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EXECUTIVE SUMMARY

The Hyacinth project, funded by the FCH-JU, has sought to investigate social acceptance issues surrounding the mass market success of FCH technologies. In addition, it developed a Social Acceptance Management Toolbox (SAMT) for use by FCH developers and policy makers that has been designed to enhance their decision making and improve the chances of mass social acceptance. This report reviews this research and investigates national differences between stakeholders and the general public in seven EU countries. It goes on the review the performance of the SAMT when highlighting these differences and demonstrates its validity as a development tool.

The report concludes with a set of recommendations for policy makers and FCH developers that should increase progress towards mass market acceptance for FCH technologies and improve public engagement.

ABBREVIATIONS

BEV	Battery Electric Vehicle
CSA	Coordination and Supporting Action
CHP	Combined Heat and Power
EC	European Commission
EU	European Union
DOE	US Department of Energy
DX.Y	Deliverable X.Y
FCH	Fuel Cell and Hydrogen
FCH-JU	Fuel Cell and Hydrogen – Joint Undertaking
FCH	Fuel Cell and Hydrogen
FCEV	Hydrogen Fuel Cell Electric Vehicle
HRS	Hydrogen Refuelling Station
IPR	Intellectual Property Rights
R&D	Research and Development
SAMT	Social Acceptance Management Toolbox
SME	Small and Medium Enterprise
TC	Technical Committee
WP	Work Package
WPL	Work Package Leader

1. INTRODUCTION

Among the alternative technologies to generate low-carbon heat and electricity and to replace fossil-fuel based powertrains, residential stationary fuel cells and hydrogen fuel cell electric vehicles (FCEVs) are receiving support towards commercialization Stationary Applications offer some important benefits over other low-carbon heating technologies, and cost reductions and financing mechanisms for the purchase or installation are bringing the technology close to commercialisation in several countries. Although the technology will likely remain comparatively expensive, it is assumed that home fuel cells have mass-market potential and will have a significant impact on reducing emissions and primary energy consumption where they are deployed. The deployment of FCEVs, although still facing several challenges, is advancing worldwide; fuelling infrastructures are being deployed in several countries and auto manufacturer actions seem to confirm their commitment to keeping fuel cell technology as an option.

Public and consumer acceptance will likely play a role in the successful adoption of hydrogen and fuel cell applications, both in the residential and the mobile sector. The future is uncertain: FCH applications might benefit from a public willingness to take up more efficient heating and transport systems, or the public may prefer other alternatives or even incumbent, fossil fuel or combustion-based technologies that might be perceived as safer, cheaper, more effective and easier to control. As markets for hydrogen and fuel cell technologies develop, citizens will react in different ways to energy policies and local infrastructures deployed in their countries, regions and cities, and end-users will decide whether fuel cells fit their particular circumstances. Although these technologies are not yet present in peoples' lives, they have the potential to influence peoples' daily life and routines in the future and so will face a range of challenges in terms of social and public acceptance.

Public attitudes towards hydrogen and fuel cell technologies have received significant attention from the social sciences in the last 20 years. Available studies in different countries have examined public awareness, understanding and acceptance of hydrogen and fuel cell technologies as well as the factors that predict support and opposition. This research includes different research designs and studied populations (general public, users, population affected by hydrogen infrastructures, selected age groups, students, and workers) and hydrogen and fuel cell applications. Generally, the available studies indicate that low levels of knowledge of - and interest in – FCH technologies coexist with relatively high levels of acceptance and support (an overview of the various conceptual frameworks and methodologies used in this research has been provided in Ricci, Bellaby, and Flynn 2008; Truett and Schmoyer 2008; Yetano Roche et al. 2010).

As part of this greater effort, the Hyacinth Project has worked to increase the understanding of cross-country differences in the social acceptance of FCH applications. The vast majority of research on public acceptance of FCH applications has focused on specific countries and very few multi-country social research studies have been carried out in this area. Therefore, the first aim of this study was to assess levels of awareness, understanding and acceptance of FCH technologies in the general public in various EU countries with different levels of market penetration and government support. Survey data was collected to examine public attitudes towards residential fuel cell and hydrogen fuel cell transport applications and related infrastructure in seven European countries: Belgium, France, Germany, Norway, Spain, Slovenia and United Kingdom. The specific objectives of this study were:

1. To estimate in the general population indicators for: awareness, familiarity, perception of benefits and costs, global attitude, acceptance and related attitudinal dimensions regarding (1) fuel cell residential applications; (2) hydrogen fuel cell transport applications and related infrastructures
2. To identify key individual and social determinants of public awareness and acceptance of these FCH applications;
3. To report on cross-country comparisons in public awareness, attitudes and acceptance about FCH applications.

Second, a mixed-methods study aimed at obtaining insights into stakeholders' views on the challenges in the adoption of fuel cell stationary applications for heating and electricity and FCEVs was developed and implemented in Germany, France, Spain, Slovenia and the United Kingdom. The specific objectives of the study were:

1. To examine acceptance of hydrogen and FCH technologies of people already involved with the technology (e.g. project partners, project environment, etc. in demonstration sites and at demonstration events).
2. To assess the perception of other stakeholders' attitudes and views regarding: (1) fuel cell transport applications and related infrastructures and (2) fuel cell stationary applications (for heating and electricity);
3. To report on cross-case and cross-country comparisons in stakeholder attitudes towards fuel cell hydrogen technologies;

Third, the development of a Social Acceptance Management Toolbox, the SAMT, that stores the responses from stakeholders and the general public and allows stakeholders to gain a better understanding of social acceptance issues by not only displaying the thoughts, attitudes and opinions of the public in the seven states where the public quantitative research was carried out but compares this with the opinions and attitudes of stakeholders. Through understanding the areas of convergence and disagreement between these two groups it is possible to gain a deeper understanding of a given situation and so adopt a more appropriate strategy for overcoming any problems or taking advantage of any opportunities that may arise.

1.1. The study on public acceptance of FCHs

A specific multi country questionnaire-survey was designed and implemented during 2015 and 2016 to assess the levels of public awareness, understanding and acceptance of hydrogen and fuel cell technologies and applications. The design of the questionnaire also aimed at building a predictive model for the acceptance of FCH technologies based on segmented responses to FCH technologies, including factors known to be relevant in this context. The questionnaire included items specifically developed by the research team and drawing partly on a technology acceptance model describing the causal links among the attitudinal elements that directly and indirectly affect technology acceptance (Huijts, Molin and Steg, 2012). It also included a selection of items from previous studies on public acceptance of hydrogen and fuel cell technologies and other energy technologies in different countries (Achterberg, Houtman, van Bohemen, & Manevska, 2010; de Best-waldhober and Daamen, 2006; Huijts, De Groot, Molin, and van Wee, 2013; Huijts, Molin, and Steg, 2012; Midden & Huijts, 2009; Truett & Schmoyer, 2008).

Given that hydrogen fuel cell technologies are generally unknown to the general public, special attention was given to the type of information provided to respondents about the technology prior to answering the questionnaire. Participants received neutral information regarding: a) hydrogen and fuel cells in general and; b) fuel cells for residential use (half of the sample in each country) or hydrogen fuel cell electric vehicles (the other half of the sample), depending on the type of application the respondent was evaluating. Participants also received information regarding the potential consequences of the implementation of the two FCH applications. Each of the consequences was related to one potential benefit/cost of the application. Participants were then asked to rate each of the consequences. The main objective of this exercise was to allow for an informed evaluation of the application by the participants. The exercise was inspired by the Information Choice Questionnaire method (Best-Waldhober and Daamen, 2006).

Nationally-representative samples of approximately 1000 adults from each country took part in the online survey. The sample consisted of panel members who had agreed to participate in online market and social research. The samples were representative for the age and gender groups in each country and had an approximate distribution regarding region and education. Invitations to take part in the survey were sent to participants through the access panel system. Data was collected during April and May 2016.

1.2. The study on stakeholder attitudes towards FCHs

This second study used a mixed methods design based on qualitative interviews and a questionnaire survey. The target group was comprised of experts and members of the stakeholder groups including research organisations, government departments/policy makers and private industry in Germany, France, Spain, Slovenia and the United Kingdom. The survey was implemented with energy stakeholders and hydrogen experts. The semi-structured interviews were carried out with members of the stakeholders groups around selected hydrogen demonstration projects in the five countries.

The stakeholder survey was conducted using an online self-completion questionnaire. The questionnaire for the survey was made-up of 16 questions regarding hydrogen production and use, stationary and transport applications. Participants were asked to provide their expectations about FCHs, their perception of the main challenges facing these applications and their overall attitude towards these applications. Some of the dimensions and items included in the questionnaire were drawn from the studies previously reviewed. Additional dimensions and items were specifically generated by the research team based on previous knowledge on the state of the applications and on the specific research objectives. As a check on face validity, survey items were sent to researchers and experts within the consortium to obtain suggestions for modification. Data was collected from 30th March until 8th June 2016.

Qualitative interviews were conducted by the members of the research team in the five countries. An open-ended interview protocol was developed to ensure that all interviewees were asked the same questions and given the opportunity to comment on the same areas. The protocol concentrated on three main issues: evaluation of a specific hydrogen and fuel cell application (benefits and opportunities; costs and threats; comparison with alternative technologies), expectations regarding the future adoption of the specific application, and recommendations for advancing the use of the technology. Interviews were carried out between 13th November 2015 and 8th June 2016. Most of the interviews were conducted by phone; some of them face-to-face. The interviews lasted between 15 and 90 minutes; most of them around 30 minutes.

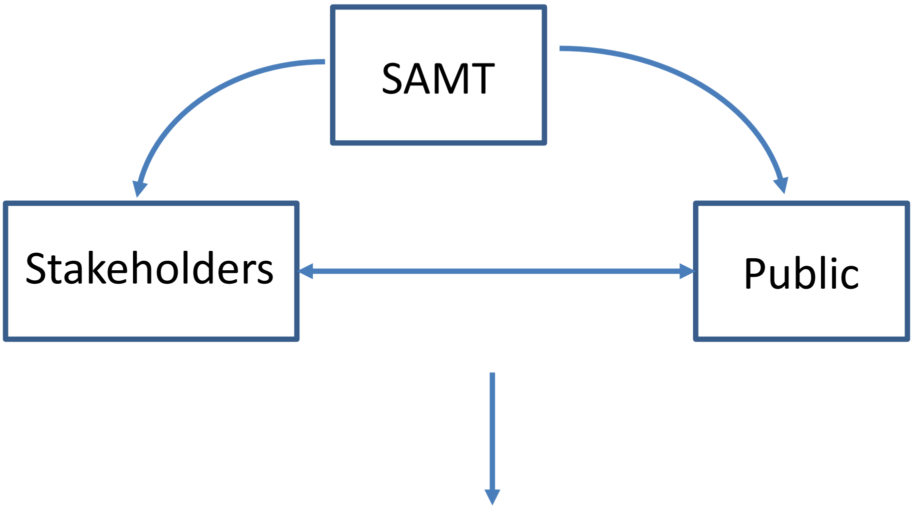
Our sampling was deliberate and systematic rather than representative in a statistical sense. This was done partly on the basis of deliberate or purposive sampling, convenience sampling and snowballing. First, interviewees and organisations were selected to reflect a range of positions in the relevant innovation system, though with an emphasis on demonstration projects (on stationary and transport applications). This stratification and systematisation reflected project's objectives and was aimed at understanding the variety of experiences and views of individuals working in a range of projects, differentiated by project objective, type, scale and country. Second, we also recruited stakeholders by snowball sampling and convenience. With the help of some interviewees we recruited new interviewees. Again, respondents were selected to represent varying levels of involvement in FCH technologies.

We distributed a questionnaire survey to 333 members of the stakeholders groups in the five countries. They were invited to participate via email. In terms of organisational background, the majority worked in private companies, followed by government organizations and non-profit organizations. The experts that participated in the survey had plenty of experience in the field of hydrogen and fuel cells: more than a quarter of the respondents have been professionally involved in hydrogen and/or fuel cell activities for 11 years or more, 26 percent are involved in these activities for less than five years and 21 percent for five to ten years. With regard to the field of work or expertise, more than half of the respondents, 53 percent, worked in research on hydrogen and/or fuel cells. Nearly a third worked in the field of hydrogen production and a quarter in systems integrations.

We conducted a total of 145 semi-structured interviews. We first recruited professionals participating in large-scale projects on hydrogen and fuel cell technologies. In order to enlarge the sample of interviewees, we also included representatives of the stakeholder groups familiarized or potentially interested in FCH applications. Overall, these included representatives from administration and government, the energy sector, industry, research and development (R&D) institutions, small and medium sized enterprises (SME). They were mainly, but not exclusively, internal (to the innovation system) stakeholders.

1.3. The SAMT

The Social Acceptance Management Toolbox (SAMT) consists of a database containing the opinions and responses of stakeholders and members of the general public. It compares and contrasts these opinions in order to highlight any gaps in understanding between the two groups. The SAMT is used in conjunction with the hand book and illustrative Best Practice Case Study (D6.4). Users are able to interrogate the SAMT which then produces a report that summarises the responses from the general public and looks for areas of agreement and disagreement between stakeholders and the public. It is often by analysing these differences that insights are gained.



+/+ Both parties agree the situation is positive
+/- Public think the situation is better than Stakeholders do
-/+ Stakeholders believe the situation is more positive than the public
- /- Both parties agree the situation is negative

Figure 1: SAMT operation

The SAMT produces a report with advisory text to help users make sense of the findings and plan a strategy to enhance the potential of social acceptance. Extracts from sample reports for a fictitious stationary application in Germany, the UK and Slovenia are shown in section 4.0 to illustrate the type of information available to the user. In subsequent sections of this report these results are compared to the results from the analyses carried out in earlier work packages to validate the results obtained from the SAMT.

2. RESULTS ON PUBLIC ACCEPTANCE OF HYDROGEN FUEL CELL TECHNOLOGIES

Hydrogen and fuel cell technologies

Levels of public awareness about hydrogen and fuel cell technologies in the context of energy production vary across the seven studied countries. Levels of public awareness are higher in Germany and Norway (50%) and lower in Spain (29%). Only around 6% of respondents in the full sample of European respondents consider themselves familiar with the technology. Despite this, the European public tends to provide a neutral to positive initial evaluation of FCH technologies as a potential solution to energy and environmental challenges. Almost 6 out of 10 respondents (57%) evaluate FCHs as a good or very good solution to energy challenges. There are small but significant differences in the initial evaluation of FCH technologies across the seven countries.

