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More support for hydrogen export than its domestic application in Australia

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Early research has suggested the societal acceptance of hydrogen to decarbonise our energy supply is relatively high. However, the specific aspects of hydrogen that citizens support remain unknown. To investigate public support for export and domestic applications of hydrogen, this study implemented an Australian nationally representative survey. Using a quasi-experimental design, information was provided to respondents as an intervention to test individual responses. The information included a short video, followed by images and text descriptions. The study found the combined information package increased societal support by 10% when compared to the baseline with the change in support for export applications being significantly higher compared to domestic applications. While encouraging the development of Australia's export industry it was also found that respondents' general support depends on their socio-economic characteristics and geographic location.

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Introduction

The rapid advancement of green hydrogen technology brings a great deal of optimism toward Australia's, and the world's, decarbonised energy future. Australia is among 15 other countries that have released a specific national hydrogen strategy and related roadmap documents. However, the development of a domestic hydrogen industry is also important—if not a condition—for Australia's hydrogen export capabilities and long-term viability. Green hydrogen production is dependent on several factors, including sufficient wind, solar or hydro resources, water, distribution infrastructure (ports, roads, pipelines)—and public acceptance. These factors can be divided into two categories of deployment:

- Firstly, hydrogen can be used for domestic and community application. Here, the majority of existing electricity and energy are based on fossil fuels, with coal still forecast to be the dominant energy source in the domestic energy mix until 2030 (De Rosa and Castro, 2020). While the use of hydrogen to decarbonise energy-intensive sectors such as steel making (Venkataraman et al., 2022) and heavy transport (Ally et al., 2015) is in its infancy, households do not currently have direct access to hydrogen as a fuel or through fuel cells (Li and Taghizadeh-Hesary, 2022). However, hydrogen is beginning to be blended into existing gas pipelines and delivered to households as an important first step to decarbonising Australia's economy (Walsh et al., 2021).
- Secondly, after being one of the largest exporters of coal, Australia now aims to become one of the largest hydrogen exporters in the world. While the majority of hydrogen is currently produced through gasification processes, accompanied by strategies to combine with carbon capture and storage to reduce its emissions, the massive potential for production from solar and wind energy is increasingly perceived as leading the way for the development of green hydrogen production with zero carbon emissions. The decreasing cost of renewable electricity means that green hydrogen is forecast to become cost-effective in the near future (Batterham et al., 2022; Graham et al., 2021; Li and Taghizadeh-Hesary, 2022). The report by Graham et al. (2021) evaluates different energy technologies and shows that the levelized cost of electricity for renewable energy, such as solar and wind, is lower when compared to gas and coal-fired power plants. The interim findings from the Net Zero Australia report[1] also show that for Australia to export hydrogen compounds like ammonia, it is cost-competitive with other countries. Something that other developed countries, with less access to abundant resources, can also benefit from (Walsh et al., 2021). While some capital mobilisation and infrastructure challenges remain, such as the need for dedicated hydrogen transport pipelines and additional water supply, countries such as Korea, Japan and Germany have expressed an interest in entering into hydrogen purchasing agreements, and there is already increasing investment in hydrogen shipping and transport infrastructure (CSIRO, 2021; Deloitte, 2016).

However, alongside the infrastructure, environmental and political considerations that are influencing the development of hydrogen for both domestic and export use, the societal factors around knowledge and acceptance of this changing energy system also need to be considered. More recently, the social acceptance of hydrogen has been studied through a political, economic and/or environmental lens (Achterberg et al., 2010; Emodi et al., 2021; Iribarren et al., 2016; Scovell, 2022). These studies have mostly been grounded in investigating the acceptance of renewable energy scale-up (Batel, 2020; Devine-Wright, 2007; Wustenhagen et al., 2007) and considering cultural factors in Europe (Musall and Kuik, 2011; Schumacher et al., 2019; Segreto et al., 2020) or Asia (Liu et al., 2013). While others have analysed renewable energy development in relation to national, regional and global sustainability strategies (Qazi et al., 2019; Sequeira and Santos, 2018).

