.4. PUBLIC PERCEPTIONS OF FUTURE FUELS (WITH A FOCUS ON HYDROGEN)

Overall, hydrogen is perceived to be a useful, beneficial, and worthwhile technology although there is not surprisingly, significant variation in the way people think and feel about hydrogen and how it should be used.

Support is linked to awareness

There is indication that support for future fuels is growing as awareness levels also increase. For example, there was a small but significant increase in the level of support for hydrogen between the 2018 ARENA survey (*M* = 4.99, *SD* = 1.20) and the 2021 National Survey (*M* = 5.31, *SD* = 1.25). However, while there was an increase in support, only a small percentage of the population reported being confident about their knowledge of hydrogen in 2021. This shows that while people are beginning to hear more about future fuels alternatives, their knowledge and understanding of the technology is still quite limited.

Support varies by gender

Males tend to be slightly more supportive of hydrogen as an energy source than females, however both genders reported increases in support as they completed the 2021 survey. Examples of gendered differences in perceptions about hydrogen include females raising concerns about NOx and CO emissions if hydrogen appliances were used in the home, specifically questioning any health effects for babies and small children at floor level, and males preferring combustion engines over hydrogen fuel cells for the noise and smells they make. In the case of the biogas survey in 2022, it was found that males are more supportive than females towards the technology. A detailed post facto analysis of the 2021 citizens' panels explicated how social norms and gender norms underlie deliberations and influence group dynamics and group discussions (Wade et al. 2024). However, the analysis confirms that gender norms underlying deliberations need not have negative effect on outcomes but can be successfully managed when facilitators are trained to spot and intervene effectively. Implications for facilitator training in future are clarified (Wade et al.)

Natural gas users had their reasons to support hydrogen whilst others had reasons against

On average, current natural gas users (those connected to a gas mains supply) were slightly more supportive of hydrogen than those not connected. Across the deliberative engagements, there was strong support for continued use of gas (and particularly for cooking) among current gas users. There were concerns raised however in relation to those living in dense housing and high-rise or apartment buildings about the safety of hydrogen blends and the potential for leakage in complex and tight networks (with lots of inlets and outlets).

Political tendencies did not sway support in either direction, but geography plays a role

Support for hydrogen does not appear to be influenced by political alignment, although those with no or unstated political alignment tend to be less supportive. This finding suggests that the development of a hydrogen industry should continue to invoke bi-partisan support across Australia and is perhaps a warning for project proponents not to align themselves too closely with one side of politics over the other for broad social acceptance.

Levels of support for hydrogen appear to be similar across all Australian states and territories although knowledge and awareness of hydrogen was reported to be higher in Western Australia.

An open invitation for further information – a neutral stance is a blank canvas

The provision of factual information can help to strengthen support for those with no prior opinion, however it does not tend to influence those who are strongly opposed (Bharadwaj, Kambo, et al., 2023; Bharadwaj, Weder, et al., 2023; Lozano et al., 2022). For a few people, additional information (especially about risks and hazards) can lead to negative views of hydrogen as we noticed in the risk perception workshops.

The table below (Table 1) has been constructed from data collected in the citizens panels, interviews and workshops undertaken as part of RP2.1. It is a summary of the most commonly mentioned perceptions (and questions) relating to the production and use of future fuels (focus on hydrogen) in Australia, categorised by the researchers as positive or negative.

Table 1: Characteristics of future fuels (focus on hydrogen) described as Positive and Negative (a focus on hydrogen)

Positive	Negative
A clean energy source – benefits for climate protection, emissions reductions	May impose additional costs to households and associated inequities
Enables continued use of gas, but a cleaner alternative (if price remains affordable).	Potential for leakage and combustion (hydrogen) – is it safe?
Protects consumer choice in energy use – many people stated a preference for gas heaters and cookers.	Retrofitting appliances and infrastructure is expensive and disruptive
Position Australia as being an innovative, trade leader, bringing skilled people to Australia and building skills among the population	Concern about storage and transport in densely populated areas – how will it respond in extreme weather events? (heat waves, etc)
Revenue as an export industry	Concerns about hydrogen in high-rise buildings and potential for leakages
May provide alternative jobs for those leaving the fossil fuels industries	Where will the water come from? It should not be taken from agriculture
Pipelines are thought of as being less (visually) intrusive than overhead electricity transmission lines	Biogas from human waste less supported
Does not require new infrastructure if existing infrastructure can be used/upgraded	
Biogas from waste solves both waste and energy issues	

Highlighting environmental benefits was effective

Support for hydrogen is stronger when it is framed as providing environmental benefits such as emissions reduction and climate protection. Hydrogen production from coal and gas is less strongly supported than hydrogen from renewable energy, although still has general support.

Export income is valued but safety is all-important

When it came to export considerations, safety in transport and production processes were considered most important. Particularly for younger Australians, creating jobs and economic benefits were also important drivers of support, as long as environmental impacts are minimised, and domestic energy requirements (including hydrogen supply) are prioritised.

Although hydrogen is commonly associated with being explosive, for many, concerns about safety are largely ameliorated through high levels of trust in Australian safety standards, regulations and training/accreditation of tradespeople. This has come out in several instances and stated in equal part by participants of expert and non-expert background. It will be critical to ensure that current standards are maintained and will apply equally to new technologies, and that public trust in the regulatory system is preserved.

Results for biogas are equally nuanced

From the biogas survey we have found once again that baseline (T1) support varies by socio-economic status.

A point to note - overall public awareness of biogas is very low; however, when presented with information about biogas on the whole, Australians are supportive of biogas as a future fuel. Although in the beginning, almost half of the respondents selected the mid-point neutral option when asked to express their support for biogas. The primary reason for selecting that option was insufficient knowledge and information about biogas. Nevertheless, Figure 1 shows participants' mean willingness to use biogas for different purposes when asked the question: *If biogas were available today, how willing would you be to use biogas for cooking, hot water heating; space heating; in your car and other vehicles; aviation fuel; and shipping fuel? Where (1 = 'Very unwilling' and 7= 'Very willing')*

Since biogas is sufficiently well tested and commercialised technology in many parts of the world (e.g Germany, Italy and so on), attending to Australian public' lack of awareness and indifference towards biogas would be a worthwhile exercise. Awareness campaigns could shift order and magnitude of support towards the technology.