Residential Fuel Cells

The level of public awareness of residential fuel cells is significantly lower than the level of awareness found for hydrogen and fuel cell technologies in general, in all of the countries studied. Only around 25% of respondents report having heard of residential applications. The level of awareness ranges from 32% in Germany to 20% in Norway. Fewer than 5% of respondents consider themselves knowledgeable about this specific application.

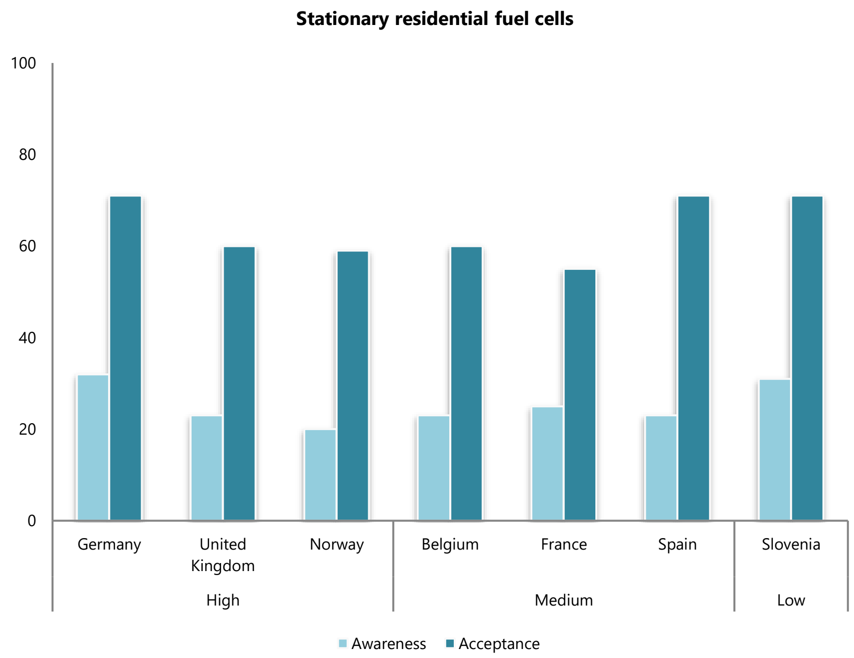


Figure 2: Awareness vs Acceptance Stationary Applications

Generally, respondents provide a positive evaluation of home FCHs (average of 3.7 in a scale of 1 to 5). Around 60% respondents consider the technology a good or very good electricity and heating system. There are small but significant differences across the countries studied. The attitude towards home fuel cells is more positive in Slovenia (mean 3.84 in a scale from 1 to 5), Spain (3.79) and Germany (3.78) and more neutral in Norway (3.48) and United Kingdom (3.62). Regarding acceptance and support, the majority of participants (64%) in the seven studied populations would be happy to have a hydrogen fuel cell unit installed in their home in the future. There is a higher level of acceptance in Germany, Spain and Slovenia (around 71%), and a lower level in France (55%), Norway (58%), Belgium (60%) and UK (60%). Support of public funding for FCHs is generally high in the seven studied countries, and higher than personal acceptance. More than 7 out of 10 respondents agree with providing subsidies to stationary residential FCHs.

Finally, only around 2 out of 10 respondents consider it likely or very likely that they would purchase a home fuel cell in the near future. The price the fuel cell is the most relevant reason for not installing a fuel cell at home (73% of respondents), followed by the perceived lack of maturity of the technology (45%). Other issues raised include not being the owner of the residence, already having other electricity and heating system installed, the suitability for various types of homes, potential installation problems, safety and lack of information.

The majority of respondents in all seven countries would support the installation of a fuel cell power plant in their town. In the full sample, around 6 out of 10 respondents would vote in favour of the siting of the power plant, 3 out of 10 are undecided and 1 out of 10 would vote against it.

Hydrogen fuel cell electric vehicles (FCEVs)

Public awareness of hydrogen fuel cell electric vehicles (FCEV) is higher than that for residential fuel cell units. Around 45% of respondents have heard a little bit about FCEV and 15% report knowing a little about fuel cell cars. There are significant differences across the countries. Norway and Germany are the countries with higher levels of awareness of FCEVs. Respondents' experience with FCEV is low across the studied countries. Fewer than 10% of respondents have had some experience with FCEVs (passenger cars or buses).

Generally, respondents in the seven countries provide a positive evaluation of FCEVs (average of 3.7 in a scale from 1 to 5). Around 6 out of 10 respondents consider the technology a good or very good option. There are small but significant differences among the countries studied. Regarding acceptance and support for FCEVs, the majority of participants in the seven countries would be happy to have a hydrogen fuel cell car in the future (assuming all things being equal, including price equivalence with contemporary cars and refuelling availability). Specifically, more than 60% in the full sample would like to buy an FCEV in the future, again under conditions of equivalence. Almost 80% of respondents are in favour of the substitution of conventional buses for hydrogen fuel cell buses, though with significant differences across countries.

Without the condition of equivalence, only a minority of respondents consider it likely or very likely that they would purchase an FCEV if they need to purchase a car in the near future. The price is reported as the most relevant factor for not purchasing a FCEV, followed by lack the maturity of the technology. Other reasons for not purchasing a FCEV include the lack of refuelling stations, having other necessities or not wanting to have a car, safety and other perceived disadvantages.

Finally, less than 5% of respondents are aware of the existence of a hydrogen refuelling facility in their city. Generally, a hydrogen refuelling station is considered by the average respondent to have more benefits than costs. Respondents generally support the siting of hydrogen refuelling stations. Around 7 out of 10 respondents would vote in favour of the siting of the hydrogen refuelling station. Differences across countries are not significant.

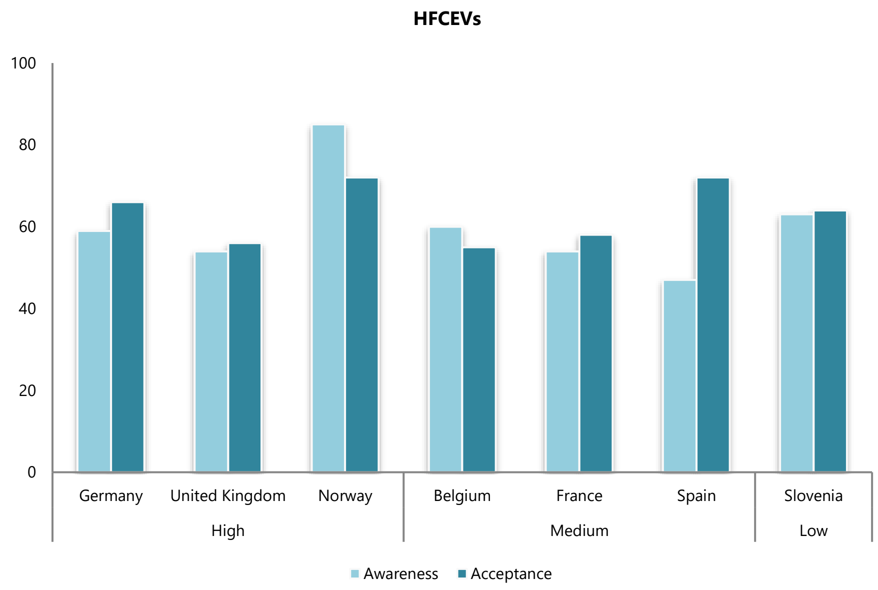


Figure 3: Awareness and Acceptance of FCEVs

Differences in awareness and acceptance per country-grouping

When the data is examined according to the country grouping developed previously in the project (countries were classified in advanced: UK, Germany, medium: Spain, France and low policy: Slovenia support to FCH technologies), some interesting patterns are observed. Norway and Germany have a similar position in terms of public awareness and initial uninformed evaluation of FCHs. As initially expected given its level of hydrogen and fuel cell implementation, Germany is the country with the highest levels of public awareness, acceptance and support to hydrogen and fuel cell applications. With regard to the two applications, the levels of awareness and acceptance of FCHs are also high in Norway, but interestingly, the public in Norway is more positive about FCEVs than they are about residential fuel cells. In the United Kingdom, the general public is significantly more sceptic or neutral towards FCH applications than in Germany and Norway. Public awareness about the technology is also lower in the UK than initially expected, given the level of implementation of these technologies. Interestingly, the UK shares a similar level of awareness of FCHs and uninformed evaluation to France.

With regard to the countries with medium policy support to FCH technologies, public acceptance and support to hydrogen and fuel cell technologies is relatively high in Belgium. In France, the public is slightly less positive about these technologies than in other countries, but the level of support to public funding for these technologies is high. The public in France seems to express a relatively higher preference for alternative technologies such as hybrid and full electric cars. In Spain, despite the low levels of awareness about the technology, the general attitude of the public towards hydrogen and fuel cell applications is very positive. Levels of public acceptance in Spain are significantly higher than in France and Belgium.

Finally, in Slovenia, despite the low level of implementation of FCH technologies, the level of public awareness and the general attitude of the public towards hydrogen and fuel cell applications is very positive. The level of public acceptance of hydrogen fuel cell applications in Slovenia is significantly higher than in countries such as France, Belgium or the UK.

In general, while some of the results of the study seem to indicate that countries with higher levels of policy support and technological implementation tend to have higher levels of public awareness and acceptance, overall, public reactions to hydrogen and fuel cell applications seem to be, to a large extent, independent from the country's level of technological implementation and policy support.

Supporters and opponents

Overall, based on the level of acceptance and support for the two FCH applications studied, respondents can be categorized into three groups: supporters, neutrals and opponents. In the full sample, 6 out of 10 respondents can be considered supporters of FCHs applications, 3 out of 10 as neutral and fewer than 1 out of 10 respondents as opponents to FCH applications (figure 3). There are significant differences across the seven countries. The highest percentage of supporters is found in Slovenia, Spain and Germany, and the lowest is found in United Kingdom, France and Belgium.

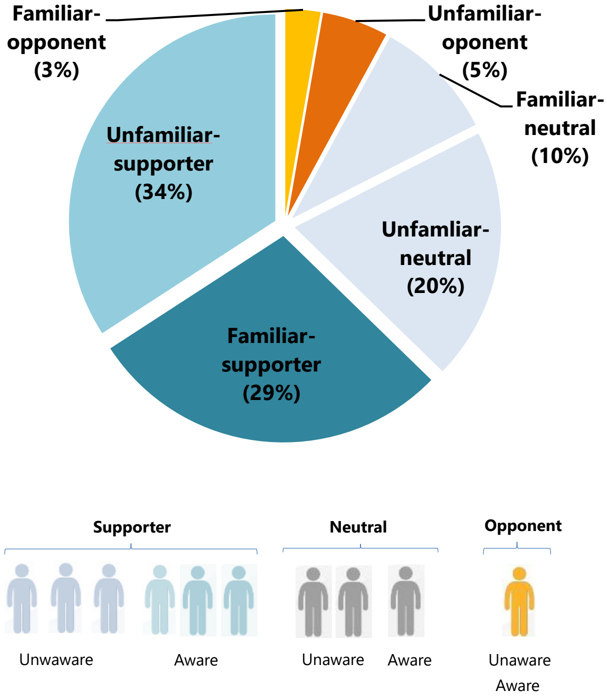


Figure 4: Classification of respondents according to their level of awareness and their attitude to FCH applications

Supporters and opponents differ significantly in their affects, beliefs and reactions towards home FCHs and FCEVs. Both categories of respondent evaluate both hydrogen fuel cell applications in significantly different ways. Although the groups share most sociodemographic characteristics, male and younger respondents are significantly overrepresented among supporters.

Sociodemographic correlates of public attitudes towards FCH applications

The data show the existence of small but significant socio-demographic differences in public attitudes towards FCH applications. Gender and age were the sociodemographic variables associated to more dependent variables. The pattern of association was very clear for sex: male respondents reported, on average, higher levels of awareness, interest, acceptance and support relative to female respondents. The pattern of association was unclear for age: Younger participants reported higher values in some of the variables, whilst older participants reported higher values for other variables. Educational level, size of residence and income were positively associated to almost half of the studied variables. Briefly, male respondents with university degrees living in cities with more than one million inhabitants and living comfortably with current income had, on average, the most favourable profile of acceptability.

The effect of information and prior attitudinal orientations

Regarding the effect of providing information on respondents' evaluation of FCEV, the data show an average non-significant increase in favourable attitude (after comparing the differences between the uninformed evaluation of FCHs and the informed evaluation of stationary FCH units and FCEV). Interestingly, the effect seems to differ between opponents and supporters: as opponents become more informed about FCH applications, their evaluation of the technology gets worse, and this variation is significantly higher than for supporters or neutrals.

Considering the previous attitudinal orientations of respondents, we find that those reporting a positive orientation towards both environment and towards technology tend to report a more positive evaluation of both applications, a higher level of interest and a higher self-reported likelihood of installing a home FCH or purchasing an FCEV. On the contrary, those without an orientation towards technology and the environment report a more negative attitude towards both applications, a lower level of interest and a lower self-reported likelihood of installing a home FC or purchasing an FCEV. Those with a positive orientation to the environment or to technology report an intermediate attitude to both applications.

A model of public acceptance of FCH applications

A number of attitudinal factors influence the acceptance of residential hydrogen fuel cells and FCEVs. First, the acceptance of both applications is influenced by the global attitude towards the applications, which in turns, is influenced by familiarity, positive affect, negative affect, the perception of benefits and costs and the preference for alternative technologies. Positive affect is the variable most strongly associated with acceptance, for both the acceptance of home fuel cell units and for the acceptance of FCEVs. Perceived benefits play a more relevant role in the acceptance of home fuel cells, whilst the preference for alternative technologies (conventional cars) plays a more relevant (though negative) role in the acceptance of hydrogen fuel cell cars. Trust, having a pro-technology belief and environmental self-identity, has a positive but small effect on acceptance of both residential FCHs and FCEVs.