Most of the research has shown that while there is a general acceptance of clean energy like solar PV (Hosseini et al., 2018) and hydrogen (Emodi et al., 2021), the biggest challenge has been community dissatisfaction with the siting of infrastructure or power plants in their immediate vicinity or neighbourhood (Schönauer and Glanz, 2022). The so-called Not-in-my-back-yard (NIMBY) or NIABY narratives (Not-in-anyone's-backyard) have been reported on in a number of studies where renewable energy projects (wind turbines, solar farms, etc.) are either rejected or not accepted with reasons relating to individuals' self-identification with their local area, neighbourhood and community, which can be threatened when new projects emerge and create concerns in relation to the disruption of the status quo of their daily lives (Devine-Wright, 2007).

The research mentioned often differentiates between *passive* acceptance (where there is no active resistance) to *active* acceptance, which may include specific actions, engagement or forms of participation via citizen initiatives. Both are highly influenced by how 'just' a project and its distribution of profits are perceived. Here, sustainability and environmental consciousness emerge as criteria that will influence acceptance of renewable energy and associated hydrogen projects, where generally higher environmental consciousness leads to more positive perception and acceptance (Adomssent et al., 2007; Bolsen and Shapiro, 2017; Druckman and Bolsen, 2011). In these instances, the role of communication and negotiation processes—more or less mediated and/or institutionalised—cannot be underestimated (Weder, 2021). It has been shown that disseminating and conveying information about sustainability, energy economics, energy use and the complex societal challenges energy can solve become essential for acceptance, engagement, and participation (see Fig. 1).

Previous research into active or passive acceptance in the renewable energy space has focused predominantly on wind and solar energy. However, it also observed that Australians express strong support for hydrogen technology (Ashworth et al., 2021; Lambert and Ashworth, 2018; Lozano et al., 2022). Understanding what aspects of hydrogen production citizens support, will help to better inform the future directions of the development of a hydrogen industry in Australia, as well as other countries. However, studies investigating the social acceptance of hydrogen that compare differences between hydrogen produced for export or domestic use and related applications are not yet available. This study fills this gap by examining whether it matters for social acceptance of renewable hydrogen, where and what the hydrogen will be used for—domestic or for export purposes.

Method

Data. Filling the identified research gap, this study uses data from a nationally representative survey undertaken to understand the Australian public's attitude toward hydrogen (Martin et al., 2021). A market research company was engaged to conduct the survey online. The survey used a non-probabilistic sampling method to collect the responses. Respondents who met basic criteria requirements, age, gender and geography, were allowed to take the survey to ensure a nationally representative response. From a total of 11,089 who commenced the survey, 3405 were rejected for

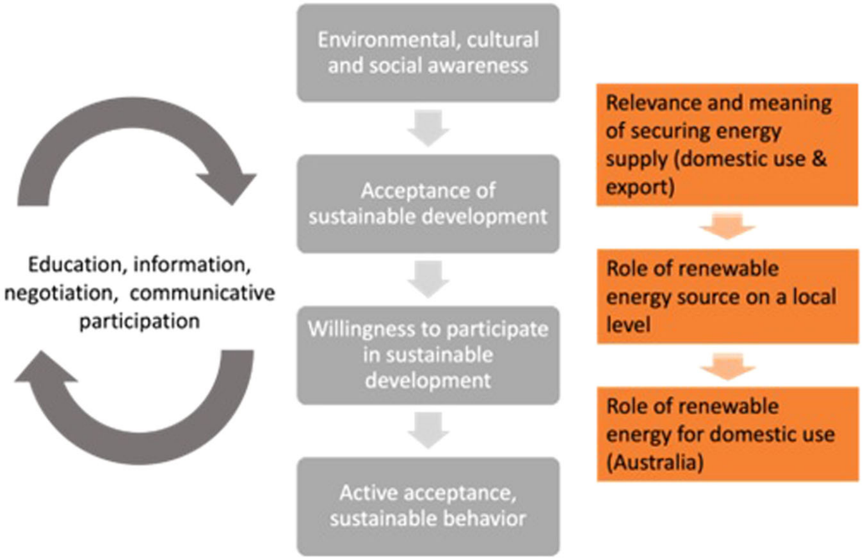

Fig. 1 Role of sustainability knowledge and information provision on acceptance and action.

not meeting the criteria, 3670 did not complete the survey and 943 failed to meet the consistency checks. The survey was in the field from 29 January 2021 to 20 February 2021, with 3020 fully completing the survey.