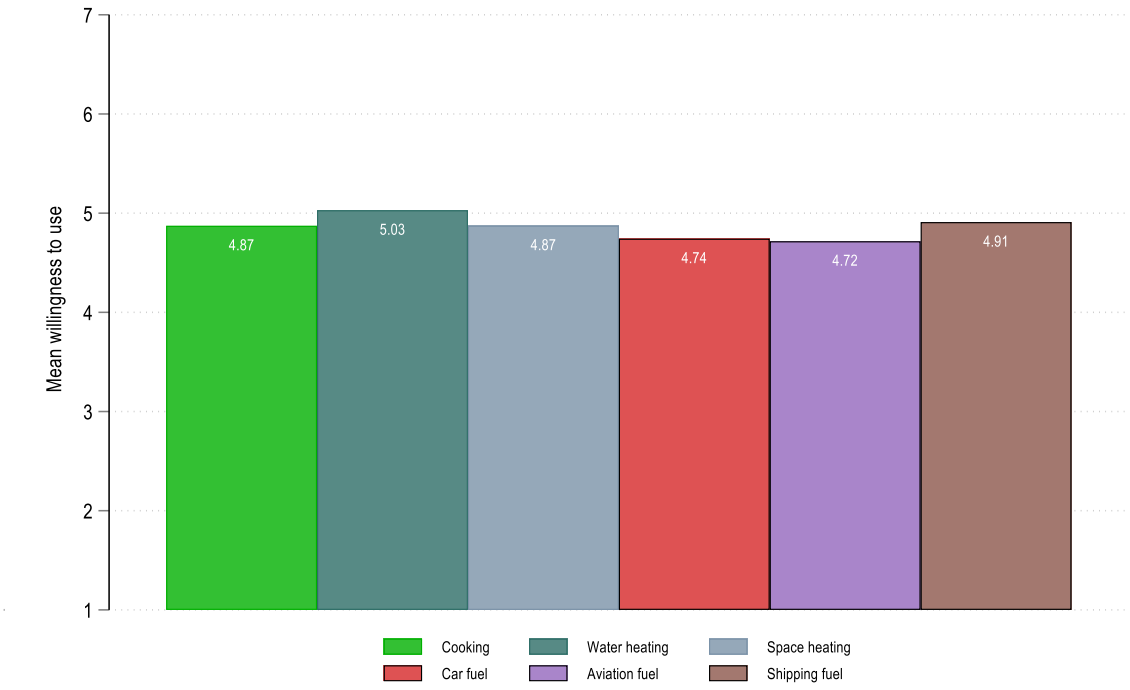

Figure 1: Mean willingness to use biogas for different purposes.

Although the figure above and (table below) is meaningless out of the context of the survey and needs to be read in conjunction with the other results (for example, those arising out of the message testing and in relation to information provided to participants through the survey), for the sake of comparison a table (reported previously) from the hydrogen survey is provided below. The reader must be cautioned that this is not an attempt at comparing like for like, as the surveys were deeply cognisant of the complex value chains associated with each of the technologies and were **not** set out to enable cherry-picking of one technology suite over another. In fact, cherry picking is the one thing social data up to date points severely *against*.

Information campaigns that need to arise from the surveys' data, must squarely address the complex value chains associated with hydrogen and biogas individually and must not attempt to water down the differences. Instead, the focus must be on drawing out dialogue on the environmental, social and economic impacts associated with each technology suite as that is the nature of information that participants have asked for time and again. If anything, the lower values (of mean willingness to use biogas against hydrogen for domestic purposes), must be a call to action to increase public awareness campaigns aimed at disseminating information around biogas, especially since we already have reports estimating the number of biogas projects (242 based on 2017 data) in Australia (Carlu et al., 2019). There will be plenty of data and case study material to expound from based on the experience of these projects:

Table 2:Mean willingness to use biogas for different purposes.

If hydrogen were available today, how willing would you be to use it in your home for the following uses?	2021		2018[c]	
	Mean[a]	SD	Mean[b]	SD
Hot water heating	5.71	1.42	5.07*	1.47
Cooking	5.57	1.47	4.90*	1.28
On-site electricity generation	5.53	1.44	5.03*	1.22
Space heating	5.45	1.47	4.91*	1.22
Using natural gas that contains some hydrogen (i.e. a blend)	5.37	1.47	5.04*	1.16
For driving hydrogen fuel cell electric vehicles	5.34	1.58	-	-

*$p < .01$
[a] Measured on a 7-point scale where 1 = very unwilling, 4 = neither willing nor unwilling, 7 = very willing; n = 1,507
[b] Scale was expanded to 7 points for this analysis. Original scale used 5 points.
[c] n = 906.

2.5. HYDROGEN COMMUNICATION

The RP2.1-02 work package (and additional studies) included one study that involved analysis of media articles. Key findings are that media communication about hydrogen has been largely dominated by positive messages that focus on the benefits and opportunities that hydrogen presents, with particular focus on environmental benefits of 'green' hydrogen, and the potential for economic benefits from an export-scale hydrogen industry. When matched with the academic literature and theory on social acceptance however, only communicating positive messages does not build trust or acceptance. Our research cautions about building hydrogen 'hype' that can result in disappointment and distrust and has shown that a combination of positive messaging along with information about timelines, trade-offs, along with acknowledgement of what is still uncertain, including being upfront about risks and challenges, is most effective for building trust[3].

3. Translating social licence into decisions and actions

Gaining a social licence to operate is about understanding stakeholders' expectations and needs and building relationships of cooperation and trust through effective engagement and communication. This work provides specific insights on stakeholders' expectations and needs and what they feel is needed in order to build trust and acceptance in future fuels technologies.

3.1. INFORMATION NEEDS OF STAKEHOLDERS

Plumbing and gas fitting trades

Working with hydrogen is not seen as a 'huge leap' for plumbers and gasfitters as they are familiar with its characteristics. Plumbers and gasfitters explained they are well-trained and experienced in handling gas at different pressures. However, they recommended that additional skills were required when working with gases at higher pressures and volumes than they may have been exposed to in current gas uses. New applications of hydrogen as an energy source (mainly it's increased prevalence if distributed within the gas reticulation network) and how it will behave in domestic and commercial appliances are the areas that were identified as requiring specific engagement, training and upskilling for plumbers and gasfitters, and to other associated trades such as electricians. If there were to be large-scale deployment of hydrogen (or other future fuels) into existing pipelines, gasfitters would like to know well (years) in advance so as to manage, plan, prepare, train and upskill personnel in time and to the scale required. There would need to be clearly defined Australian standards for the safe handling and use of future fuels and accreditations for workforce training and upskilling would also be needed. Those interviewed made the observation that there was no agreed risk classification system for Type B gas-fitting work. Many felt that there was too much focus and investment into the production side of future fuels, that is in

3 An additional UQ study funded by FFCRC (RP2.1-11 Framing Issue Legitimacy. An international comparison of media representations of natural gas and hydrogen) identified that communication around technical issues such as the need for infrastructure is significant communication gap that industry must seek to fill. The report argues for a strong response from industry re-iterating the role gas can play in the transition to net-zero and highlighting the values and benefits that it either brings or protects from an ecological, social and economic perspective

the technology and infrastructure required to produce it, with less attention being given to who the consumers would be, how it would be distributed and who would need to be involved at “the consumer end of the equation”.

Trades representatives requested specific information relating to hydrogen. This includes information relating to:

- the safety of the fuel (as an energy source);
- how it behaves when mixed with natural gas;
- the temperature range it is combustible;
- how the existing gas reticulation system can handle it,
- what impact would the characteristics of hydrogen have (i.e. no odour and no flame colour) on the end user and for safety considerations,
- the propensity of hydrogen to cause corrosion,
- propensity to leak and subsequent impact of such leaks

Gasfitters could see some confusion arising with the maintenance of hydrogen fuels cells as they “not fundamentally gas and not fundamentally electric, they are both”. Gasfitters and associated trades were keenly interested in being kept informed about the progress of research and technology advancement and the learnings from hydrogen pilot and demonstration projects. Demonstration projects were also seen as an opportunity for trades to gain first-hand experience and could inform planning and preparations within the plumbing and gas-fitting industry.