Discussion

Europe needs to decarbonize its economy and this requires action within the domestic and transportation sectors. Among the alternative technologies for generating low-carbon heat and electricity and to replace fossil-fuel based powertrains, residential stationary fuel cells and hydrogen fuel cell electric vehicles (FCEV) are receiving support towards commercialization. Consumer preferences and choice will likely play a role in the degree in which these applications will impact on reducing emissions and primary energy consumption. Existing public preferences may become a hurdle to a hydrogen future. Understanding attitudes and behaviours provide insights into the factors that influence how individuals and households take decisions on technologies for electricity and heat and transportation. Together with other measures, European carbon targets should be underpinned by an evaluation of the likely role of public and customer preference and choice.

3. RESULTS ON STAKEHOLDER ATTITUDES TOWARDS HYDROGEN FUEL CELL TECHNOLOGIES

During the Hyacinth project, partners carried out in depth interviews with 145 research, commercial and government stakeholders to understand their views on FCH technologies and augmented this with an online survey of 333 stakeholders from the same groups, the factors necessary for the further diffusion of the technologies and the anticipated public attitude to them. Respondents were asked to choose whether they wished to respond to questions regarding stationary applications or Transport applications. During the coding of the results of the interviews it was decided to divide the responses into three categories:

1. Hydrogen supply and distribution. These are projects that are primarily about hydrogen production, use and distribution, without a specific reference as regards the use of that hydrogen.
2. Stationary Applications. These applications include systems to provide heat and power for domestic and commercial properties, Uninterruptable Power Supplies (UPS) systems and portable power for laptops, etc.
3. Transport Applications. This category includes FCEVs, hydrogen refuelling stations and other transport applications. It is taken to mean applications related to transport in general.

In general, of the stakeholders participating in the on line survey, 88 % think that FCH technologies are a good or a very good solution to these challenges. There is some variance in the evaluation across countries. However, these differences do not turn out to be significant.

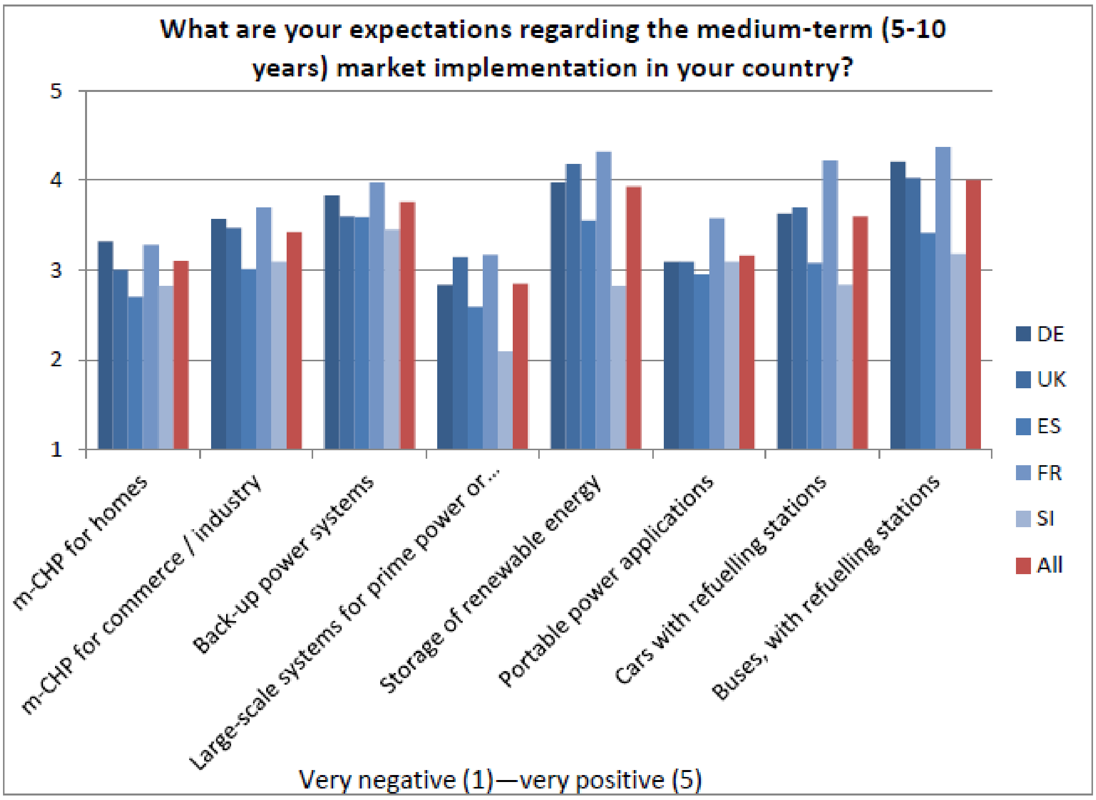


Figure 5: Medium term expectation for FCH technology market by country

When asked about their medium term expectations for FCH technologies some differences were noted by country. France and Germany were most positive regarding micro CHP for homes. The UK less so possibly due to the prevalence of natural gas grid powered heating and the focus upon transport applications at present within the UK (European Projects and Policies: deliverable report from WP2 of Hyacinth). Micro CHP for industry was seen as a more likely scenario by stakeholders in these three countries. Slovenia, having a lower level of hydrogen projects is understandably more cautious regarding the medium term outlook. However, Spain is an interesting case, where stakeholders are generally pessimistic. Storage of renewables and FCEV buses were also seen as a growth area by France, Germany and the UK although much less so by Spain and Slovenia.

Stationary applications

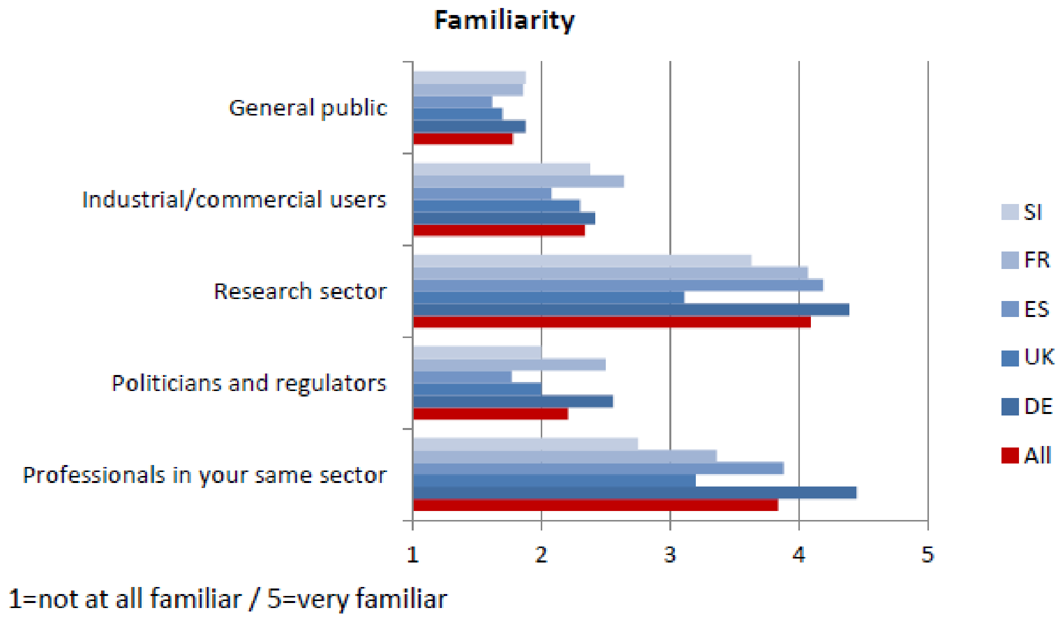


Figure 6: Expectations of familiarity by country

Stakeholders generally agree across all states that the general public and politicians and regulators will have a low awareness of FCH technologies, with Spain having the lowest expectations regarding this. Only France and Germany buck this trend with regard their politicians and regulators. Interestingly, given its advanced hydrogen support status, the UK lags other advanced hydrogen states with regard the levels of familiarity of FCH technologies with in the research sector and other professionals. Whether this is an accurate picture as only 40% of respondents rated themselves not at all familiar with FCH technologies, or is due to the influence funding and policy decisions is unclear. Certainly the UK has a strong bias towards transport applications but this is also true of France and Germany who do not have similar expectations in these areas. However, the results are broadly in line with those gained by polling the general public.

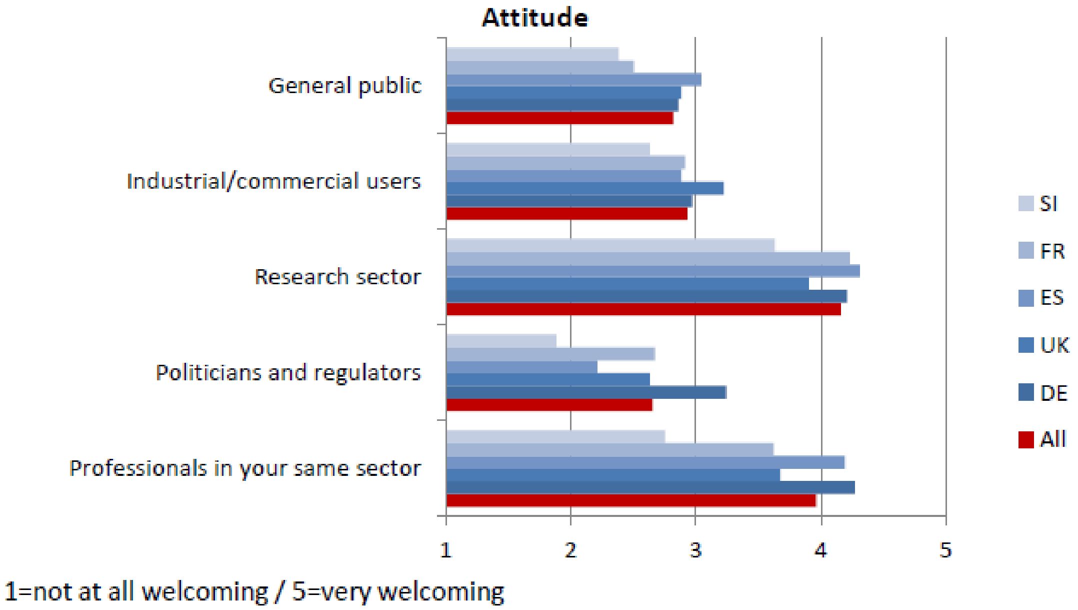


Figure 7: Expectations of attitude by country

Interestingly the stakeholders did not anticipate the generally supportive attitude of the general public for FCH technologies. Of the five states from which responses were gathered, Slovenia understandably lagged behind the others. This is potentially due to the lower level of familiarity with FCH technologies. None of the states considered in HYACINTH project, apart from Germany, that has the most comprehensive set of policies regarding hydrogen and alternative energy sources, expected politicians and regulators to have a particularly positive attitude towards FCH Technologies.

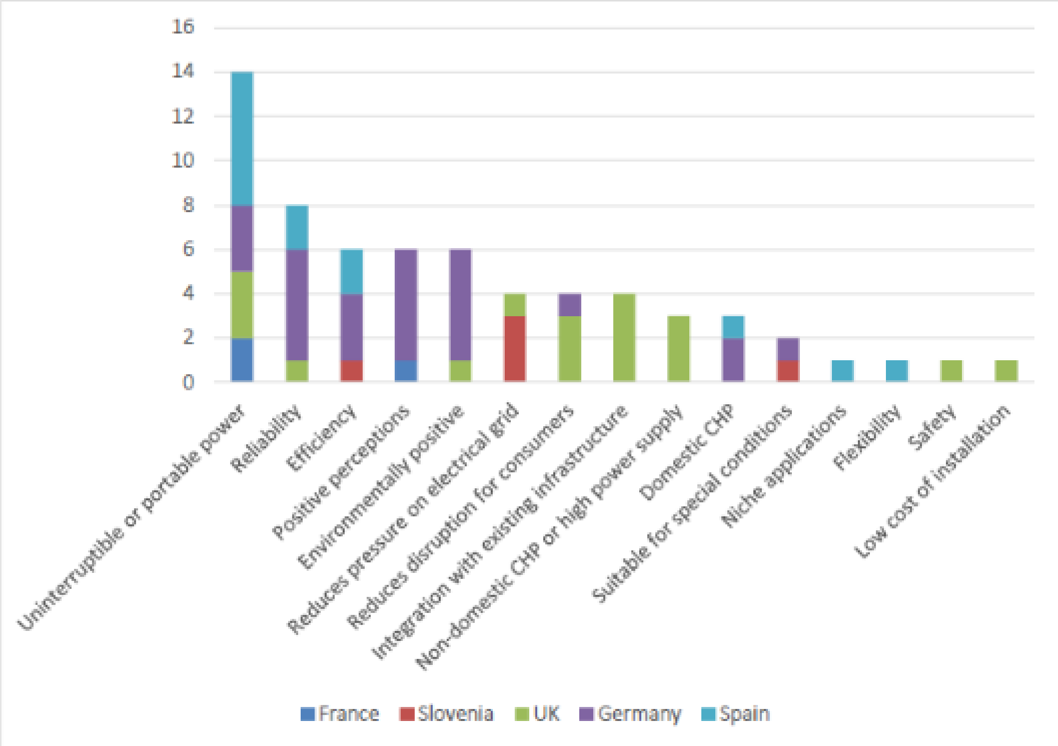


Figure 8: FCH Technology strengths

During the in depth interviews, respondents from most states can see the potential of using FCH Technologies in UPS applications. Some differences may be seen when responding to questions regarding reliability and efficiency. Whilst the UK respondents highlighted reliability, they did not mention efficiency, unlike German respondents for instance. This may possibly be due to the reliance on fossil fuels for electrical power generation rather than renewables in the UK at the time of writing. Alternatively it may be a reflection of the uncertainty regarding Carbon Capture and Storage (CCS) within the UK. The more comprehensive national gas grid in the UK may have had some influence upon UK respondents highlighting infrastructure and disruption issues. The UK respondents did not see domestic CHP as a particularly attractive option and seemed to favour burning hydrogen in new or repurposed cookers, boilers and so on.