Survey design. Respondents were randomly divided into two groups and provided with a brief information package which included a short video along with additional information on either domestic use or export considerations of hydrogen. Figure S2 (see Supplementary Information) illustrates the flow of the study design. All responses were recorded in the same survey round.

Pre-survey baseline. The survey was designed as a pre- and post-survey. In the pre-survey, the respondents were asked to indicate their baseline support for hydrogen in Australia using a Likert scale between 1 (very unsupportive) and 7 (very supportive). Respondents were also asked to rate their subjective knowledge about hydrogen production and its application.

Brief information packages as treatments. Respondents were then treated with a brief information package that combined a short video with different images and text information as treatments. This design element of the study, was based on recent insights from research around public communication of science and technology. Here, explanatory videos, web videos, science slams and even art are increasingly discussed, applied and evaluated regarding their potential for information dissemination and education (Boy et al., 2020; Leßmöllmann et al., 2019), as well as used in strategic communication activities for raising awareness and understanding likely acceptance in the renewable energy space (Cranmer et al., 2020).

To avoid gathering pseudo-opinions surrounding the acceptance of hydrogen, as discussed with other technologies (Bishop et al., 1980; Daamen et al., 2006), after the pre-survey, respondents were first asked to watch a short video[2] produced by the Australian Renewable Energy Agency, called "What is renewable 'green' hydrogen gas?" The 1-minute and 42-second long video used graphics designed to inform the viewer about hydrogen production, its application in various aspects of daily life and industry, and for export from Australia. To ensure the respondents watched the video, they were asked an information check question at the end of the video. Respondents who failed to answer this question correctly were automatically excluded from the survey.

Following the video, respondents were randomly assigned to one of two streams: Domestic or Export. Each stream was comprised of information containing separate images and text. Here, we differentiated between the benefits associated with hydrogen. The first benefit relates to using hydrogen domestically to decarbonise Australia's energy use. The second focuses on Australia's huge potential for producing green hydrogen to export to markets such as Korea and Japan (Ally et al., 2015; Walsh et al., 2021; Wang et al., 2021). Respondents in the Domestic stream were provided with two figures showing domestic applications of hydrogen along with a brief description of how it can be used. While respondents in the Export stream were given information about the hydrogen export routes and destinations from Australia (see Supplementary Information Note 1). We refer to this combination of a short video, images and text information treatments as "SV".

Post-survey. After the short video and the specific information exposure in either stream, the respondents were presented with a post-survey. In addition to respondents being asked to again rate their support for hydrogen in Australia (using the same Likert scale as the first question), they were also asked additional stream-specific questions as well as demographic information. The section on demographics also included questions about climate change beliefs, environmental identity, trust in groups, and general attitudes toward hydrogen. These questions were particularly relevant to the theoretical considerations outlined above, where acceptance was identified as being related not only to the object/issue (hydrogen as a source of energy) but also to the radius of action and impact (local, national, international), as well as the general acceptance of sustainable development and climate change awareness.

Estimation strategy. We implemented an ordinary least square (OLS) regression to estimate the effect of the information presentation (SV) on subjective support for hydrogen based on their before and after responses using a before and after set-up. We assume the change in support for hydrogen for each respondent before and after the treatment is the effect of treatment. We estimate the effect of SV on support for hydrogen using Eq. (1).

$$S2H_{rst} = \alpha + \beta_t SV + \delta_t + \varepsilon \quad (1)$$

In Eq. (1), $S2H_{rst}$ is subjective support for 'r' respondents in the 's' stream at 't' time. SV is the treatment arm that takes the value of 0 for responses before the information treatment (at the baseline (pre-survey)) and 1 for responses after the respondent is treated with information presentation (in the follow-up post-survey). δ_t respondent-fixed effect. β_t is the parameter of interest that estimates the average treatment effect of the information treatment on support for hydrogen.