Emergency services workers

Emergency services workers (mainly fire and rescue) expressed a degree of familiarity with the properties of hydrogen and were not fearful of responding to emergencies that involved hydrogen. Their main concern was the need to be able to quicky identify whether hydrogen was involved or not, so as the proper decisions about safety and incident response can be made. They needed to have clear markers or labels that enabled them to identify (preferably from a distance) where hydrogen might be found, either in a pipeline, in a domestic or vehicular fuel cell, or an appliance. This demarcation is critical in informing risk management approaches and emergency response plans, and especially for the safety of emergency workers and all those involved in an incident. Emergency service workers expressed a need for clear labelling of homes (and/or other facilities, vehicles, equipment and appliances) where hydrogen was expected to be present. For example, knowing in advance that hydrogen was involved in a situation would help emergency responders to prepare and arrive at incident sites with the appropriate equipment and personnel. One innovation that has emerged with electric vehicles is the use of Q-Codes that manufacturers had developed. A participant reported that Q-Code stickers are placed in five different positions around the vehicles. Scanning these codes links responders to all the necessary safety information required for responding at the scene of an accident. It was hoped that a similar approach would be adopted for hydrogen vehicles.

They expressed some concern that the hydrogen industry appeared to be expanding very rapidly and the pace of technology deployment may be too quick for training requirements to be rolled out amongst emergency services in preparation. This was of particular concern given a large proportion of Australia’s emergency responders are volunteers and would need to be trained appropriately. Emergency services coordinators expect that the industry and government would provide them with the “essential knowledge that everyone (including volunteers) needs to have” about hydrogen. This would begin with studies that elicit a baseline of understanding among the emergency services sector. Specifically, to understand the essential knowledge requirements and whether they differ across different responder types, “what knowledge they already have and what gaps in knowledge exist, and what is the best way for the sector access and deliver information to fill those gaps”.

Based on this, if hydrogen was to come to fuel homes (and or/other facilities, cars or equipment or appliances), clear markers, early communication and notification around hydrogen’s presence would be expected by emergency service workers. They referred to clear precedent around this - where facilities, equipment, pipework, fixtures and fittings are clearly marked – disclosing the presence of any hazardous materials and instructions on how to safely handle those materials. For example, pipework is clearly marked to indicate what material flows within it – whether rainwater, sewage, gas and so on. Similarly, a standardised marking for hydrogen would be needed for early detection and inform all first responders (ambulance, police, fire and rescue) in how they manage incidents and accidents.

Emergency services requested specific information relating to:

- Physical impacts on skin, eyes and breathing arising from contact with (or proximity to) hydrogen

- How different fuels react in different situations (heat, oxygen levels, etc)
- Time criticality – how much time for response? (particularly for regional areas where response times can be longer)
- Time sensitivity – how much time between reactions?
- Flammability and reactions with other materials (such as plastics, metals)

Several interviewees explained the "doctrines" for different response issues. A doctrine is a short operational document that allows crews on the ground to "make sure that they're meeting the needs of the incident they're attending". Behind this summary document is the training or advanced information on the topic as well as links to other related topics. Respondents advised that (at the time of the interviews in 2020) there was yet to be a doctrine developed in relation to responding to hydrogen.

Similar to gasfitters and trades, emergency services see opportunities to become familiar with the use of hydrogen in demonstration projects. If there were any requirement for additional training around hydrogen in domestic settings (an/or with vehicles), emergency workers would like to be involved in advance of any large-scale domestic roll-out of hydrogen. Emergency workers see themselves as being pro-active in sourcing information around new technologies (for example, as in the case of battery powered scooters and cycles), that they might encounter at incident sites. However, they would expect that there would be early and close engagement, particularly at the regional scale, about where there might be a more widespread rollout of hydrogen.

The general public

This section highlights the information needs and expectations arising from the general public as collected from citizens' panels (in RP2.1-07) and from representative samples of the public in national surveys on hydrogen and biogas. In the citizens panels, participants were specifically asked to construct a set of principles that they agreed articulated what was essential to them in relation to Australia's pathways to decarbonisation. Several of these related explicitly to information provision. We relay these principles here using the exact words provided. Citizens state the need for a "*a positive, engaging, and comprehensive education campaign for renewable energy. This should also include up to date information on the risks of current energy sources and their effects*." In other words, people want to be provided with information about the full range of future energy options (including renewable energy options) to allow them to weigh them up against current energy options. There were just as many questions about renewable energy infrastructure and technologies as there were for current gas and future fuels. This finding aligns with the recent Community Engagement Review report released by the Australian Energy Infrastructure Commissioner that highlights a need for an (government-led) information initiative "articulating why there is an urgent need for new renewable energy and transmission infrastructure" as many citizens do not understand the scale of infrastructure required or why it is needed so quickly. In the citizens panels, we found a variety of views about decarbonisation pathways, but these included continued support for gas as a reliable, cost effective (and potentially less intrusive) future energy source. Citizens provided more detail about the desired features an information initiative should have and the topics it should cover that is relevant to industry as well as government. Again, using their own words:

> Citizens seek multicultural, reliable and transparent information/education on all low carbon energy technologies that are being considered. The basis of consideration should be scientific evidence and research and not political grandstanding. The choice to settle on a particular energy suite should be driven by Australia's willingness to participate in global efforts to reduce CO2 emissions; and demonstrate how current and future generations will benefit. Further in this regard, citizens seek that government and industry work together to produce a national, public, up-to-date database of research findings (with respect to all low carbon technologies) to facilitate transparent and informed decision- and policy- making.
>
> Citizens would like to understand how the energy is produced (methods of generation); how it is going to be used and how energy infrastructure (particularly solar panels and wind turbines) will be disposed of, seeking to understand whether there will be an increase in overall efficiency/efficacy in the transition to cleaner energy while reducing waste/misuse; citizens also seek information on long-term impacts that are associated or anticipated with the technologies being considered.
>
> Citizens are seeking a 'code of conduct' informing them about how to make smart, conscious energy choices, seeking clear rules and guidelines that contribute towards sustainable future living. Citizens

seek to know how every aspect of the life cycle of the built environment is considered - from design, construction, and operation - to reduce energy footprint and increases energy efficiency.

Citizens seek transparent reporting from (energy) companies describing how their supply chains and dealings meet clean energy standards and carbon emissions targets; showing a preference for transparent, locally based supply chains and reduced risks.

Policy makers and policy influencers

The evidence collected though the surveys and the deliberative processes (2021 round) was shared with individuals who work in policy-oriented roles in government and industry. In order to differentiate between the two sets of participants, the terms 'policy maker' is used to refer to participants from government and 'policy influencers' refers to participants in industry (to be noted that a policy influencer could also be a person responsible for creating an intra-organisational policy, and/or be person who is in a position to liaison with a policymaker in government in relation to industry wide issues)

Policy makers are obligated to respond practically and responsibly to ensure the needs of the public (and /or stakeholders) are met by designing policies that facilitate given objectives without causing inequities or additional costs. They require sound evidence and factual information on which to base policies and their justifications. They need to be able to understand the trade-offs involved in the range of energy options, including any risks and costs. From this perspective, when we shared results from the survey and the deliberative processes to the policymakers (in government), they responded positively to the fact that there now existed some solid evidence around the needs and requirements of the public (albeit restricted to the views and opinions of the participants involved in the research).

Those in government commented on the struggle they experience in meeting the expectations of the general public for reliable, equitable, affordable energy at a price that is not prohibitive. They also often struggle to reconcile the expectations of the general public with the regulatory, institutional and political systems within which they operate. Clear and upfront communication is important to them about the costs and benefits of future fuels technologies and projects.