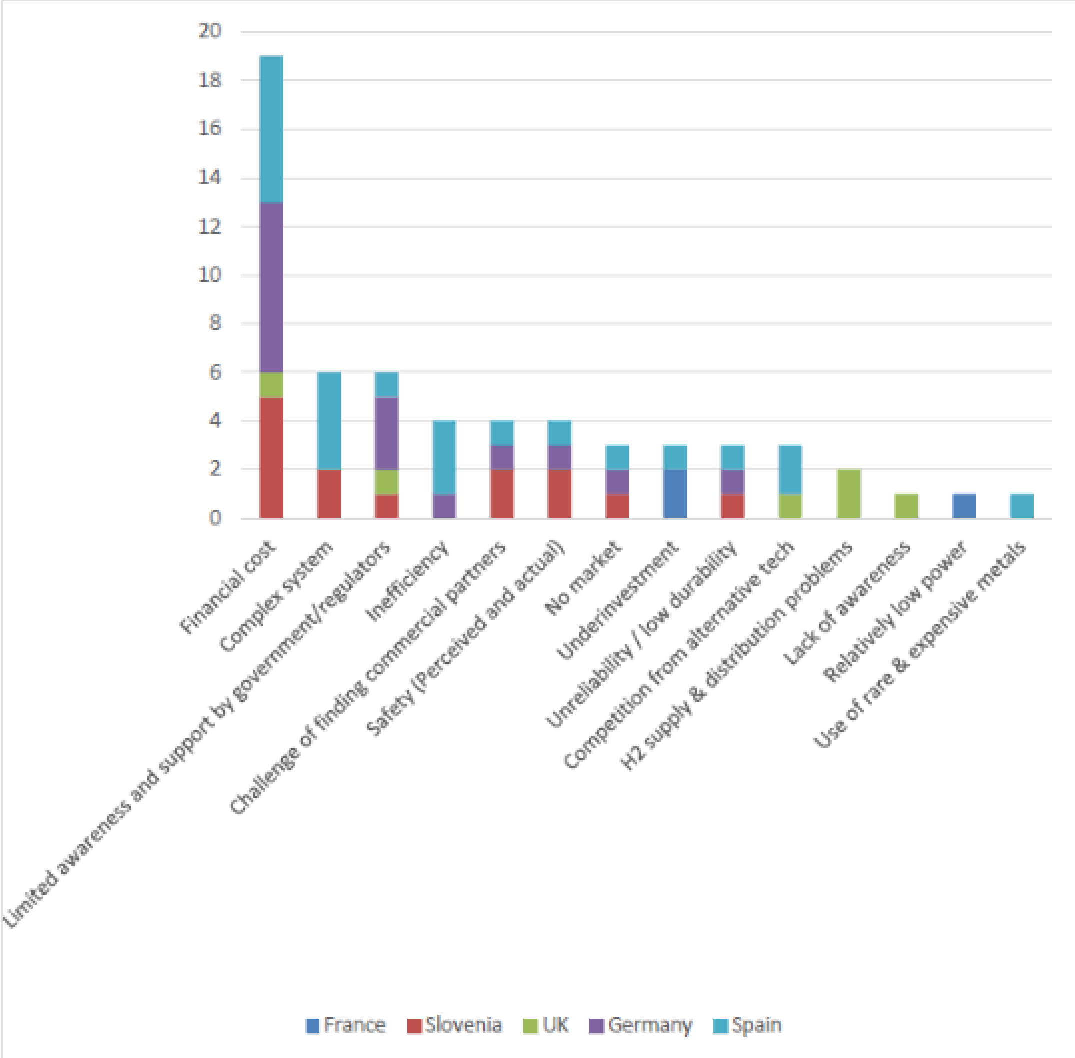


Figure 9: FCH Technology weaknesses

Most stakeholders agree that cost will be the most significant issue for stationary FCH technologies. Interestingly stakeholders in Germany and Spain have also identified inefficiency as an issue in direct contradiction to other stakeholders from the same states. This seems a topic that might be worth further investigation. Safety and the challenge of finding commercial partners is seen as an issue by stakeholders in Slovenia, Germany and Spain. This mirrors the relatively weak strengths regarding niche applications, Domestic CHP and, for the UK, the potential for non-domestic CHP. France and Spain highlighted the issue of underinvestment.

Transport applications

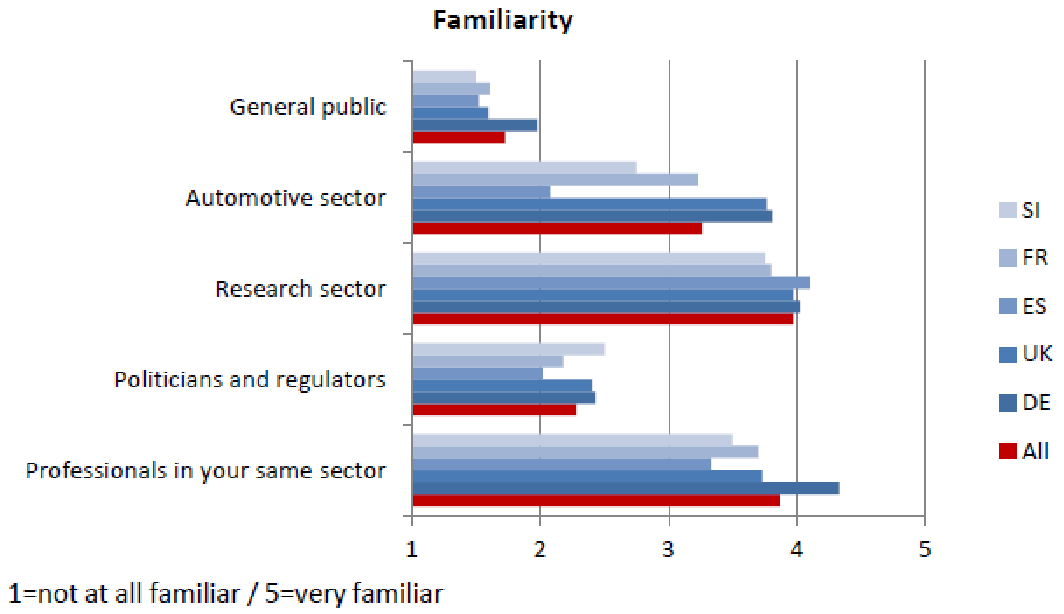


Figure 10: Expectations of familiarity for transport applications by country

If anything transport applications stakeholders feel that the public will have a much lower awareness of the technologies than those respondents who were primarily interested in stationary applications. Only German respondents felt that their public had a relatively good grasp of FCH technologies, albeit a weak one. In the automotive sector the UK and Germany claimed higher levels of familiarity. This is perhaps understandable given both governments have given support to transport applications over several years. Interestingly this is at odds with stakeholders expectations regarding familiarity amongst politicians and regulators. All stakeholders rated other professionals in their sector as being familiar or very familiar with FCH technologies with German respondents having the highest expectations. It is interesting to observe clear differences between member states in transport applications that do not appear to exist within stationary applications.

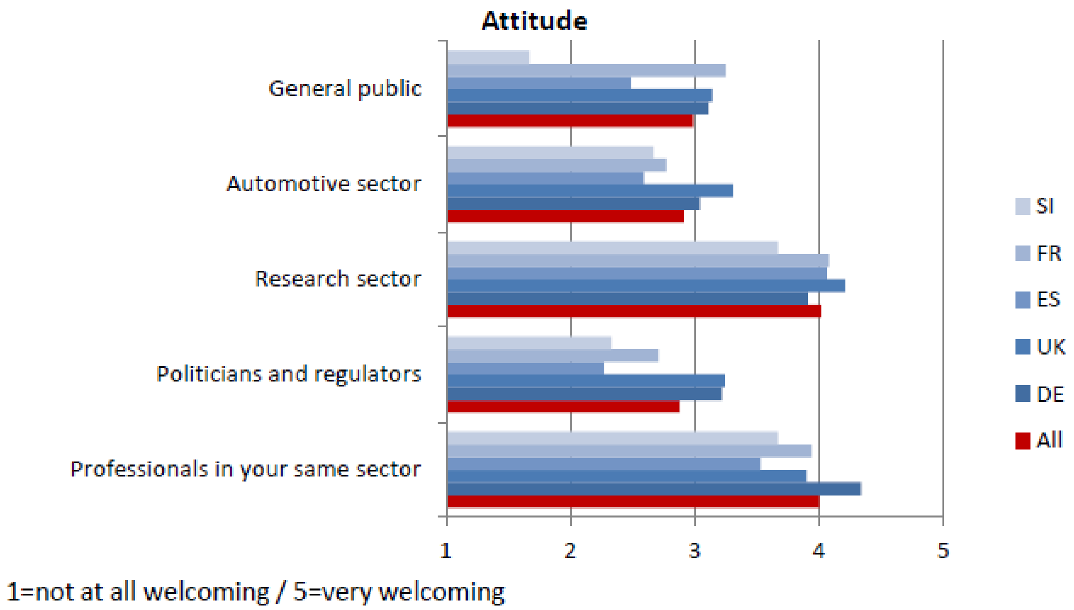


Figure 11: Expectations of attitude towards transport applications by country

In general the public is seen as welcoming of FCH technologies. The country that appears to buck this trend is Spain. Whilst their stakeholders expect the public to have a positive attitude towards stationary applications, they feel much less confident with transport applications. This may reflect the relative lack of transport demonstration projects within Spain. The other notable change is the increase in positivity felt by respondents in the UK regarding the attitude of politicians and regulators. This may be a result of widely promoted technology competitions aims at the transport (and in particular the automotive) sector in the UK.

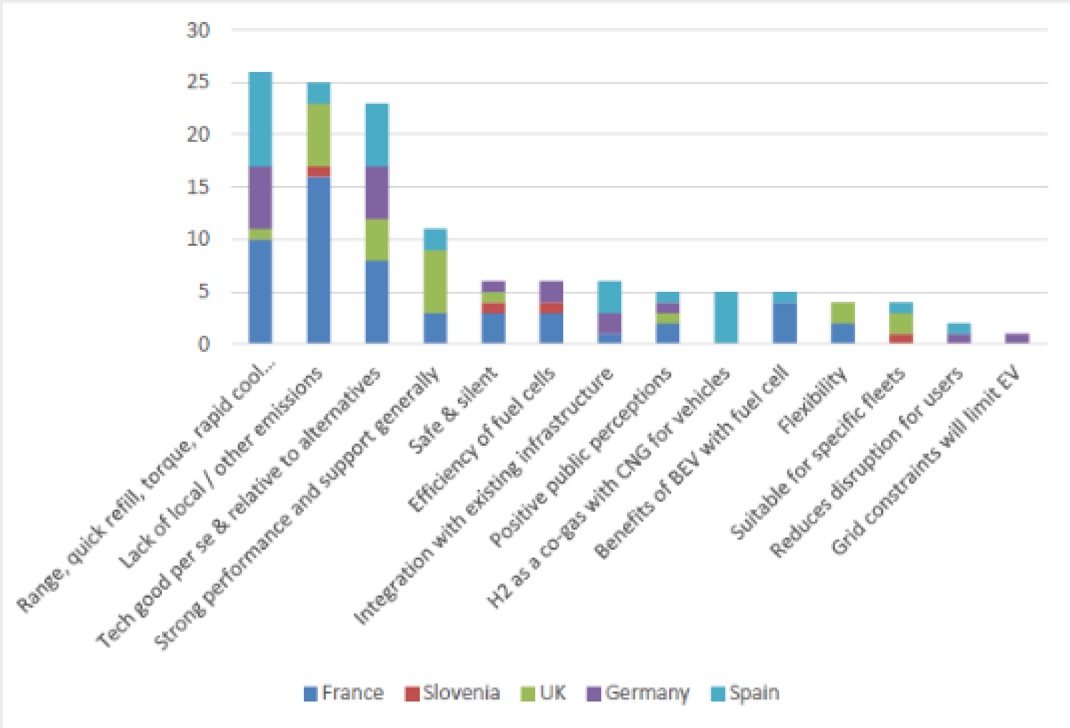


Figure 12: FCH Technology strengths

For transport applications there was little difference between stakeholder responses during the interviews for the three biggest perceived strengths: "Range", "Lack of Local Emissions" and "Technology good relative to alternatives". Only Spanish respondents mentioned the potential of using hydrogen as a co-fuel with CNG. France and Spain felt that FCH technologies could act as a useful range extension device for BEVs.

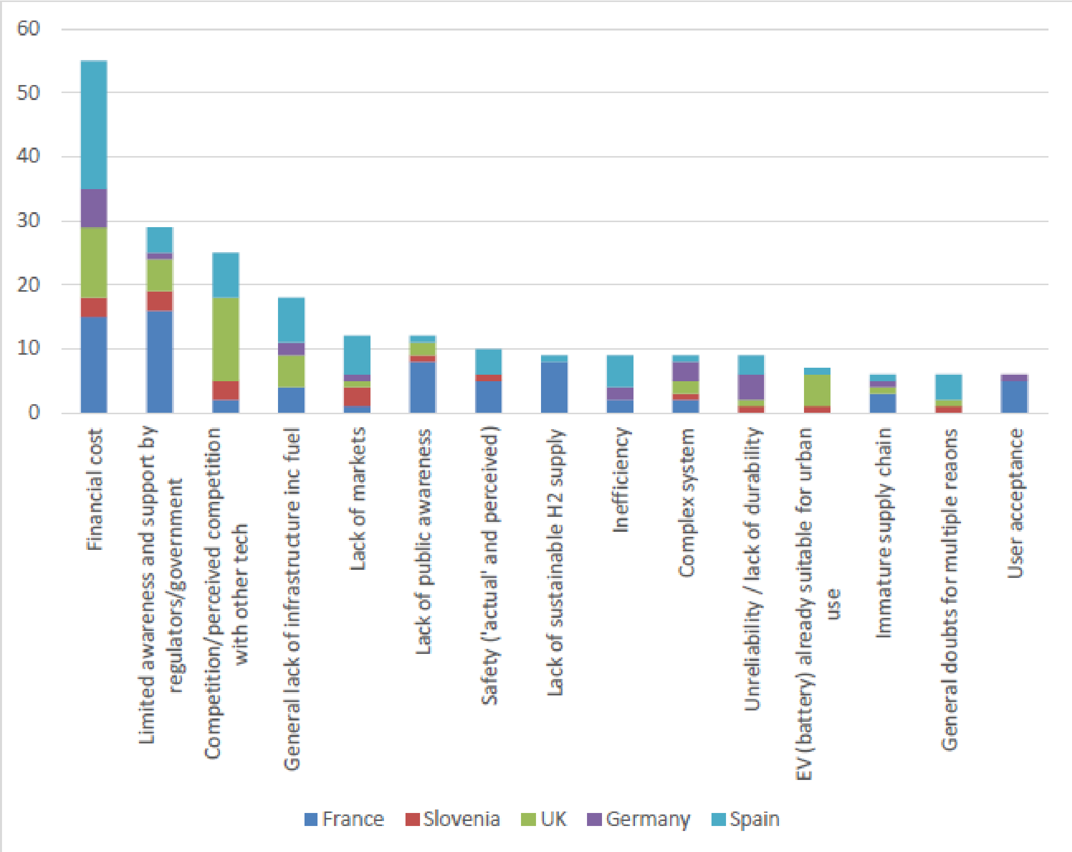


Figure 13: FCH technology weaknesses

Once again cost is seen as the biggest weakness of FCH technologies. This is closely followed by the limited support from governments and regulators, strong competition from competing technologies and a general lack of refuelling infrastructure. This is echoed in France whose respondents raised the problem of a lack of sustainable hydrogen production. Perhaps this point to Frances higher reliance on nuclear energy which would presumably be utilised in hydrogen production in this country. This raises the question that if the issue of cost was taken away, would it increase the appeal of FCH technologies and reduce the competition due to its superior performance. This view is supported by Slovenian, UK and Spanish respondents who point out that BEVs are already very suitable for urban environments. The advantage of FCH technologies being fast refill/recharge provided the issue of poor infrastructure is overcome.