However, we note that the estimation strategy has three potential perceived limitations. First, subjective support for hydrogen is influenced by individual characteristics such as age and gender and their external context (Lozano et al., 2022). Some of these confounding factors are captured in the survey such as place of residence and level of innovativeness (through the diffusion of innovation scale). However, there are respondent-level unobserved confounding factors such as beliefs and attitudes. To control for respondent-level confounding factors, we use a respondent-fixed effect δ_t as shown in Eq. (1). The summary statistics of variables are provided in SI Table 1 (see Supplementary Information).

Second, one can argue that not having a control group could bias the estimates as it ignores the change in support for other reasons such as exposure to survey questions and response bias. Given that the gap between the timing of when the two responses were collected was short and within the same survey round (before and after information presentation), a significant change in individual views within such a short period is less likely. However, to ensure the support for hydrogen is not different from other populations, we conducted a balance test between the Export stream and the Domestic stream. As respondents were randomly assigned to streams using the market research company algorithm, we assume these two streams are not related to each other. Similarly, the lack of a control group may also raise a concern about the influence of external factors on support for hydrogen. But again, given the same respondents were asked to identify their support twice in the same online survey, it is plausible to assume that the change in support for hydrogen due to external factors is negligible.

The third arises with the use of OLS when the dependent variable is an ordinal response variable. Note, our dependent variable ranges from 1 to 7 where the variable takes a value of 1 as 'very unsupportive' to 7 as 'very supportive'. To address this concern, we complement the OLS estimate with an ordered logit regression estimate. An ordered logit regression estimates the probability of change in support in response to the treatment (Chhetri et al., 2013; Grilli and Rampichini, 2014).

To estimate whether Australian citizens are more sensitive to the Domestic or Export treatment we used stream dummies as the treatment variables and estimate the coefficient as shown in Eq. (2).

$$S2H_{rst} = \alpha + \beta_E \text{Export} + \beta_D \text{Domestic} + \delta_t + \varepsilon \quad (2)$$

Export takes the value of 1 for respondents who are presented with export-related information or otherwise is zero. Similarly, Domestic takes the value of 1 for respondents who are presented with domestic-related information or otherwise is zero. β_E and β_D are the parameters of interest that estimate the change in subjective support for Hydrogen (S2H) due to the export and domestic-related information, respectively. We use a linear hypothesis test after each estimate to investigate whether the coefficient between the Export and Domestic results are significantly different.

Table 1 Effect of information treatment on support for hydrogen for all respondents.

Variables	(1) Ordinary least squared (OLS)	(2) Ordered logit	(3) Ordinary least squared with respondent FE
β_t (Effect of SV treatment)	0.537***	2.320***	0.537***
	(0.031)	(0.111)	(0.020)
Constant	5.314***		5.314***
	(0.023)		(0.010)
Observations	6040	6040	6040
R-squared	0.048		0.193
Number of ids			3020

Dependent variable is the respondents' subjective support for hydrogen as a future fuel for Australia. Estimates in Col (1) are based on Eq. (1). Respondents were asked to scale their support using a Likert scale where 1: very unsupportive to 7: very supportive. The β_t estimates the effect of information treatment. Information treatment (SV) takes value 1 for the response after the information otherwise 0. The mean support at the baseline or before the treatment was 5.31 with a standard deviation of 1.25. Robust standard errors are in parentheses.
***$p < 0.01$.

We also used alternative specifications, described in SI Note 2 (see Supplementary Information), to check the robustness of our estimation strategy.