Policy influencers remarked on the key role that local government bodies will need to play in the energy transition as they are at the forefront of planning and in some cases, approvals, whilst also being the representative voice for local residents. It was thought that there needed to be better engagement with local governments and councillors so they can better envisage and understand "what a whole (hydrogen) industry would look like". It was thought that individual projects were "bearing the brunt" of this lack of understanding. For example, local government officials will need to understand for themselves the difference in scale for an export-oriented facility and a domestic or locally oriented demonstration facility. Once aware, local government officials could be in an ideal place to explain the different scale requirements of a hydrogen industry and its implication to their local constituents. Local governments could be uniquely placed to influence social acceptance of future fuels in relation to both acceptance of individual facilities and in land use planning[4]. This has been witnessed already in those LGAs (for example, Sydney) where new gas connections are being stopped, even when the states (in this case, New South Wales) are not completely ruling out gas. More recently a green hydrogen hub development in Western Australia was denied approval as it did not include enough renewable energy sources to meet the LGA's planning definition of a 'renewable energy facility', On the other hand, there still remain many local government councils which maintain a proactive stance towards gas such as Western Downs Regional Council who remain "committed" to operating their gas reticulation network based on a belief that gas is a 'low-cost premium fuel'[5]. In a sense, local governments are more closely in touch with their constituents needs, and their polices (whether pro- or anti- gas) uphold (or do their best to uphold) democratic processes at the grass root level. Sometimes the reasoning behind a specific policy or process may not be wholly evident to an outsider. Nevertheless, when an LGA's stance sits at odds with the state and then the federal policy, it brings home a very clear message that a pan-Australian policy on future fuel infrastructure may be too ambitious a goal to pursue. Instead, participants in the policy workshops (across governments and industry) highlighted the need to engage better with local governments, to be able to understand how to cater to the diversity (of opinions) which may be present. From a research perspective, a working hypothesis emerges: *deliberative processes, conducted at the local government*

[4] As seen in recent news in both WA and SA.
[5] As stated on the council's website: Gas Western Downs Regional Council (wdrc.qld.gov.au)

scale as part of the formal planning and approvals processes could make decisions about projects more transparent, establish a project's legitimacy, while being authentic and representative of the people's voice. When used in this context, deliberative processes could prove useful in enhancing support for policies and decisions that enable future fuels projects to go ahead.

Larger future fuel projects may also create significant population growth in a town/region with implications for housing and service provision, as currently forecast for Whyalla. LGAs will need to manage relevant building approval processes and increased LGA services, and advocate for additional resourcing from State and Federal levels of government where appropriate. Effective management of these issues is necessary to maintain community support for these projects. In the meantime, it was thought that an openly accessible resource of the most current scientific information and updates (similar to those used to communicate information about the COVID-19 pandemic) would be a useful resource to provide some generic (not necessarily project-specific) information materials on the technical, economic, environmental and social aspects of future fuels technology and infrastructure. Some of the questions they seek answers to include: what type of facilities are deemed as future fuel infrastructure? What do the facilities look like and how do they sit in the landscape? How are future fuel facilities siting decisions made? How big or small can these facilities become? How many are needed? What are the resource requirements and inputs? What is the outlay? What does the outlay look like? What is the significance of that outlay from a decarbonisation perspective?

From the participatory workshops participants from both government and industry agreed that the onus of meeting citizens' information needs would most likely fall upon governments. However, our work under RP2.1-02 has found that the sometimes the government of the day is not the most trusted source of factual, neutral information (and neither is industry). Citizens are more likely to trust information from universities, the CSIRO and those NGOs who are interested in social justice and objective science. Although governments would be better placed and better resourced to constitute nationwide communication campaigns, our work shows that partnerships with trusted information providing individuals and organisations should be considered.

3.2. TYPES AND FORMS OF COMMUNICATIONS/MESSAGING

Since the hydrogen value chain is very complex, owing to many ways in which it can be produced, transported, and used, understanding how to communicate about hydrogen to the public is not an easy task. The biogas value chain is similarly complex. In our work, we tested short messages through surveys and deeper engagement through the citizens' panels. Both methods were successful in determining levels of support and the nature of concerns in relation to the technologies, although there is more to learn. Some key learnings are highlighted as follows:

Particularly in the in fast-moving digital communications world, short messages about the technologies can be effectively disseminated and widely understood. Carefully designed short messages can invoke responses that reveals aspects of the technologies that appeal to some people over others and they can prove effective in building social acceptance for future fuels technologies (Bharadwaj, Kambo, et al., 2023; Bharadwaj et al., 2024; Bharadwaj, Weder, et al., 2023).

From the deliberative style of the citizens' panels, a more layered and nuanced understanding of individual responses was possible (and stands reiterated in subsequent participatory research engagements). For example, citizens considered it important that Australia should "keep its options open" in terms of energy sources and a future energy mix. Many times, participants relied on a popular idiom 'putting all my eggs in one basket' whilst reiterating their concerns if options were lost or the energy mix was compromised (for example in the context of shifting to an all-electric pathway over one that had a place for future fuels, several participants held reservations about 'placing all their eggs in one basket', particularly in relation to energy security and reliability as well as making them vulnerable to electricity price increases). Future fuels were seen as an important part of a future energy mix, particularly if they enabled the preservation of choice in energy use. Particularly in Victoria, there was a general feeling that although electrification would suit many people, it should not be made compulsory. For those who choose to use gas, they should not have that choice denied (nor should they incur any penalty for continuing to use gas; nor feel pressured into changing systems/appliances without economic support to do so). More so for current gas users, if future fuels enabled the continued use of gas through either blending or full substitution, this was considered to be a positive attribute so long as safety was assured to the same standard as they have come to accept for natural gas and prices remained affordable. Some participants shared anecdotes related to previous transitions (e.g. from analogue to digital TV, when town gas was switched over; when NBN was introduced; or when COVID-19 regulations were imposed) and relayed an expectation that they would be

“gently shepherded" towards change rather than be forced into a situation where their choice and agency has been removed.

Given a social landscape where large tracts of the population (whom we engaged with through the surveys and citizens’ panel) still hold a neutral stance towards the technology, the offering of neutral fact-based information from publicly accessible sources did much to improve support for the technology amongst the respondents. The changes in support as observed through the 2021 hydrogen survey, 2022 biogas survey and 2021-22 citizens panels’ are shown below in Figure 2, Figure 3 and Figure 4.

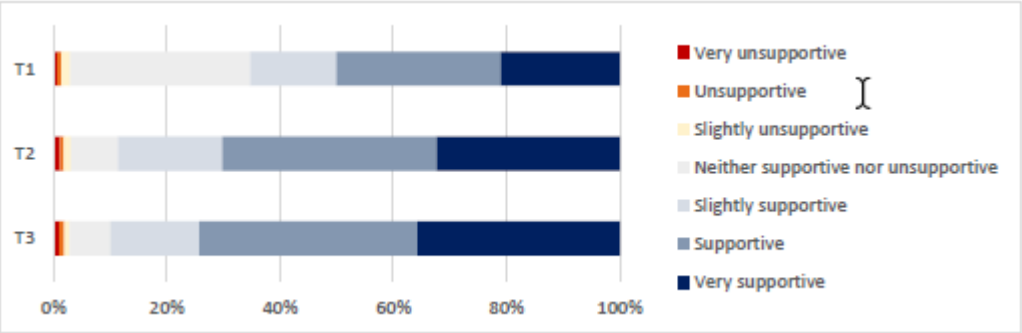

Figure 2: Support for hydrogen measured three times in survey (T1 = start; T2 = after information; T3 = after messages)