Discussion

There are some differences that may be observed across the five EU states taking part in this part of the research. However, on the key issues there is a good deal of agreement between the stakeholders from different states. Differences appear to exist where policies differ between countries regarding investment and promotion of FCH technologies at a state level or where a particular set of stakeholders are aware of an opportunity that is very specific to their country. Interestingly sustainable hydrogen supply is not seen as an issue in heavily industrialised countries such as Germany and the UK but it is seen as an issue within French stakeholders. Given the levels of industrial maturity within France this is puzzling and may point to a heavier reliance on nuclear energy for electricity generation in this country.

4. THE SAMT OUTPUTS

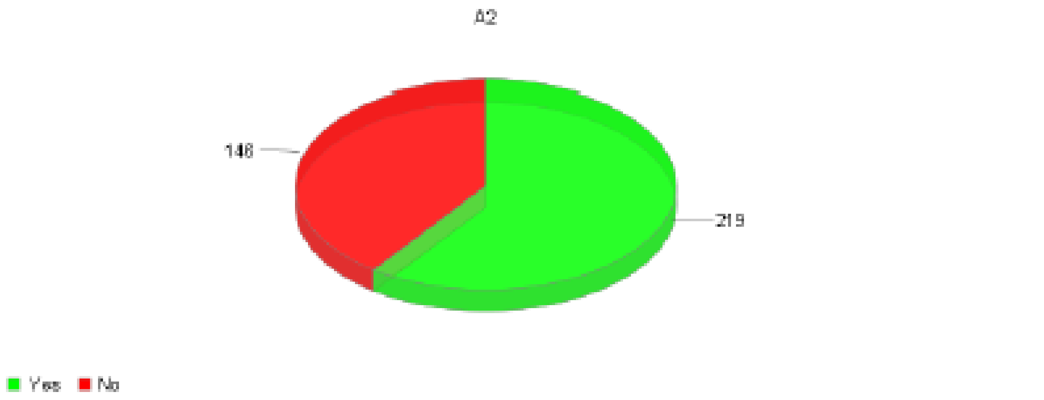
The following is shown to illustrate and validate the SAMT outputs. The SAMT was asked to produce results for a fictitious stationary application to be based in Germany, the UK and Slovenia. All regions were selected in these case studies.

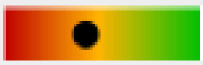
4.1 Knowledge and Experience

In this section participants were asked questions regarding their knowledge and experience of FCH technologies. The public responses are seen in the top half of the output for each question. These responses are then compared with the expectation or opinions of the stakeholder groups and the results shown in the colour mapped bar below the public response. The colour map is green for agreement and red for disagreement. A black dot signifies the strength of any agreement or disagreement between the two groups.

For this exercise we are comparing the results from German, Slovenian and UK respondents to see if any national differences are discernible. Certainly, the thematic analysis of the stakeholder interviews and surveys shows some clear differences in those issues that are seen as most important.

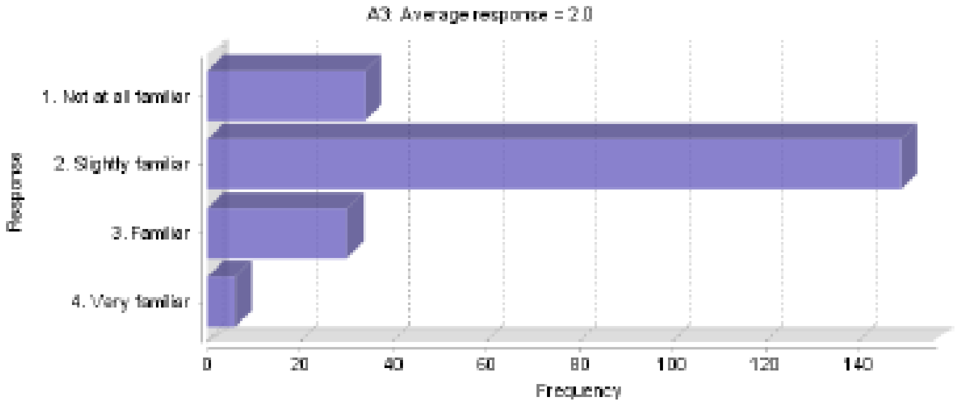
A2: Before participating in this study, had you ever heard of hydrogen fuel cell technologies in the context of energy production?

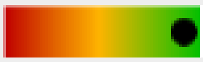




Industry mapping » Public's level of awareness of HFC technologies
There is a disagreement between stakeholders and the public. Members of the public believe that the situation is more positive than stakeholders. Attention should be paid to discovering the reasons why the public believe the situation is good or acceptable while stakeholders are more pessimistic. This may reduce significant amounts of needless work or highlight major gaps in the knowledge and understanding within the general public.

A3: Please rate your familiarity with hydrogen and fuel cell developments. Are you...?

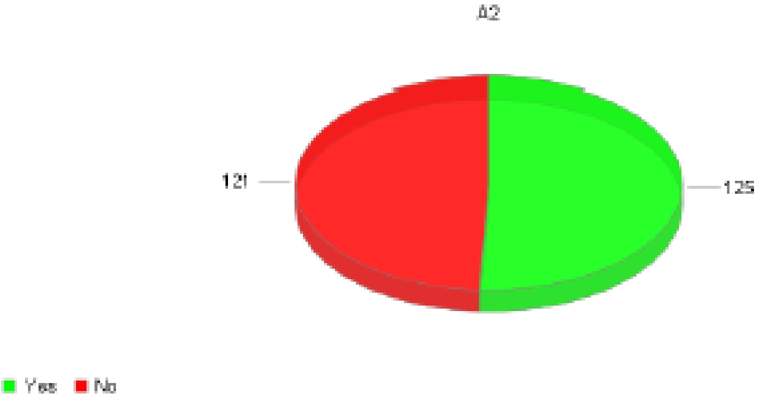


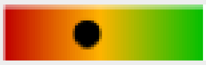


Industry mapping » Public's level of awareness of HFC technologies
There is a strong agreement between you and the public respondents that the situation is negative. It should however be recognised that these views may not be held for the same reasons and care should be taken when proposing ways to address this. In general however, it is possible that this sort of situation will arise due to external influences such as government policy. Alternatively it may be due to reliability or convenience issues that are recognised as product deficiencies. Whilst this may mean that managing the situation will be tricky, it is also an opportunity to differentiate your product from your competition and gain an advantage over your rivals by entering the market earlier with a better product.

Figure 14: FCH technology weaknesses

A2: Before participating in this study, had you ever heard of hydrogen fuel cell technologies in the context of energy production?





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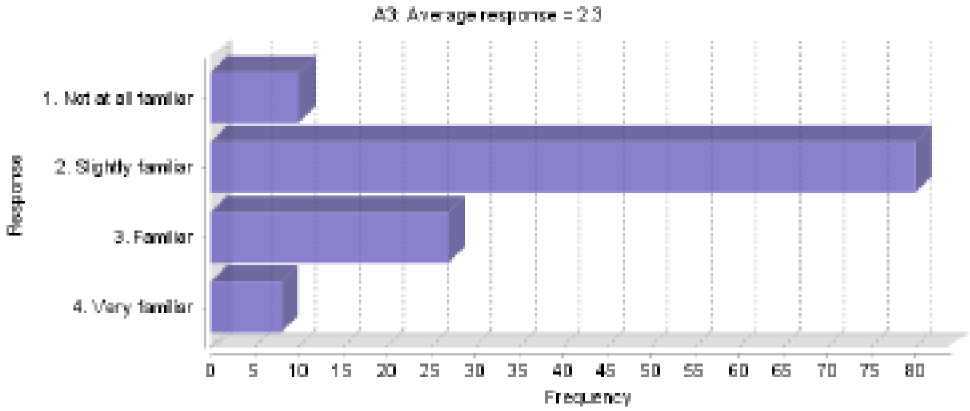

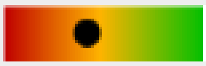

Industry mapping » Public's level of awareness of HFC technologies
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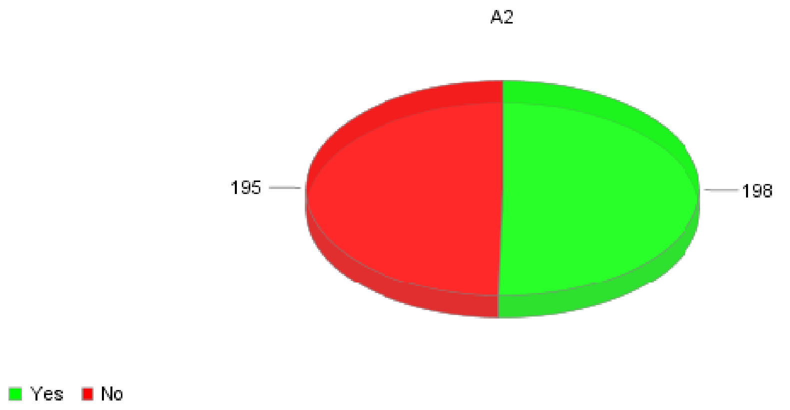
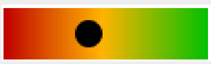
Figure 15: The situation in the UK

A2: Before participating in this study, had you ever heard of hydrogen fuel cell technologies in the context of energy production?





Industry mapping » Public's level of awareness of HFC technologies
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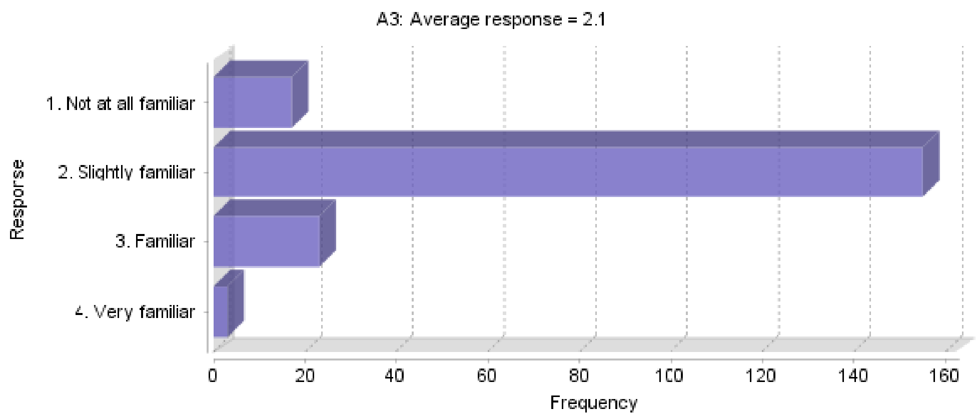

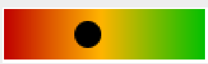

Industry mapping » Public's level of awareness of HFC technologies
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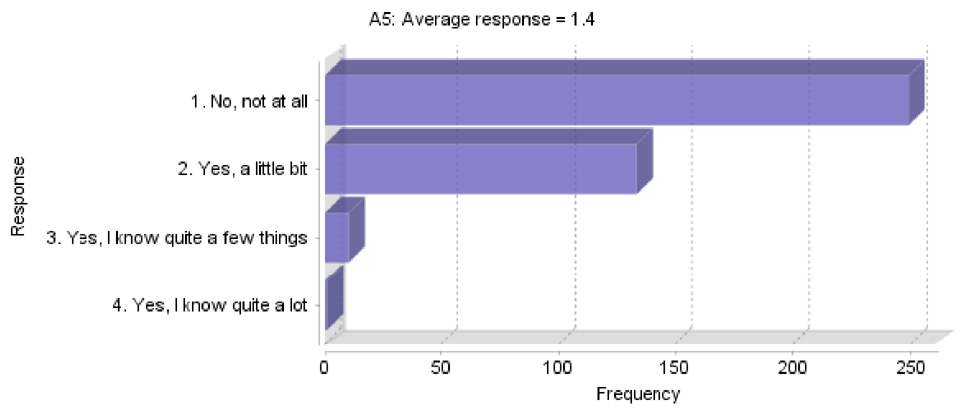
Figure 16: The situation in Slovenia

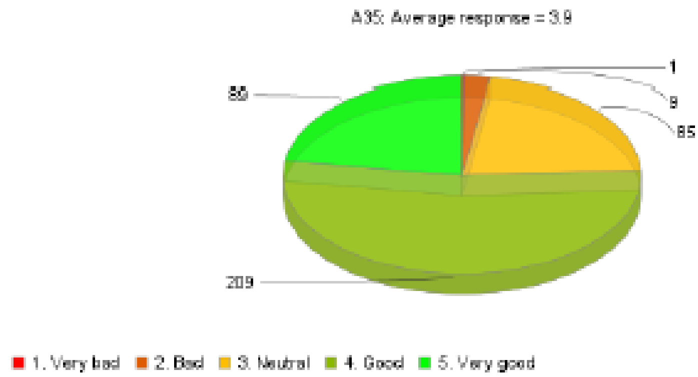
All stakeholders had low expectations of the levels of awareness within the public. However, the public in all three countries had a much higher awareness of the applications than anticipated (50% or higher). Whilst all public respondents did rate their familiarity as low this is a relative term. Clearly the public are more aware than the stakeholders think they are. This may be a symptom of stakeholders having a higher threshold for rating one as familiar than the public do. This may have implications for communication strategies later on.