Results

Information increases societal acceptance of hydrogen. We first estimated the change in subjective support for hydrogen using the pre- and post-measures of subjective support. Table 1 shows the changes in subjective support due to the SV using Eq. (1) (see the "Methods" section). On average the SV increased support by 10% when compared to the baseline. Because Likert scales provide an ordered response, in Table 1, Col (2) we also report the ordered logit estimates. This shows that the probability of respondents jumping to a higher order of support increases by 2.3 times when they are treated with the information. However, because of the potential for confounding factors that may have influenced individual support, to control for any unobserved influences, Column (3) uses respondent-level fixed effect. The result shows that OLS using fixed effect is consistent with the OLS estimates. The *R*-squared value of the OLS with the fixed effect model is higher than the OLS without fixed effect. This increased *R*-squared suggests that controlling for the individual-level confounding factors increases the dependent variable variation explained by our model.

The estimates presented in Table 1 show the average change before and after the SV. Because respondents were divided into the Domestic and Export streams, we separately estimate the effect of the domestic and export SV on support for hydrogen. However, before estimating the change due to SV, we needed to make sure the respondents in the two cohorts are comparable. Table 2 reports the balance test between the Domestic and Export streams using a difference in difference balance test (Villa, 2016). The balance test indicates respondents in the two streams are similar in terms of their demographic characteristics, socio-economic circumstances, cooking fuel use and climate change belief.

Societal acceptance of domestic use and export of hydrogen. Figure 2 presents the balance test of subjective support at the baseline for both the Domestic and Export streams and the change in subjective support due to the SV on the Domestic stream (Fig. 2b) and the Export stream (Fig. 2c). Figure 2a shows that at the baseline, subjective support for both the Domestic and Export stream is not significantly different. That is, the

Table 2 Balance test of variables between Domestic and Export streams at the baseline.

Variable	Domestic	Export	Difference	*t*	Pr(*T* > *t*)
Support for hydrogen (dependent variable)	5.306	5.309	0.004	0.09	0.931
Dwelling type is separate house (0/1)	0.614	0.618	0.004	0.22	0.829
Living as couple with child/children (0/1)	0.352	0.324	−0.028	1.58	0.115
Have a university degree (0/1)	0.388	0.402	0.014	0.75	0.456
Full or part-time employed (0/1)	0.558	0.554	−0.004	0.22	0.829
Born in Australia (0/1)	0.765	0.747	−0.018	1.07	0.286
Believes climate change is not happening and won't happen (0/1).	0.065	0.073	0.008	0.83	0.407
Is of Aboriginal or Torres Strait Islander origin. (0/1)	0.047	0.038	−0.009	1.33	0.184
Age in years	46.957	47.57	0.613	1.06	0.292
Respondent is a male (0/1)	0.492	0.486	−0.006	0.36	0.717
Uses gas (mains) (0/1)	0.605	0.591	−0.014	0.83	0.409
Subscribes to Green Power (0/1)	0.204	0.194	−0.011	0.72	0.470
Resides in a regional area (0/1)	0.229	0.25	0.021	1.36	0.174

Results based on diff command in STATA 16. Bootstrapped standard error using 500 replications.