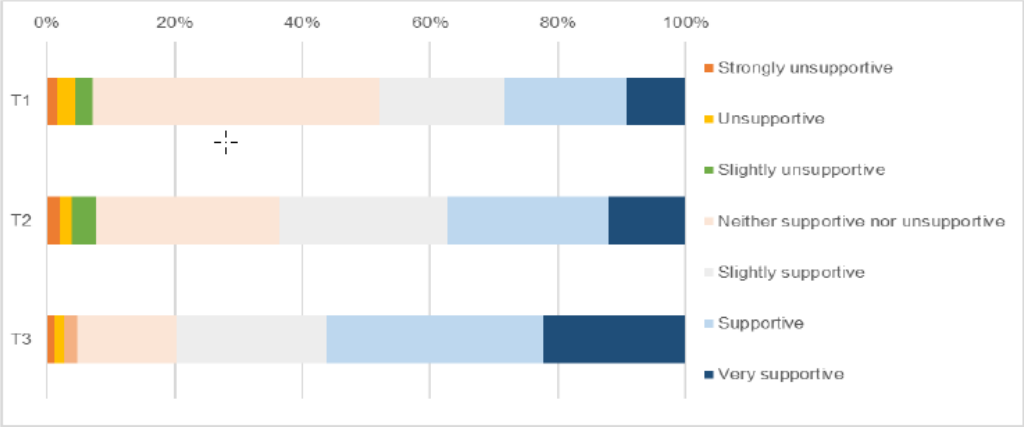

Figure 3: Support for biogas measured three times in survey (T1 = before treatment; T2 = after definition; T3 = after image and messages)

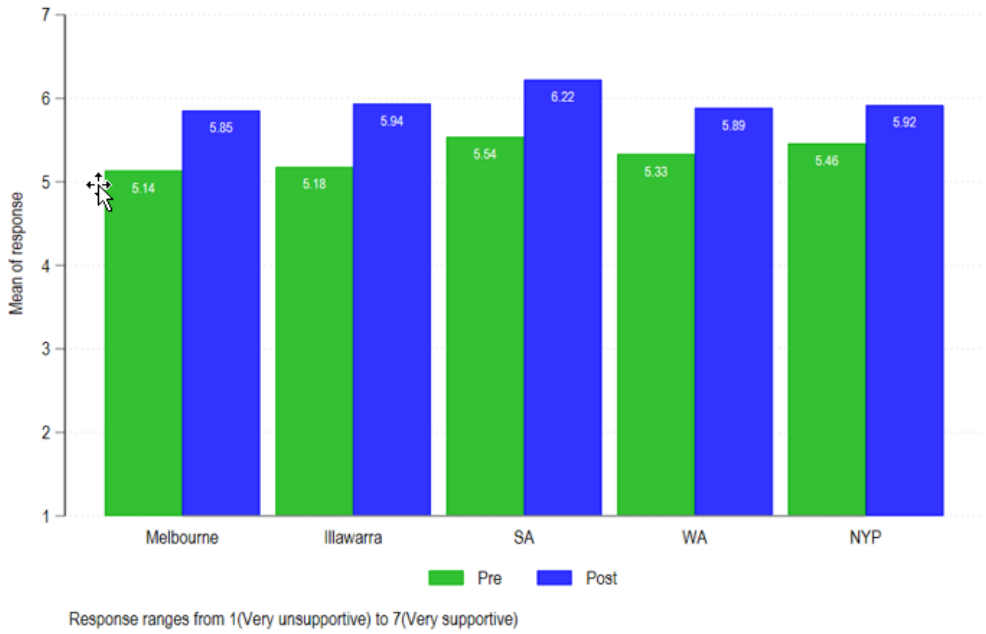

Figure 4: Changes in stated support for future fuels measured with pre- and post- participation surveys in citizens' panels across different sample groups. Citizens'' panels were conducted with representative samples of populations in a regional area (Illawarra), an urban area (Greater Melbourne) and statewide (South Australia) where connected to the National Energy Market (NEM) and then additional panels held in Western Australia and with a nationwide sample of young people aged between 18 and 35 years old.

3.3 POLICY AND REGULATORY NEEDS

A common and recurring theme throughout the engagements in this work package has been the low levels of knowledge about hydrogen and biogas technologies or projects amongst the general population. In our experience, where the public has entered engagement with our research, the provision of information from a trusted institution has been very much welcomed and had a mostly positive effect on social acceptance. Based on this outcome, a government-led public education and information campaign on renewable energies (including future fuels and other emergent technologies) would be useful in building awareness and knowledge amongst the general public. A coordinated effort between government, industry and trusted organisations may be expected to have greater effect in building trust and garnering support for future fuels technologies.

Another recurrent theme in our engagement was that participants expressed an increasing frustration and impatience with the 'politicization' of climate and energy policies. Many people scorned governments who picked one energy technology or transition pathway to promote over another because it might be seen to align better with their set of political values and be popular amongst their voters, without a thorough and robust evaluation of all options and alternatives (which it is expected would be clearly communicated to the general public). Examples given were the 'no new gas connections' policies in some jurisdictions and the inability of the federal government to implement a clear energy transition policy. Once again, we refer to the working hypothesis emerging from our interpretation of dialogue at the policy workshops and refine it as follows: *if deliberative processes were to be applied in a more formal sense, at the local government scale, any outcomes that emerge may be perceived as transparent, authentic and representative of the people's need; and could therefore, directly translate into a formal policy that holds a wider level of support.*

The general public want to see strong leadership from government in providing information and education, incentives and subsidies, and to ensure social and environmental justice in the energy transition. The need for financial incentives and subsidies for households to transition – either by investing in upgrades, appliances or renewable energy was a strong and common theme. It was noted that current incentives are targeted to homeowners and leave renters with little choice or flexibility.

At the time the workshops with the policymakers and policy influencers were conducted (Jan-Feb 2022), the future of the gas industry was being questioned in public discourse, coupled with a loudening discourse promoting an all-electric pathway to decarbonisation. Industry participants felt it important to communicate messages that justified and defended the gas industry, including how it will respond to decarbonisation

challenges, and address what they perceive as the false dichotomy of 'electrification vs renewable gas'. Government participants sought the need to gauge what the public interest and public good was in relation to a range of pathways and to understand the diverse perspectives, particularly from regional communities. Looking across all of the engagements undertaken as part of this work package, our work suggests that gas (be it conventional, unconventional or renewable) is seen to have a role to play in Australia's future fuel mix. It is therefore unhelpful to position gas as an alternative (an 'either or') to electrification given that participants (across surveys and citizens' panels) repeatedly stated an unwillingness to put 'all their eggs in one basket'. As evidence we present some principles from the panels, where we can see how participants from the different cohorts asked for a variety (of renewable, non-renewable, low-carbon energy technology types in a bid to arrive at the net-zero carbon scenario):

> *Public policy should be adjusted to keep electricity providers honest and transparent seeking to meet clean energy usage targets as well as assisting and incentivising consumers and businesses to move towards renewable energy to achieve a carbon neutral home and businesses by 2050. This should be done by exploring alternative options including emerging technologies* (South Australia).
>
> *Australia should be investing in their own research into renewable technologies, while also encouraging and incentivising the private sector to join and collaborate. This will ensure that Australia becomes a world leader in renewable energy innovation* (National Young People).
>
> *Transition to net-zero carbon emission and future energy usage in general requires early investment in ground-breaking scientific research and innovation - including more directional research into non-renewable and low-carbon energy. That research should be future focused, drive sustainable power, ensure new technology is safe for all Australians and the environment and inform industries and Government decision processes* (Illawarra/ Wollongong).
>
> *Government and private support for education and research with a purpose to encourage innovative and progressive technology with an objective to produce financially viable renewable sources of safe, environmentally friendly and reliable energy* (Greater Melbourne)
>
> *Produce the required combined renewable energy using the technologies available today and the emerging technologies, in a reliable and affordable price structure, to meet the agreed climate change deadline* (Western Australia).