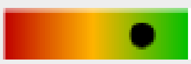
A5: Had you ever heard (before this questionnaire) of hydrogen fuel cell applications for home use?



Industry mapping » Public's level of awareness of HFC technologies
There is a strong agreement between you and the public respondents that the situation is negative. It should however be recognised that these views may not be held for the same reasons and care should be taken when proposing ways to address this. In general however, it is possible that this sort of situation will arise due to external influences such as government policy. Alternatively it may be due to reliability or convenience issues that are recognised as product deficiencies. Whilst this may mean that managing the situation will be tricky, it is also an opportunity to differentiate your product from your competition and gain an advantage over your rivals by entering the market earlier with a better product.

A35: Taking into account all the information, what is your overall evaluation of hydrogen fuel cell stationary home applications as a heating and electricity source?

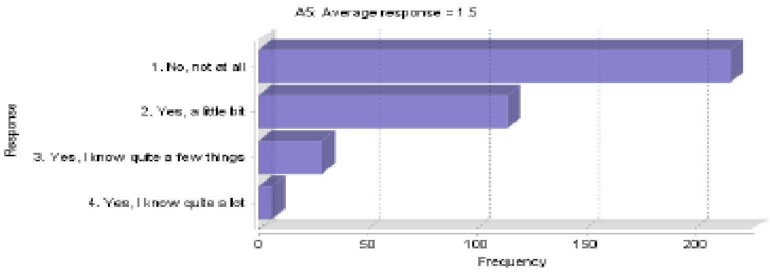


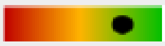


Industry mapping » Good for domestic and non-domestic applications
There is a strong agreement between you and the public respondents that the situation is positive. Whilst this a beneficial position to be in you should take care to establish the reasons for this. This should reduce the risk of inadvertently damaging product strength and help to build on this.

Figure 17: Slovenia

A5: Had you ever heard (before this questionnaire) of hydrogen fuel cell applications for home use?





Industry mapping » **Public's level of awareness of HFC technologies**
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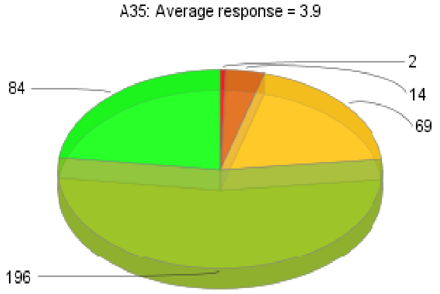
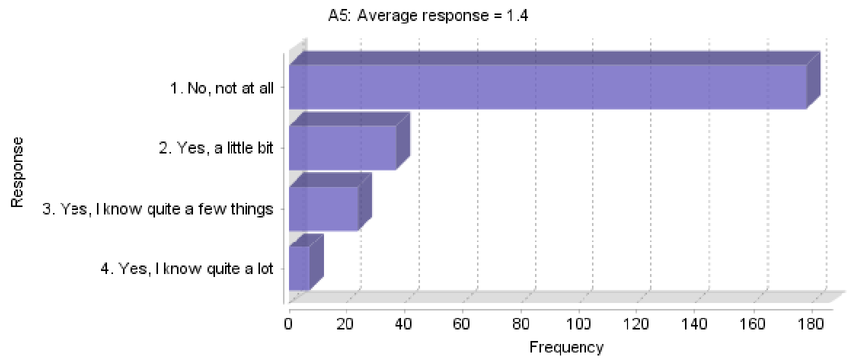


Industry mapping » Good for domestic and non-domestic applications
There is a strong agreement between you and the public respondents that the situation is positive. Whilst this a beneficial position to be in you should take care to establish the reasons for this. This should reduce the risk of inadvertently damaging product strength and help to build on this.

Figure 18: Germany

A5: Had you ever heard (before this questionnaire) of hydrogen fuel cell applications for home use?



<u>Industry mapping</u> » Public's level of awareness of HFC technologies
There is a strong agreement between you and the public respondents that the situation is negative. It should however be recognised that these views may not be held for the same reasons and care should be taken when proposing ways to address this. In general however, it is possible that this sort of situation will arise due to external influences such as government policy. Alternatively it may be due to reliability or convenience issues that are recognised as product deficiencies. Whilst this may mean that managing the situation will be tricky, it is also an opportunity to differentiate your product from your competition and gain an advantage over your rivals by entering the market earlier with a better product.

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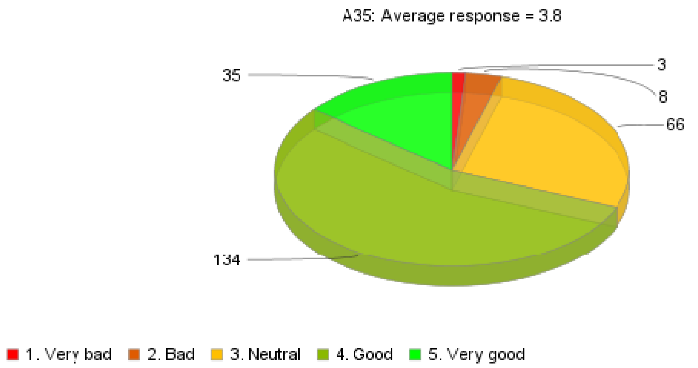
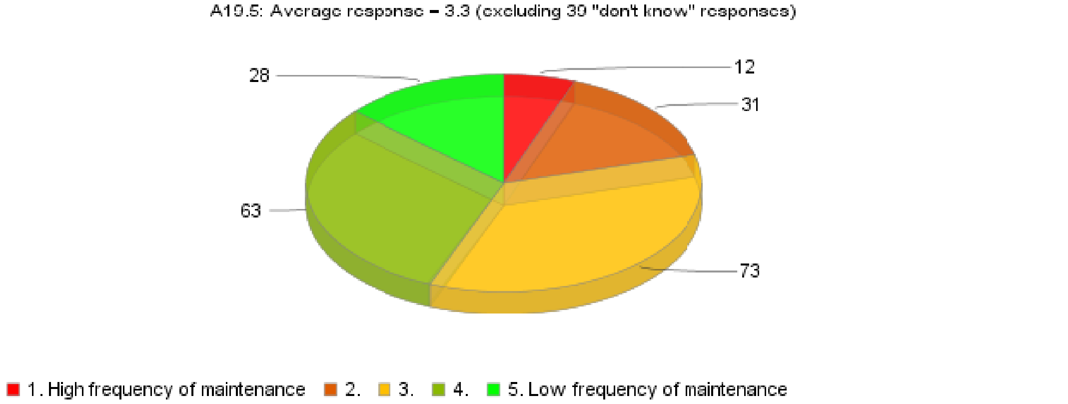


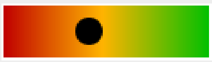
<u>Industry mapping</u> » Good for domestic and non-domestic applications
There is a strong agreement between you and the public respondents that the situation is positive. Whilst this a beneficial position to be in you should take care to establish the reasons for this. This should reduce the risk of inadvertently damaging product strength and help to build on this.

Figure 19:UK

*A19.5: Require a **high frequency of maintenance** » **low frequency of maintenance** (sliding scale from 1 » 5)*



Industry mapping » Silent
There is a strong agreement between you and the public respondents that the situation is positive. Whilst this a beneficial position to be in you should take care to establish the reasons for this. This should reduce the risk of inadvertently damaging product strength and help to build on this.

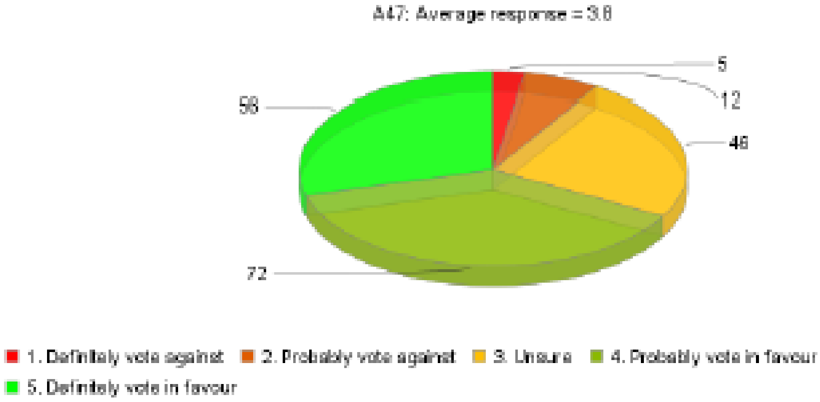


Industry mapping » Reliable
There is a disagreement between stakeholders and the public. Members of the public believe that the situation is more positive than stakeholders. Attention should be paid to discovering the reasons why the public believe the situation is good or acceptable while stakeholders are more pessimistic. This may reduce significant amounts of needless work or highlight major gaps in the knowledge and understanding within the general public.

Figure 20: UK

In general, all respondents agreed that they expected FCH CHP systems to be quiet and reliable. However, although stakeholders agreed with regard quiet, their opinion regarding reliability was at odds with that of the public. This is potentially due to their deeper knowledge of the systems and the problems they encounter with them. Occasionally it is due to a "myth of failure" that surrounds technology as those most technically involved often only see those that fail and ignore the many that operate reliably. More data would need to be collected regarding actual system reliability before stakeholders should act.

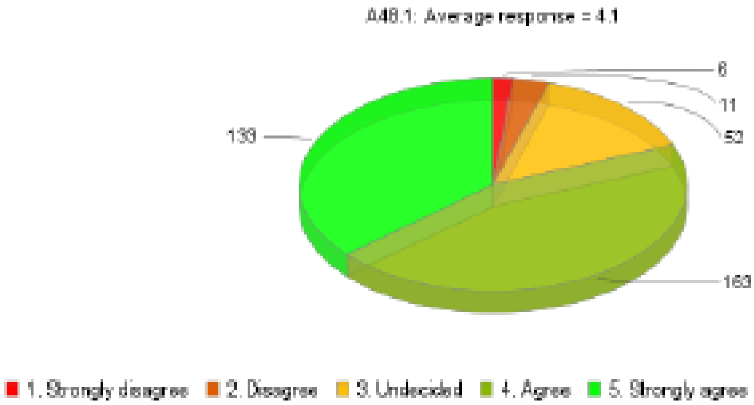
A47: Imagine you could vote in your homeowners association on placing a hydrogen fuel station at your building, would you vote in favour of it, or against it?

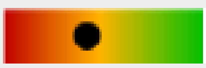


Industry mapping » Generally positive attitude to technology
There is a strong agreement between you and the public respondents that the situation is positive. Whilst this a beneficial position to be in you should take care to establish the reasons for this. This should reduce the risk of inadvertently damaging product strength and help to build on this.

A48: To what extent do you agree with the following statements?

A48.1: All else equal (price, comfort, maintenance cost, etc.), I would be happy to have a hydrogen fuel cell unit in my home in future

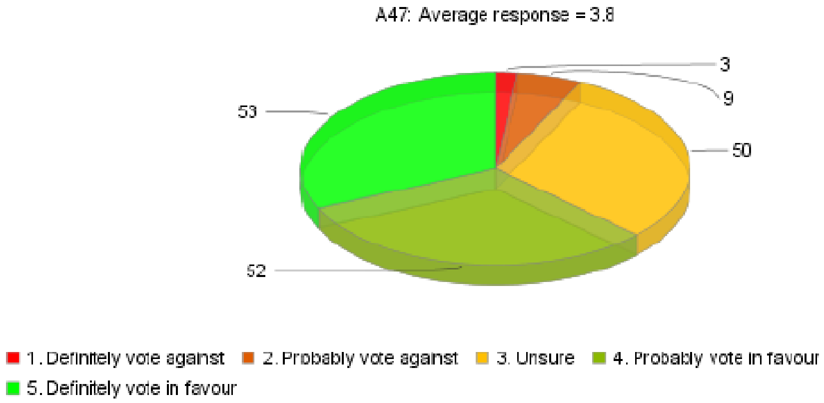




Industry mapping » Customer acceptance
There is a disagreement between stakeholders and the public. Members of the public believe that the situation is more positive than stakeholders. Attention should be paid to discovering the reasons why the public believe the situation is good or acceptable while stakeholders are more pessimistic. This may reduce significant amounts of needless work or highlight major gaps in the knowledge and understanding within the general public.

Figure 21: Germany

A47: Imagine you could vote in your homeowners association on placing a hydrogen fuel station at your building, would you vote in favour of it, or against it?



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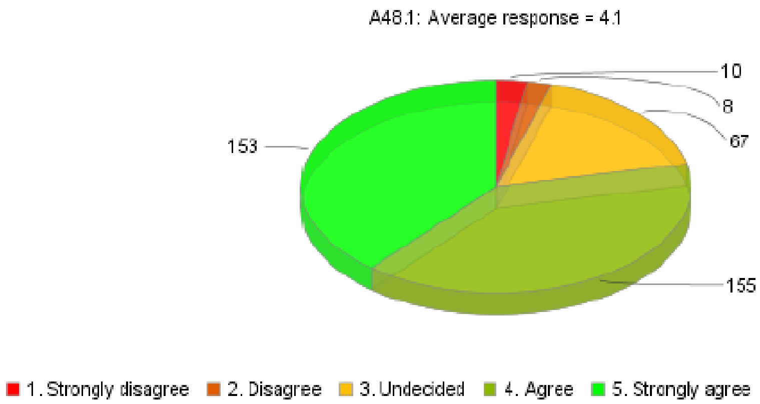

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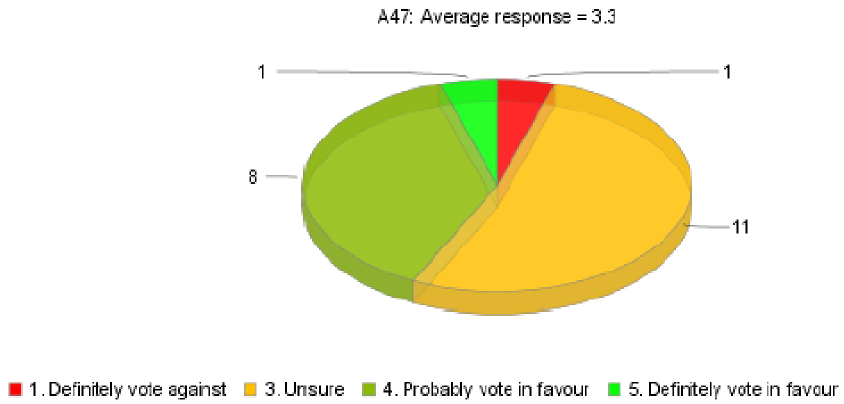
Figure 22: Slovenia

A47: Imagine you could vote in your homeowners association on placing a hydrogen fuel station at your building, would you vote in favour of it, or against it?