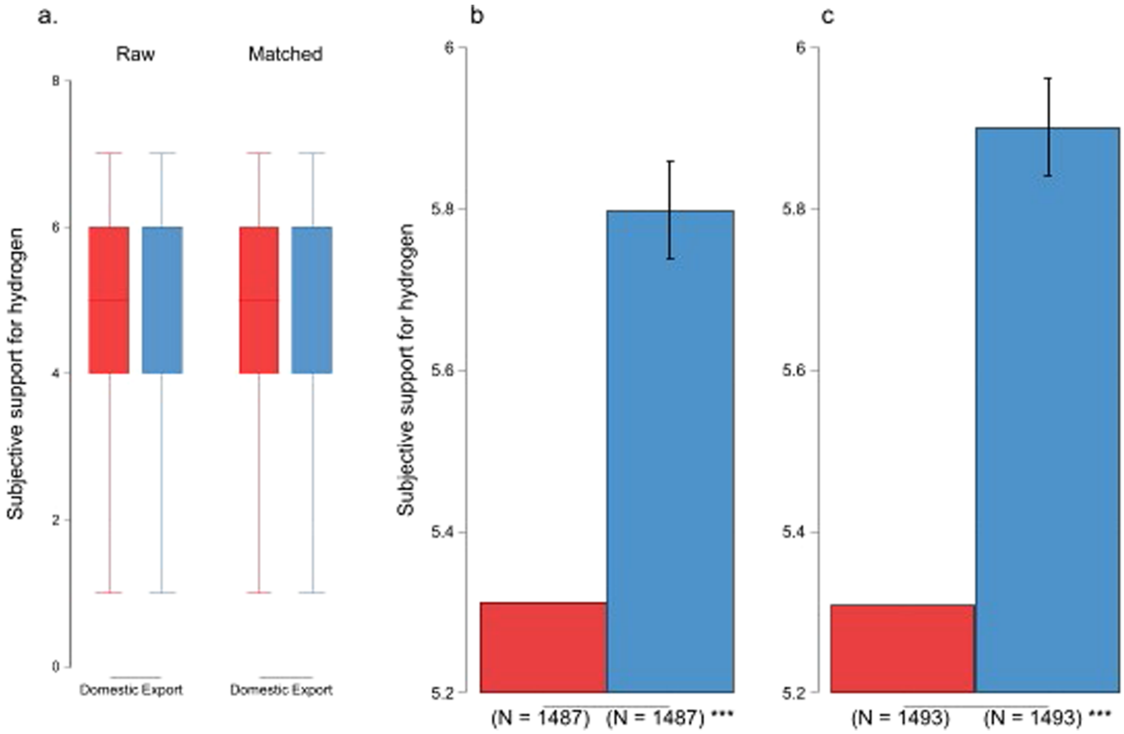

Fig. 2 Effect of information treatment on subjective support for hydrogen. Plot **a** shows the balance between domestic and export cohorts before the treatment. This is a diagnostic box plot to check the balance of outcome variables based on psmatch to estimate the treatment effect at baseline observational data. The average treatment effect of the cohort is 0.0242(0.0537), indicating the subjective support for hydrogen for respondents in the two streams is not significantly different. The middle and right plot shows the effect of **b** domestic application of hydrogen and **c** export consideration on subjective support before (red) and after (blue) the information treatment. Plots **b** and **c** use OLS estimates and graphs based on Bjarkefur et al. (2022).

respondents' mean level of support for the Domestic and Export streams was 5.31 and 5.30, respectively. Figure 2b shows the change in mean support in the Domestic stream due to the SV which reached 5.85 in the post-survey. The regression estimates for the Domestic stream, provided in Table S2, show subjective support for hydrogen increased by 9% from the baseline support due to the SV. The odds of higher-level support after the SV for the Domestic stream increased by 2.1 times without a fixed effect and 3.77 times with a fixed effect.

Figure 2c shows a change in support for hydrogen in the Export stream. The support was 5.30 at baseline and 5.90 in the post-survey. The estimates, reported in Table S3 (see Supplementary Information), show SV increases subjective support by 11% for OLS with and without respondent-level fixed effect. The odds of higher-level support after the information for the Export stream increased by 2.57 times without a fixed effect and 5.3 times with a fixed effect.

Hydrogen export is favoured more than domestic. Figure 3 plots the estimate by exploiting the variation in mean support at pre- and post-survey due to the SV for both the Domestic and Export streams using Eq. (2). The figure shows the change in support for hydrogen in both the Export and Domestic stream and that the change in the Export stream is larger than the Domestic. The coefficients are also significantly different (*p*-value = 0.0059). The detailed estimates are presented in Table S4. The results show subjective support for export consideration is 0.10 (2% of mean baseline support) higher when compared to domestic use.

Context matters. Further analysis identified that the effect of the SV does vary by who, where and what characteristics the respondents belong to. Table 3 reports the heterogeneous effect of the SV on respondent characteristics. The 'Treated' row in Table 3 shows the effect of the SV in the subsample. The effect of SV is significant and positive. However, the size of the effect varies by respondent characteristics. For example, households having solar PV are likely to change their support in general by 0.333 whereas those without PV change by 0.55. Similarly, respondents in regional areas are more sensitive to the SV than those living in metropolitan areas. Likewise, respondents who identify themselves as fast followers of technological innovations are more likely to be positively influenced by the SV than those who consider themselves innovators. The *R*-squared of the model ranges from 0.095 to 0.22. This *R*-squared indicates that more than 80% of the variation in subjective support for hydrogen remains unexplained and therefore further research could help to elucidate these factors.