Another finding is that support for future fuels does not appear to be politically aligned and so bipartisan support should continue. In the citizens' panels, participants expressed being very frustrated with the 'politicisation' of the energy transition and that such an important issue was being used as a way to win popularity in political power plays. Clear emphasis was given on the need for information and public debate that was "neutral", "factual;" "balanced", "trusted" and not "hype", or "politicking".

Another theme was that support is not only based on environmental benefits but also economic benefits and a strong sense of social justice, including the provision of benefits for regional communities. Policies and regulations must take into consideration any externalities that may incur costs, especially to remote and vulnerable people. Citizens also expect that there should be unique benefits specific to the local public in those strategic locations where future fuel infrastructure (whether for production, distribution or end-use) is going to be sited. For example, the hydrogen survey data has shown that the citizens expect hydrogen exports to bring in nation-wide economic benefits (as export income currently coming in from fossil fuels will be replaced by a clean, green energy commodity). Biogas survey data has shown that citizens expect biogas to be a 'reliable, local source of energy'. Therefore, policies and regulation now need to demonstrate how well (or not) these expectations can/ought to be met.

Lastly, our report following the workshop with policymakers and policy influencers drew attention to the fact that in a climate of disruption and transition, a 'wholesome' approach towards policy making is highly recommended. Based on criteria highlighted in the report, it is easy to see what values are commonly shared amidst the publics we engaged with. A 'wholesome' policy would seek to attune to these values and consider the whole system at play. Wholesome was a term deliberately coined to describe *policy and processes that are 'holistic' in the sense of considering the 'whole system' but that go further to promote shared values in the creation of social, economic, environmental and political conditions in which individuals and communities can flourish. In other words, wholesome policies and process consider the whole and promote community wellbeing.*

3.4 TRAINING AND EDUCATION NEEDS

Consistent, adequate, affordable and easily accessible training in handling future fuels (particularly hydrogen and hydrogen blends) is seen as a vital component in developing a new industry. Training is seen as necessary not only for those directly involved in the production, storage or transport of future fuels but also among emergency services, associated trades who may encounter hydrogen (such as welders, boilermakers and metalworkers, vehicle mechanics) and those selling hydrogen appliances and equipment.

There was a strong need identified for nationally uniform and consistent training and accreditation to enable trained and accredited workers to be mobile across Australia.

Participatory risk workshops also identified a desire for basic consumer education if hydrogen blends were to be introduced in a domestic context so that people knew what to do if they encountered a leak or problem. There was an expectation that if blends higher than 10% came to the home, there would be sufficient training and education on how to handle those blends safely in the home. Consumers would expect to know how to react and behave in case they suspected a leak to have occurred.

Commercial users were less concerned about risks and accidents as they already had acquired sufficient knowledge and experience through the workplace; but they would happily accept any further professional development as long as they were supported in acquiring any additional knowledge if they were to work with hydrogen blends or 100% hydrogen.

4. Conclusions

This research investigated the state of social acceptance for future fuels technologies in Australia and what stakeholders believe would be needed to build social acceptance to ensure its uptake. This research found that there is general support for hydrogen; and demonstrated that an individual's support for both hydrogen and biogas could be increased through education regarding the production technologies, household and broader applications, and associated infrastructure. Findings from research surveys were consistent with the findings of the citizen panel research. The latter process in particular, showed that participants have relatively sophisticated questions regarding the whole of the energy system (both production and consumption), want to understand the scientific basis of energy policy decisions, and want choice. Representatives of the relevant trades and emergency services were able to draw on existing experience with hydrogen and managing gas under high pressure to provide constructive advice regarding regulatory processes, system requirements, specialist training needs, and timeframes for adaptation. Government and industry personnel valued the opportunity to undertake social licence training, welcomed detailed information regarding community perspectives and concerns, and identified Local Government as a key tier of government with the potential to influence social acceptance of future fuels technologies.

The environmental impact assessment processes for major developments e.g., hydrogen hubs will require comprehensive and inclusive stakeholder engagement strategies, preceded by information provision. As the hydrogen industry is in its infancy globally there are currently no industry-specific domestic or international precedents to follow. However, lessons are readily available from other major energy projects e.g., coal seam gas, transmission line and renewable energy projects, to inform practice.

Public Awareness, Education and Acceptance

Public awareness and education regarding various hydrogen production technologies and potential industry development were the main focus of engagement from government and industry during the study period due to the early phase of industry development. Continuing to build on this foundation will be critical to gaining acceptance of the technology and broad support for this new energy industry. While environmental impact assessment processes have commenced in respect of specific hub projects, the comprehensive and targeted stakeholder engagement requirements of these developments will be much more effective if supported by an ongoing, concurrent public education program for the Australian community.

Knowledge of and familiarity with hydrogen technology supports acceptance. Demonstration projects are valuable for building awareness, confidence and trust in technology and subsequently acceptance. Transparent public reporting of major projects is expected to have similar impact and should be encouraged. Demonstration projects also have potential to be used to familiarise trades and emergency service personnel with new technology and infrastructure ahead of large-scale implementation.

Public awareness of biogas is very low, but with information respondents indicated willingness to use it for a range of options. Given it is well understood technology, and well tested and commercialised in other countries there is good potential to increase support through public education.

Support for future fuels is not influenced by the political alignment of respondents/participants and maintaining political neutrality will assist industry to establish.

All stakeholder groups need ready access to reliable and current information about technology and industry developments that suits their specific needs. Trust in information sources will be a major factor in building support for the industry.

Messaging

Based on survey responses, the most effective framing of the hydrogen industry outlined the potential economic, employment and environmental benefits. Messages that appeal to an individual's underlying personal and environmental values, in addition to providing factual, neutral information are more effective in building support for a hydrogen industry. Given the diversity of people and their interests/values, a range of messages is needed to effectively engage at the individual level. An individual's support for the industry is not static and can increase or decrease based on information received over time.

While understanding social acceptance from the individual perspective is important for designing effective information provision, social acceptance (or social licence) is best gained through involving communities in deliberative processes where they can participate in discussions that lead to planning and decision-making, learn from others, share their experiences and concerns and build trust and confidence in the technology, the regulatory environment as well as the project proponents.

The Policy and Regulatory Environment

Surveys and citizen panels indicate that people want choice in energy provision and that they want to be well-informed about all aspects of energy generation and supply (existing and future fuels) so that they can make rational decisions. Panel participants wanted access to complex and comprehensive information that would allow them to make decisions made on scientific evidence. Information needs to be balanced – impartial reporting of positive elements, risks, uncertainties, timelines etc is required.

Safety concerns are evident in relation to uncertainty around potential emissions from household appliances and for leakage in complex and tight networks servicing high rise or apartment buildings. Importantly, these safety concerns are ameliorated by public trust in Australia's regulatory systems and safety standards. Similar high-performance standards and regulatory frameworks are required to ensure trust in and support for new energy systems based on future fuels.