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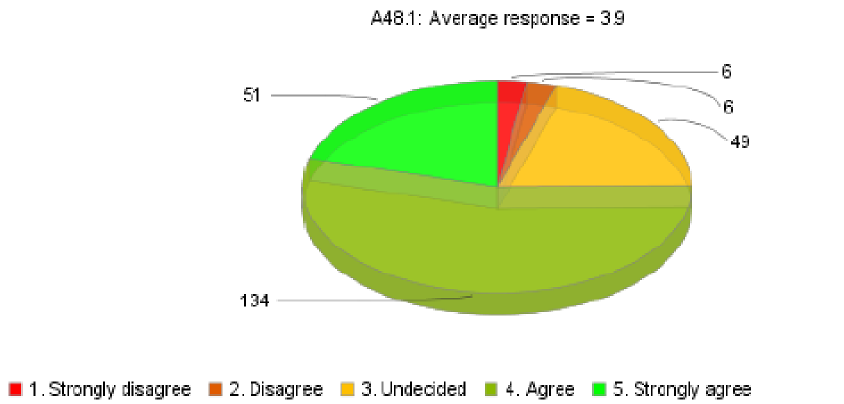

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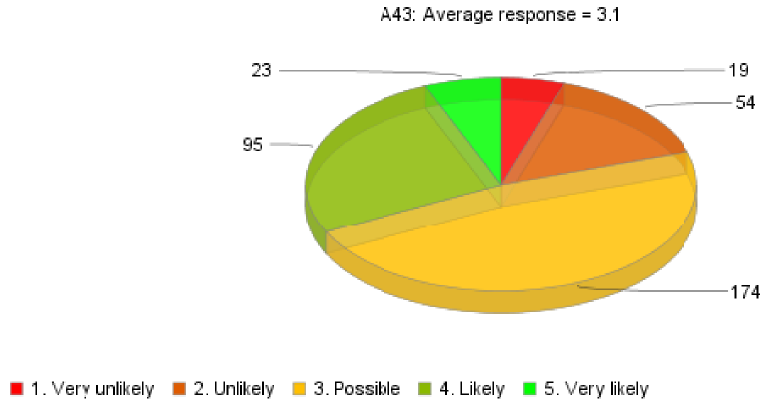
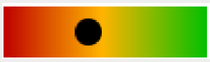
Figure 23: UK

UK public respondents are more likely to have negative feelings regarding the placement of hydrogen installations such as refuelling stations compared to those in Slovenia or Germany. However, they are in general positive which is shown in the response from stakeholders. However, whilst a large proportion of public respondents would be happy to install a hydrogen fuel cell into their homes, stakeholders did not anticipate this. This is possibly due to the more in depth knowledge of stakeholders regarding the likelihood of reducing the real costs of such systems in the near to mid-term. There are differences between the views of the stakeholders in the different states but these are small and in general they can be taken to be in agreement.

A43: Imagine that you are considering replacing your current heating system. How likely, if at all, would you be to install a hydrogen fuel cell system as a heating and electricity source?





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There is a disagreement between stakeholders and the public. Members of the public believe that the situation is more positive than stakeholders. Attention should be paid to discovering the reasons why the public believe the situation is good or acceptable while stakeholders are more pessimistic. This may reduce significant amounts of needless work or highlight major gaps in the knowledge and understanding within the general public.

A44: If you answered "very unlikely" or "unlikely" to A43, why is this (select all that apply)?

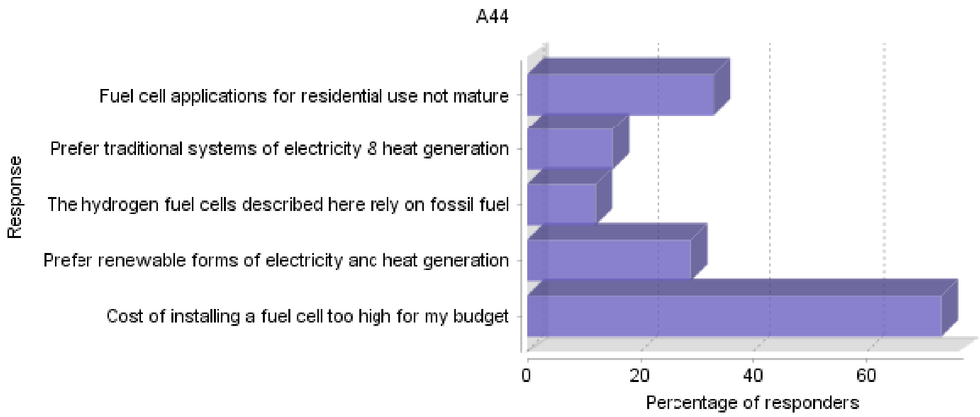
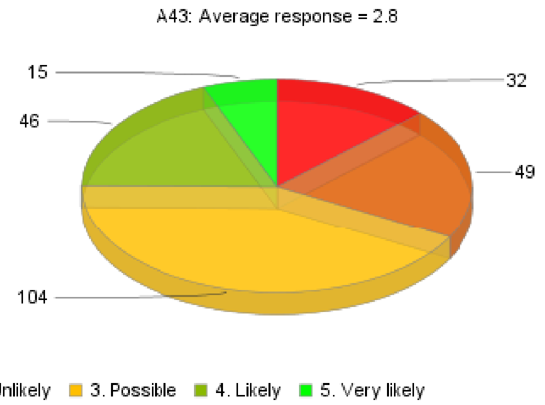
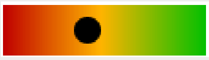


Figure 24: Germany

A43: Imagine that you are considering replacing your current heating system. How likely, if at all, would you be to install a hydrogen fuel cell system as a heating and electricity source?





Industry mapping » Customer acceptance
There is a disagreement between stakeholders and the public. Members of the public believe that the situation is more positive than stakeholders. Attention should be paid to discovering the reasons why the public believe the situation is good or acceptable while stakeholders are more pessimistic. This may reduce significant amounts of needless work or highlight major gaps in the knowledge and understanding within the general public.

A44: If you answered "very unlikely" or "unlikely" to A43, why is this (select all that apply)?

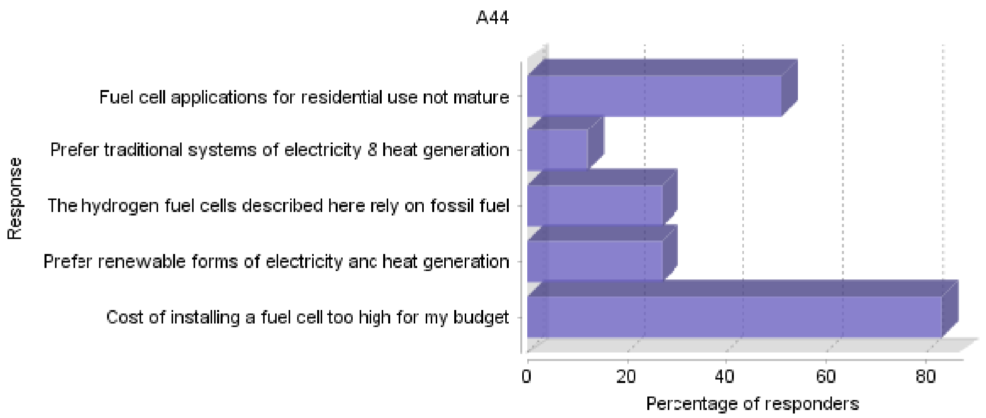
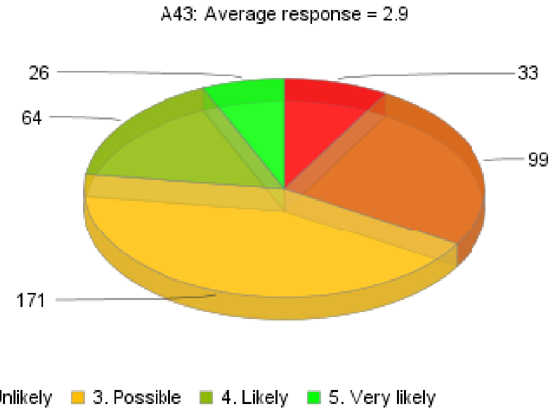
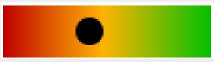


Figure 25: UK

A43: Imagine that you are considering replacing your current heating system. How likely, if at all, would you be to install a hydrogen fuel cell system as a heating and electricity source?





Industry mapping » Customer acceptance
There is a disagreement between stakeholders and the public. Members of the public believe that the situation is more positive than stakeholders. Attention should be paid to discovering the reasons why the public believe the situation is good or acceptable while stakeholders are more pessimistic. This may reduce significant amounts of needless work or highlight major gaps in the knowledge and understanding within the general public.

A44: If you answered "very unlikely" or "unlikely" to A43, why is this (select all that apply)?

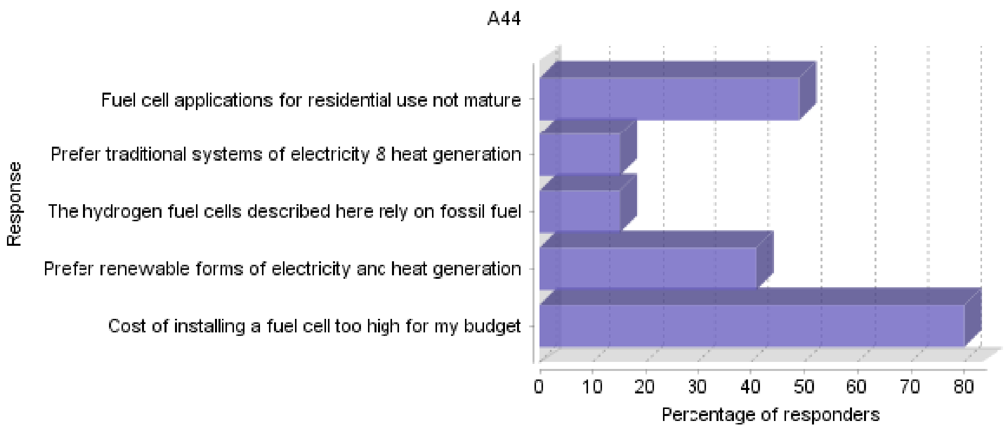


Figure 26: Slovenia

All three countries returned results that are in line with those predicted by the stakeholder interviews. Germany was the most positive country regarding this with the UK and Slovenia proving more negative. All populations were slightly more positive than anticipated although cost was a major factor in indicating that respondents would not invest in FCH CHP systems which is in line with stakeholder's views. Lack of maturity was also a major factor in all three studies and in the UK doubts were raised about the carbon neutrality of the hydrogen being used. This may be due to negative news stories.

Summary

When comparing the output of the SAMT to that of the survey or the interviews of stakeholders, it is sometimes difficult to recognise national traits and differences across the EU states. Indeed many of the views expressed may be said to be common across all states. However, caution should be applied as the SAMT looks only at a sub set of the data and as such may be misleading when viewing the situation as a whole. With all this in mind, however, it can be said that the SAMT has been shown to accurately reflect the views of both stakeholders and the general public. Whilst it is not always easy to highlight national differences, possibly because FCH technologies are so new, it does highlight differences in the understanding of issues and situations between the public and the stakeholders. This in itself may lead to a deeper understanding of the public's motivations that will enhance the potential of mass market acceptance for FCH technologies.

5. RECOMMENDATIONS FOR PUBLIC ENGAGEMENT

When considering recommendations relating to public 'acceptance' or support of hydrogen and fuel cell technologies, there are several findings of the public survey that we should keep in mind and which we recap below.

Characterisation of the present situation:

1. *Awareness differs by country*

Across all seven countries, the level of public awareness of hydrogen and fuel cell technologies for energy supply was on average below 50%, but this varied. The highest levels of awareness were found in Germany and Norway, where almost 50% of respondents reported having heard of FCH technologies in the context of energy production, but only 30% of respondents reported having heard of these technologies in Spain. Around 40% of respondents were aware of FCH technologies in general in Belgium, Slovenia, France and United Kingdom.

2. *Awareness differs by technology*

Around 60% of participants in the whole sample reported having heard about FCEVs. This percentage ranged from 85% in Norway to 47% in Spain. Public awareness of FCH residential stationary applications was lower than awareness of hydrogen and fuel cell technologies in general, in all the countries studied: around 25% of respondents reported having heard about residential fuel cells. The level of such awareness ranged from 32% in Germany to 20% in Norway.

3. *Most people are supportive of FCH technologies – at least in principle*

Our data first show that across all countries surveyed, a majority of the public supports the introduction of hydrogen and fuel cell technologies – at least as far as can be determined within the typical constraints of a survey of people who do not face 'real', cost-incurring choices. In these terms, between 50% and 70% of the population in the seven countries accept and support the introduction of these applications, while fewer than ten percent of participants are opposed.

4. *However people are price-sensitive*

Despite in-principle support, across the seven countries, respondents reported a low likelihood of installing a home fuel cell if considering replacing their current heating system. The percentage of those considering this likely or very likely was significantly higher in Germany (25%) and significantly lower in Norway (13%). The price of the fuel cell was the most relevant reason for not installing a fuel cell at home (reported by 73% of respondents), followed by the perceived lack of maturity of the technology (reported by the 45% of respondents).