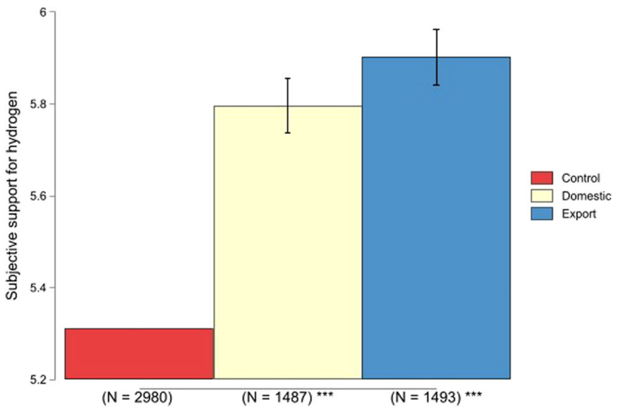

Fig. 3 Effect of SV on the subjective outcome before and after the treatment using the Stream dummies as treatment variables. The result is reported in Table S4 (Model 3). The graph is based on Bjarkefur et al. (2022).

The difference row shows the difference in subjective support between the domestic and export information. A positive coefficient shows the Export stream has a higher increase in subjective support when compared to the Domestic stream. We also test the hypothesis that the coefficient for Export and Domestic are equal and report the *P* value of the test in the last row of Table 3. The results in Table 3 show, that while all respondents had a positive coefficient, the coefficients are significant for some groups rather than others. For example, those having solar PV and using gas had significantly higher support for hydrogen. Respondents living in households connected to gas, residing in metro areas, having PV and identifying as fast followers of technological innovation are more likely to increase their subjective support for hydrogen in response to the SV.

Policy implications. This study analysed the change in subjective support for hydrogen use after treatment with a brief information package from which three key insights arose as a result.

Firstly, as mixed information packages combining videos, images and text are becoming more and more popular as ways to communicate new scientific topics, this study confirms that such packages can be helpful in potentially increasing support for emerging technologies like hydrogen. Our results have shown that the SV treatment increased support for hydrogen by roughly 9% compared to the mean baseline support. Although the effect of information packages on subjective support for technologies is not new, this finding for hydrogen and its associated uses, suggests that the use of such a brief information package will help to enhance positive attitudes towards hydrogen. This in turn may assist in enabling greater societal acceptance of a hydrogen industry over the longer term which is important given the growing international focus on hydrogen with its decarbonisation potential.

Secondly, while the SV increases subjective support, it does matter how the information is framed. Our findings show that variations in subjective support for domestic and export use changed to a differing extent. Unlike previous studies that focus on the psychological aspects of message framing (Ho et al., 2020; Scovell, 2022), this study tested the effect of the real-world application of hydrogen to understand what aspects of hydrogen people might support. The study reveals Australians are more supportive of hydrogen for export when compared to its domestic application.

Thirdly, the study shows the effect of the SV varies by respondent characteristics and their context (Andor et al., 2020;

Table 3 Heterogeneous effect of the SV on support.

Variables	(1) Yes Gas	(2) No Gas	(3) Metro	(4) Regional	(5) Yes PV	(6) No PV	(7) Innovator	(8) Follower
Domestic	0.470***	0.498***	0.457***	0.561***	0.333***	0.546***	0.332***	0.560***
	(0.037)	(0.043)	(0.033)	(0.056)	(0.051)	(0.034)	(0.047)	(0.035)
Export	0.588***	0.597***	0.579***	0.630***	0.516***	0.630***	0.348***	0.723***
	(0.037)	(0.044)	(0.032)	(0.062)	(0.046)	(0.035)	(0.044)	(0.036)
Constant	5.364***	5.244***	5.355***	5.187***	5.514***	5.220***	5.835***	5.037***
	(0.013)	(0.015)	(0.011)	(0.021)	(0.017)	(0.012)	(0.016)	(0.012)
Observations	3538	2502	4408	1552	1932	4108	2098	3942
R-squared	0.190	0.202	0.191	0.209	0.146	0.220	0.095	0.255
Number of id	1769	1251	2204	776	966	2054	1049	1971
Difference	0.118	0.099	0.122	0.07	0.183	0.084	0.016	0.163
Test *p* value	0.0250	0.1065	0.0079	0.4076	0.0078	0.0851	0.8010	0.0011