Personnel in key industries (plumbing and gas fitting) and services (emergency services) feel they have good foundation skills and experience for dealing with future fuels. However, they have each raised significant needs for safety systems development and specialised training. Each group highlighted the need for early and comprehensive engagement to fully understand the system and training needs; and several years to ensure that these are embedded before the industry is operational.

Policy personnel welcomed evidence of public expectations regarding energy systems, energy sources and information provision. However, they also noted difficulties in balancing these expectations against those of low-cost energy provision.

Local government has a key role in relation to the establishment of future fuels. Key areas of responsibilities include land use planning, selected industry approvals, business attraction, and managing systems for housing and service delivery. They will be a lead voice in public discussion of proposed projects and in advocating for projects to deliver positive outcomes for their local community.

5. Implications and recommendations

Broad public awareness of future fuels is growing but there is still little knowledge or understanding of specific projects or details of what hydrogen infrastructure would “look like” (especially at scale). Factual, objective and timely Information to build understanding, enhances social acceptance in most cases.

This finding aligns with a recent survey conducted with residents in proposed hydrogen hub localities in the U.S.A, where three quarters of respondents said they had “never heard of” hydrogen hubs before. A similar proportion said they wanted to be kept in the loop with regular information updates on the proposed projects.[6]

Acceptance or not can be aligned with personal values. People who have strong objections are less likely to change their view in the face of balanced information being offered. However, majority of our respondents have conveyed that they “sit on the fence” initially given a lack of knowledge and awareness. In these cases, when balanced, factual neutral information is offered (whether in the form of a short message, image or video in the surveys; or the detailed information and long discussions in the deliberative citizens’ panels), participants’ initial neutrality is shifted towards a more positive stance.

There is also general support for an export-scale hydrogen industry, based on messages of job creation (and replacement of fossil fuels exports) and economic benefits. This support is with the caveat that economic benefits would be shared across the community (from local to national) and not land solely in hands of a private, or multi-national venture. If profits previously held solely within the hands of fossil fuel profiteers make their way back into the hands of everyday Australians (as payment for new appliances, further education with an assurance of future employment; incentives to change systems; investment in civic infrastructure to improve scenic amenity and so on), it could serve to enhance acceptance as some citizens might be persuaded to take on the risks associated with change.

Despite this conjectural willingness, there is very little general understanding of the scale of renewable energy, associated infrastructure, workforce, or other inputs to hydrogen production such as water, minerals and chemicals required for an export-scale hydrogen industry amongst the general public.

Support for domestic use of hydrogen and hydrogen blends is stronger among current users of the natural gas network. This is particularly so when hydrogen blends are seen to enable the continued use of gas in appliances such as cooking and heating. Support for hydrogen was also based on perceptions that it enables consumer *choice*, which was highly valued among the Australian population. Hydrogen blends would be less supported if they were imposed on consumers, especially if there were costs to households incurred by the change, and the burden of cost (for example, to test homes for leaks and/or retrofit homes to new safety and compliance standards) falls upon consumers.

Concerns about domestic use of hydrogen are mainly about safety and costs to consumers. If hydrogen blends provided an affordable alternative to electricity, this would be attractive to consumers. Commercial users (with caution in interpretation given small numbers engaged in the research) appear to be more supportive of hydrogen blends but are concerned about additional hidden costs such as more frequent maintenance or upgrading of equipment, additional training, more expensive spare parts, longer waits for skilled repairers or parts as well as costs associated with upgrades to connections, property and infrastructure to be compliant with safety standards.

Safety is a factor in people’s considerations about hydrogen but there is also a strong level of trust in existing safeguard mechanisms such as Australian an international standards, trade and skills accreditations, safety regulations. Most people understand there is a level of risk associated with the use of gas, but as long as the risks of using hydrogen can be demonstrated to be similar to that of using natural gas, or other more familiar fuels it would be seen as acceptable.

[6] Environmental Defense Fund 2023 The Hydrogen Hubs are here. What do communities think about them? (edf.org)

RECOMMENDATIONS

Based on the key points from the previous section, some key recommendations are made:

Share the lessons learned from pilot projects and trials

Over the last few years, a number of hydrogen demonstration and trial projects have come to fruition. To the extent possible, lessons learned during the lifecycle of these projects – i.e. from the design, engagement, construction and operation phases - should be shared widely. Our research has shown that the public will look to demonstration projects to build their knowledge, familiarity, and trust in the use of future fuels, particularly in domestic applications. Sharing the successes and challenges encountered through trials and demonstrations with local communities, and benchmarking these with the learnings from projects around the world, will go a long way in building public confidence in the technologies. The public and other stakeholders have clearly expressed that they would expect to hear about pilot and demonstration projects, especially if they are in their local region, and be provided clear information about (i) what works well, (ii) what can go wrong and (iii) how to respond if things do go wrong. Additionally, it was expected that projects would be able to learn from the experiences of others to build a library of best practices, particularly in relation to community engagement. There has been some progress in this direction since the beginning of this research package that deserve mention. The Australian Government's Australian Renewable Energy Agency (ARENA) ARENA Knowledge Bank is an open-source library of reports and is a first step in sharing lessons learned, but the learnings are not distilled across the multitude of downloadable reports or targeted for a broad (lay) audience. Also within ARENA, The Australian Hydrogen Centre has knowledge sharing as one of its three core deliverables, with a 2023 report detailing the first years of operation and community experiences with the Hydrogen Park in South Australia.

However, technology development is an inherently competitive space and (privately funded) projects may not be so forthcoming when asked to share their successes and challenges publicly as it may affect their investment or future markets. The process of sharing relevant information while protecting commercial interests will likely need some form of facilitation by either governments or industry bodies, and the task of reviewing project reports to distil key lessons learned for a range of stakeholders, including consumers, communities, industry, investors and governments, may be more appropriately allocated to an independent and trusted research institution such as a university.

It is recommended that a centralised information portal providing a 'one stop shop' with details from across projects be developed.

Harmonisation of training, standards and regulation across states and territories

Trades, emergency services, policy makers and influencers, and some members of the public all called for the harmonisation of regulations and standards that would be needed to ensure the safe production and handling of hydrogen. For training and accreditation, this was to ensure the mobility of the hydrogen-ready workforce across states; for emergency services, it was around early and clear identification of the presence of hydrogen in emergency situations; and for policy makers, it was to manage competition between projects for resources, approvals, etc., that might lead to a "race mentality" where the pace of development outstrips the ability of stakeholders, policies, communities to keep up. Lastly, for participants from the general public, harmonisation was needed to ensure strong and consistent leadership and to mitigate any injustices, especially between regional and urban communities.

Balanced information provision

Continuing the point above, a balance of information is advisable. Too much talking 'up' and 'down' can lead to poor outcomes. Instead, what was seen to work was the provision of neutral and factual information. Balanced, neutral information was found to strengthen support for those participants who arrived with no prior opinion (Bharadwaj, Kambo, et al., 2023; Bharadwaj, Weder, et al., 2023; Lozano et al., 2022). However, if participants were strongly opposed, provision of information did not appear to influence their views. It was seen in our risk workshops that overly focussing on risks alone, tended to strengthen oppositional views in those participants who were admittedly reserved. It was seen in our risk workshops that for a few people, additional information (followed by lengthy group discussion only about risks and hazards), lead to negative views of hydrogen. However, focussing purely on positive messages about hydrogen and leaving important questions and concerns about safety and costs unanswered, is equally a poor strategy. To build trust and acceptance requires honest and upfront communication about all aspects of the technology, including acknowledgement of risks and

explanation of how they are being managed. An admission of the extent of knowledge that is yet to be discovered is always important.