The pattern is the same for FCEVs. Self-reported likelihood of purchasing an FCEV was very low in the seven countries: fewer than 20% of respondents considered it likely or very likely purchasing an FCEV if they were considering replacing their car or they needed to purchase a car. There were some marked differences between the countries. Respondents in Germany and Norway reported a lower likelihood of purchasing an FCEV (8 and 11% respectively). The price of the car was reported as the most relevant factor for not purchasing an FCEV, followed by lack the maturity of the technology. Those who reported it unlikely that they would purchase a FCEV (specifically a car) were asked to provide additional information to explain their opinions. Around 10% of these respondents provided additional reasons with the majority stating that lack of refuelling infrastructure would put them off a purchase.

5. *Supporters and opponents are distinguishable on cross-national dimensions*

Supporters and opponents differ significantly in a number of attitudinal variables such as interest, perceived benefits, global evaluation and self-reported likelihood of purchasing a fuel cell application in the future. Opponents and supporters are very similar in their sociodemographic characteristics, although younger men are over-represented in the group of supporters. However, opponents and supporters have different prior orientations towards the environment and technology. Specifically, supporters are more likely to be male, have a university degree, live in a city with more than one million inhabitants and perceive themselves as living comfortably with their current income. (Plötz et al, 2014)

Moreover, supporters react differently to the provision of information compared to opponents: the effect of providing additional information is positive for supporters and negative for opponents. This is consistent with cognitive dissonance and self-perception theories, whereby people seek attitudinal and perhaps behavioural consistency. Bearing in mind these cross-national findings, it is likely that we are not dealing with differences in national culture as underlying causes, but more likely differences in cognitive culture or worldview that vary within countries. The latter, however, has to remain speculation at present. For the time being, all we know for sure are that opposition and support relate to factors that are not simply country-specific. In an interconnected world, particularly within a set of developed European countries, this is to be expected.

5.1. Summary of the present situation

The present situation *might* be characterised as one in which awareness and support for FCH technologies is highest in those countries where there is most R&D activity and policy support. We have not sought to regress against R&D indicators, though – as with many of the findings, this merits further investigation. We can more confidently say that support and opposition is associated with specific characteristics that span countries (gender, education, urban and affluence), though again further work would be needed to characterise any further associations. Finally, we can say that although the publics studied are largely supportive in principle, willingness to purchase at current prices is not surprisingly very low.

5.2. General recommendations to target and engage the public

Avoid an overly technological focus

The policy response options are arguably not particularly technology-specific: many of the same issues apply to other new energy technologies and indeed to other new technologies in general. This is because public responses to a technology are not simply determined by the characteristics of the technology in question. The characteristics of the population – of individuals and their social groups – are in many ways more important. Thus although FCH technologies have specific characteristics, the populations who are faced with choices and who experience responses are common across technologies. When considering issues of communication, engagement, dialogue and even persuasion, it is necessary to understand relevant psychological and social processes. Different technologies may elicit different responses, but these are as much a function of psychological and social factors as technological factors. Consequently, these issues have been well-rehearsed in other technological contexts and below we draw on Whitmarsh, Upham et al (2011).

Consider why one is communicating or engaging

There are both normative and pragmatic rationales for public awareness raising in novel energy supply contexts. The normative argument concerns the public's 'right' to learn about and shape public research and innovation relating to FCHs. From a pragmatic perspective, awareness raising contributes to a more informed populace, potentially better able to make decisions about energy for their own benefit and that of society and the environment.

When considering public engagement to raise awareness, it is important to consider (a) which groups within the public may benefit most from education (e.g., those most likely to be affected, those with particular interests), (b) how best to communicate with each group (using appropriate communication tools, media, messages, etc.), (c) to what end (e.g., to promote science or science careers, raise awareness about particular risks or innovations), (d) where researchers themselves may benefit from public engagement (e.g., in gaining feedback on results and debating their implications; to explore potential public reaction, uptake and/or use of novel technologies or social/behavioural innovations); and (e) how to evaluate the impacts of this communication. In summary:

- Define engagement objectives (e.g., correcting misperceptions, changing attitudes to science or energy issues, viewing the public as resource of inspiration, oversight and legitimacy);
- Define engagement forms (information provision, education, and consultation and deliberation) and the limits and challenges associated with each;
- Define 'successful' engagement (e.g., makes a difference to decision-making; is transparent; has integrity; is tailored to circumstances; involves the right number and right types of people; treats participants with respect; gives priority to participants' discussions; is reviewed and evaluated to improve practice; participants are kept informed etc.); and
- Learn from related engagement activity, such as public engagement with climate change.

Resources and expertise

It should be clear that the expertise and competences relating to the above lie with professional communicators, psychologists and sociologists. The enthusiasm, inspiration and technology-specific knowledge of engineers is a necessary but not sufficient condition. Relevant social scientists and practitioners need to be involved at an early stage of project and indeed programme design where the public are an intended participant, be these projects research or practice focused.

Application to the present case

Bearing in mind the above, cross-technology, issues, what might we infer specifically given the findings of the present study? Below we make a number of suggestions, some of which involve the need for further research.

1. Educated, affluent, pro-environment, urban men are the likely first movers. They are the most pre-disposed and likely to be the most receptive to messaging, implying particular choices in terms of media and content. Note that pro-environment means that 'brown' hydrogen would be a problem. Other population segments should not necessarily be ignored, but a better response can be expected from the already-predisposed segment. Note that these potential first movers exist in all of the countries, despite country-level differences on average.
2. Price is a key problem at present, but willingness to purchase at present prices is not zero – it would be worth looking more closely at the characteristics of people who indicated a willingness to purchase and worth considering how to move them closer to purchase or lease or trial, if that is the intention.
3. How should one raise awareness, message or engage? We have listed some options below. Again different methods suit different purposes. As the FCH technologies considered are mostly potential consumer goods, lifestyle trials with potential first movers and opinion formers ('mavens') would be an option, with the intention of raising awareness through networks. Of course if things go wrong, knowledge of this will also spread, but it

is still preferable to anticipate this in localised contexts than later on in larger numbers. Some further research may be needed with regard to differences in "energy culture" within the different states of the EU (Stephenson et al, 2010)

4. The processes by which supportive policy contexts influence public perceptions needs more research. This may be via familiarity, seeing the products in use, or via awareness of national economic benefits. Or technological advance per se or in particular sectors (notably the automotive sector) may be more salient in some national identities – we can only speculate.
5. Understand the reasons for opposition and support in more detail – it may be that the underlying factors are difficult to change, but it should at least be possible to engage with opponents and supporters on the basis of a better level of understanding.
6. Understand relevant purchasing influences: during the process of purchase consideration, what influences are at play? Who is influential in families, partnerships and so on. As stated above, many of these issues are not specific to FCHs.
7. The non-FC options of injecting (renewable) hydrogen to gas grids for use in standard or modified domestic boilers, use of hydrogen as a blend in CNG vehicle engines and the use of stored hydrogen for power grid balancing raise somewhat different issues, depending on the extent to which domestic or business consumers need to make any modifications to their appliances. If such modifications are not required, then most likely a rather small number of people will attend to the issue and they will do so as citizens, to the extent that they are interested in energy policy (though bearing in mind that most people have an indirect interest in energy policy via its financial cost to them). If modifications of consumer / business appliances are required, then this will involve detailed planning, consultation and communication and the issue will acquire greater political salience, significance and quite possibly risk.

5.3. Specific recommendations on actions and messages

Organizations working on hydrogen and fuel cell demonstration projects in transport and energy should develop and implement strategic and integrated multifaceted awareness and engagement interventions aimed at addressing the information needs of the public. Organizations should have the expertise necessary to develop and implement campaigns that utilizes engagement tools to disseminate messages and to promote the public involvement with hydrogen and fuel cell applications. Implementing a program of this design will improve knowledge, familiarity, and acceptance among European citizens. For the purposes of tailoring and disseminating an integrated communication campaign should:

1. **Promote awareness and familiarity with hydrogen and fuel cell technologies**. Familiarity with hydrogen and fuel cell applications is positively associated to the acceptance of the technology. It is therefore necessary to increase the efforts to familiarise the public repeatedly with fuel cells for residential use and with hydrogen fuel cell vehicles. **Organizations involved in demonstration projects should employ engagement mechanisms to create awareness of and familiarity with both applications**.
2. **Win minds of the public by emphasizing how the new technology will make citizens' lives easier and benefit society**. Beliefs about hydrogen and fuel cell applications and its potential impacts play an important role in consumer acceptance. Any information

campaign should emphasize the societal and environmental benefits of hydrogen fuel cell applications (e.g. reduction in CO_2 emissions) but also the personal benefits of these applications (e.g. user-friendliness, convenience to use, reduction in the need to purchase electricity from the power company). Table 1 indicates the main benefits and costs regarding stationary residential fuel cells and FCEVs as perceived by respondents.

Table 1. *Perceived benefits and costs associated with hydrogen and fuel cell applications*

	Stationary residential fuel cells	**FCEVs**
Perceived benefits	- Positive effect on the environment. - Moderately user friendly. - Convenient to use (in terms of noise, vibration, specific location). - Safe. - It will reduce the cost of producing energy. - It would reduce CO2 emissions. - They would reduce the need to purchase electricity from the power company.	- FCEVs are environmentally friendly. - Safe to drive. - Reliable. - Easy to refuel. - Will make citizens' life easier. - Will have sufficient range. - They would reduce the need for petroleum. - It would produce lower CO2 emissions than conventional cars. - The price of hydrogen.
Perceived as beneficial to neutral consequences	- Costs of the installation. - Cost to run the installation. - Maintenance. - House space requirements. - Potential risks.	- Initial costs. - The range. - Safety issues.
Perceived costs	- Initial capital costs.	- Infrastructure needed. - Price of fuel cell material.

3. **Work to increase positive emotions associated with the technology**. Positive emotions (interest and hope) are significantly associated to acceptance. Individuals who report feeling interested and hopeful about hydrogen fuel cells tend to support the implementation of the technology. **Organizations should strive to enhance positive emotional reactions to the technology**. It is critical to associate the technology to feelings of interest, hope, joy, pride.
4. **Respond to potential concerns about specific issues that potential consumers might have**. Concerns about the potential risks of hydrogen fuel cells can play a role in acceptance. Our study shows that providing evidence-based neutral information about the risks of hydrogen and fuel cells technologies is not associated with a strong risk perception and concern among participants. However, it is important to address this and other concerns as valid. The risks of unfamiliar technologies are often evaluated by comparing them with the risks of more familiar ones. Finding better ways to compare risks from

hydrogen and fuel cell technologies to other more familiar technologies is thus an important part of improving communication. Explaining risk information both accurately and in a way that will make sense to people with no technical training is critical.

Table 2. *Concerns directly expressed by respondents*

Stationary residential hydrogen fuel cells	FCEVs
▪ The price of the fuel cell unit as too high for a home. ▪ The potential risks associated with handling the hydrogen in a residential context. ▪ The lack of information and experience with the technology. ▪ The environmental impacts, positive for the majority of respondents, of home fuel cells. ▪ Related to the production of hydrogen. ▪ The maintenance of the fuel cell units. ▪ The suitability for different types of homes. ▪ The often perceived as spurious interests of governments and companies. ▪ Issues of installation and delivery. ▪ Recycling of fuel cells.	▪ Price and cost. ▪ Environmental impacts. ▪ Safety. ▪ Fuel production. ▪ Refuelling stations. ▪ Information. ▪ Reliability. ▪ Political interests. ▪ General disadvantages. ▪ Car range. ▪ Refuelling time. ▪ Noise pollution. ▪ Attitude change.

5. **Address potential inaccurate beliefs about the technology**. Understanding and countering misperceptions or unsupported beliefs is an important part of communication. However, unless great care is taken, any effort to debunk misinformation can inadvertently reinforce the myths one seeks to correct. The refutation must focus on core facts rather than the myth to avoid the misinformation becoming more familiar.
6. **Emphasize the relative advantage of hydrogen fuel cells applications compared to alternative energy and transport technologies**. People might compare hydrogen fuel cell applications to alternative technologies. In fact, people might prefer other alternatives. In this sense**, it is critical to emphasize the strengths of hydrogen fuel cell technologies relative to other technologies.**
7. **Work to develop trust**. In communicating information about emergent technologies, trust and credibility are critical assets. If organizations working on hydrogen and fuel cell projects have low credibility or inspire no trust, information campaigns might fail to promote support. Gaining and keeping trust can be critical, for instance, to minimize action against a local hydrogen fuel station.
8. **Address the needs of the various audiences.** Acceptance of hydrogen and fuel cell applications is linked to individuals' cultural predispositions and sociodemographics. Ac-

ceptance might also significantly vary from one community to another. Individuals' attitudinal responses to hydrogen and fuel cell technologies might differ based on a number of factors, some of them examined in our study. **The different audiences may even respond differently to the same information and messages**.

5.4. Key actions and messages

For Governments:

- Specific national plans and international cooperation for funding and for dissemination. Besides, establish a periodic plan to assess awareness and acceptance of FCH.
- Use best practices and cases of higher supportive countries in lower level ones.
- Demo "real" facilities. Increase visibility of application with demo and dissemination actions.
- Development of training programs on the use of FCH technologies, starting with schools and Universities
- Improve familiarity among general public, industrial / commercial users and politicians Provide information to regulators and politicians. Improve the awareness between Government, Manufacturers and regulators. Improve the expectations of potential Manufacturers
- Ask Governments for more support related to FCH technologies. Incentives for acquisition of applications (e.g.: financial incentives). Support programs for reducing application costs.
- Support the development of a distribution infrastructure. Produce and encourage the use of green H2.

For Neutral Supporters:

- Increase visibility of application with demo and dissemination actions. Highlight benefits vs other technologies.
- Carry out campaigns of dissemination and communication on FCH technologies. Explain benefits, features and consequences of use on energy / environment, policies.

For Governments and Manufacturers:

- Support from manufacturers / companies and government for installation of FCH applications.
- Support from government to R&D programmes to reduce the costs of FCH applications.
- Support from government to R&D programmes to improve the technologies (e.g. Regulations, facilities of testing....).
- Support project demonstration in order to show the maturity of technology.
- Encourage investment for the implementation of HRS. Support through policies, programmes to install new refueling stations.
- Creation of joint ventures involved in development of infrastructure.

- Campaigns of information on technology for improving the awareness between Government and Manufacturers.
- Identify expectations of potential manufacturers for making regulations about them.
- Establish jointly a framework regulatory for both applications.

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