Dependent variable is the respondents' subjective support for hydrogen as a future fuel for Australia using Eq. (2). Respondents were asked to scale their support using a Likert scale where 1: very unsupportive to 7: very supportive. Estimates with the subsample are shown as the column heading. Robust standard errors are in parentheses. The row 'Difference' calculates the difference between Export and Domestic [Export coefficient−Domestic coefficient]. The last row 'Test' presents the *p*-value of the linear hypotheses test after estimation. The hypothesis is Domestic and Export coefficient are equal.
***$p < 0.01$.

Bharadwaj et al., 2022). Respondents with gas connections and solar PV in their homes are more supportive of export—which partially supports but partially contradicts previous studies. While those who have a solar PV system on their property can be interpreted as being more sustainably aware, the higher increase in support for hydrogen export is likely to be driven by more than just sustainability—such as broader economic interests for Australia and supporting global decarbonisation efforts, for example. One assumption could be that those households who have already adopted solar PV are less willing to pay for another clean energy source, hence, favouring hydrogen for export rather than having to consider converting their homes to another fuel. Those with gas connections may simply favour the need for diversity in the choice of energy fuels.

Respondents who live in metro areas also favour export compared to those from regional areas who were more supportive of the domestic use of hydrogen. It is difficult to confirm why this is the case except that individuals living in regional areas are more likely to be more reliant on various energy production processes for employment, as most of Australia's power is currently produced in the regions. There has been much discussion about the need to transition Australian regional communities into low-carbon jobs and domestic use of hydrogen could help to do this. It can also booster the potential for alternative manufacturing opportunities which has also been the focus of much of the conversation around the use of hydrogen domestically in Australia.

Another group of respondents identifying as fast followers in the diffusion of innovation were more sensitive to the SV treatment. This suggests that awareness increases support among those who are more likely to wait to see the impacts of technology and then follow. This higher effect among followers also highlights a reason why education campaigns using information, such as the video, images and messages used in this study, can help to increase technology adoption. Note these are potential explanations and will require further investigation in future research.

In conclusion, while the SV treatment on hydrogen increases social support, the size of the change in support does depend on what is the message and who is receiving it. Furthermore, the study supports our assumption that a general understanding of the global nature of sustainable development seems to add support for the importance of global export activities that can help to decarbonise the world's energy supply. At least for Australia, the policy implications of this study are that the development of a viable domestic hydrogen industry will underpin—or is even a necessary condition for—the longer-term growth and export potential of hydrogen. Real project-based information will help to make clean hydrogen production technologies more tangible and will also help to increase public understanding and acceptance of them. Transparency around the strategies and implementation, particularly when local communities will be impacted, will be key for further development and the use of information packages can play an important role in helping to assist this at the same time being relatively low cost.

Data availability

The datasets generated during and/or analysed during the current study are not publicly available due to a lack of permission to share the data but are available from the corresponding author on reasonable request.

Code availability

A complete log file of analysis is available on request.

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Notes

1 See https://www.netzeroaustralia.net.au/interim-results/.
2 Link for the video: https://www.youtube.com/watch?v=fFGT2z82tOM.

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Competing interests

The authors declare no competing interests.

Ethical approval

The questionnaire and methodology for this study were approved by the Human Research Ethics Committee of the University of Queensland (Ethics approval number: 2020002474).

Informed consent

Participant consent form respondent was obtained as a part of the online survey.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-022-01476-y.

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