The public want to see strong leadership from government to ensure social and environmental justice in the energy transition. However, participants in this research were clear that the energy transition should not be a politicised issue – policies should be based on scientific evidence and not just aligned with party values or matters that appeal to party voters.

Given the scale and pace of change required, a comprehensive public education campaign is recommended. Collaboration across government, industry and trusted institutions e.g., universities, CSIRO and specialist non-government organisations is expected to have the greatest impact on levels of support.

Bring people along as the technology moves up the technology readiness levels.

There was an increase in acceptance of all forms of hydrogen production from 2018, including with carbon capture and storage (CCS), although levels of support for hydrogen production with CCS were lower. Respondents clearly indicated a preference for hydrogen produced from renewable energy and electrolysis. However, these responses do not take into account any reflection on the scale of renewable energy and associated infrastructure or water use required for ensuring a viable export industry. This includes considerations of competing land and water use, and changes in lifestyles that may be bought about from hosting large scale renewable energy projects. Similarly, while many people were accepting of hydrogen for export use, they were more likely to agree to a production facility near them for domestic use rather than for export. When considering developing an export market there are multiple factors that need to be considered in equal amounts. Safety is key, but there is also a strong expectation to ensure economic benefits for Australia, including jobs, while ensuring social and environmental impacts are minimised. Many of these issues could be addressed through innovative and inclusive community benefits packages. As some of these issues continue to evolve and as the technology proceeds to mature, communities have expressed a strong desire to be “kept in the loop” so they can understand and capture any opportunities presented and also understand and be prepared for any impacts. Research participants would like to see coordinated and aligned community engagement activities at crucial phases in both project and industry development. This could be coordinated through industry bodies such as the Australian Hydrogen Council or the Clean Energy Council but also through the Hydrogen Hub and Renewable Energy Zones concepts.

Industry and government should engage with the community as the industry, specific project proposals, and key policy positions are evolving. Discussions regarding industry direction and future projects need to provide the community with realistic assessments of impacts, trade-offs and benefit-sharing.

Test the working hypothesis on deliberative processes with LGAs expected to host future fuel infrastructure

If FFCRC partners are keen to engage with specific LGAs where future fuel infrastructure is being considered, then we offer a working hypothesis on deliberative processes as an opportunity to further test and refine methods with which to engage with publics on the topic of future fuels:

> *If formalised deliberative processes were to be applied, targeting the involvement of local governments, the outcomes that emerge may be perceived as being derived from a transparent, authentic process that is representative of the peoples’ needs; and could therefore, directly translate into policy and practices that hold a wider level of support.*

Testing this hypothesis with involvement from local governments could bring benefits in terms of raising awareness, building capacity and empowering local communities to engage with and benefit from new future fuels projects. For example, such an initiative could be designed to both provide information and tease out issues related to proximity and closeness (of future fuel infrastructure), issues related to design, construction and operation, issues related to local governance and so forth.

It is recommended to initiate deliberative processes with local governments (in hydrogen hub localities) to identify priority issues to be addressed, and potential solutions.

Develop appropriate industry standards, regulation and training

This research elicited constructive and well-considered recommendations from trade group representatives and emergency service personnel regarding standards, regulatory processes, training and timeframes for development/implementation. This work needs to be continued promptly to ensure that these elements are embedded in time. A growing future fuels industry will also require increased personnel in government and industry with understanding of social licence theory and practice.

It is recommended that government prioritise detailed consultation with relevant trade group representatives, emergency service personnel, and associated experts to develop the necessary standards, regulatory systems and training programs to underpin robust management of the industry and meet community expectations. Outputs from these processes should be consistent across Australian jurisdictions to the greatest extent possible.

It is recommended that social licence training, based on the online training developed under RP2.1-09, be made available to industry and government employees on a regular basis.

6. Next steps and future research

In this section, we consider some crucial next steps, based on the lessons enumerated above:

Continue unpacking what it means to 'enhance' acceptance and a social licence to operate

In the case of the future fuels industry, where we know it is very early days yet and that techno-economic considerations continue to seek resolution, it was considered prudent to scope out the social research in a way that was firstly participatory – involving a set of strategically identified stakeholders; and secondly focussed on primary data collection to provide evidence with regards to prevalent levels of knowledge, awareness, attitudes and responses towards future fuel energy technologies.

Keeping in mind the participatory nature of the work, the very first scoping report for the work package was constructed based on a series of interviews with FFCRC partners. From the first set of recommendations available in this report, a series of project milestones/deliverables were constructed. This report now stands as the final deliverable of RP 2.1-02 and recounts how each piece of work that was executed to honour the initial recommendations and agreed milestones. In all the learnings recounted above we **demonstrate how the work done to date served to enhance acceptance and social licence to operate for future fuels through community engagement and deliberative processes.**

Based on our efforts, a precedent has been set here for future work: we have 'tried and tested' methods which can be repeated as many times as is needed in the future to continue enhancing acceptance for future fuels. However, in true participatory sense, determining when, where and how such exercises will bring most benefit, is a matter of open discussion between wider public, government, industry and the research community. Nevertheless, a few social experiments, could bring immediate benefits:

- Continued testing of levels of public support for hydrogen, biogas, biomethane, to see what happens if the message frames are altered. For example, as hydrogen has been in use for many industrial applications without too much public attention so far, testing messaging that incorporates facts and figures from hydrogen's industrial journey in the past (particularly around safety); and ascertaining whether presenting it as a 'new' technology builds support.
- Improve coordination and alignment of social science experiments with the developmental cycle of pilot projects and technology development. As the technology suites mature, collecting and looping social feedback into product development and improvement is always advisable. For example, there is an opportunity to engage with communities directly affected by the development of future fuel infrastructure projects such as electrolysers, biogas plants, methane blending plants – researching public attitudes from the proposal development phase through to evaluation of outcomes.
- Engagement with finance/investor sector experts to understand how to gain community acceptance of the cost and affordability of future fuels against a background of rising costs of living.
- Ongoing review and analysis of information content which has been disseminated through community and stakeholder engagement drives for specific projects. This was identified as an area of interest in the initial scoping report, and the number and scope of relevant projects is now reaching the point where useful analysis can be undertaken regarding communication strategies. The AGIG's HyHome project is of particular interest due its testing of infrastructure and appliances in the household environment, and

therefore the potential to address some of the safety concerns identified through the research reported here.

- Developing an online toolkit of communication materials based on the results emerging from RP2.1-02 and RP2.1-07.
- Given our participants were very open to knowledge and information about the future fuel technologies, it may be worthwhile to test how and (whether at all) participants continued to seek information through other channels. It will be interesting to test whether an enhanced sense of discovery manifests as a change in behaviour over time; and such a result may be considered a true validation of the engagement process.

The research team will continue to disseminate the work done to date at conferences and seminars as the opportunity arises and take in feedback to inform future research priorities. Journal publications arising from the work to date are listed in the references. Two papers are yet to be finalised. One has been submitted to a journal and another is being internally reviewed at UQ:

- Kambo, A. et al (2024). Using the 'participatory decision-making' to unpack conversations collected through a deliberative engagement process – An emerging policy direction for Australian energy and future fuels. Frontiers in Sustainable Energy Policy (Work in progress)…
- Kambo, A. et al (2024). Detecting environmental values. Work in progress…

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