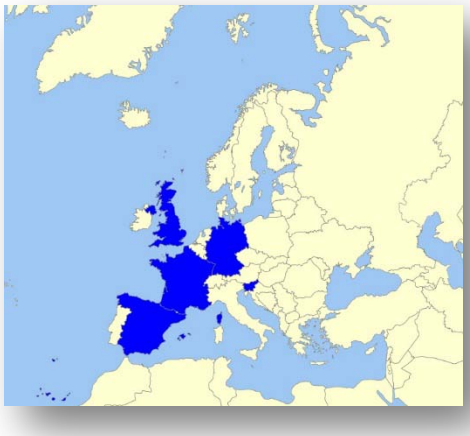
HYACINTH Project

Findings on stakeholders' views on the social acceptance of hydrogen fuel cell technologies

Context of the study

Among the alternative technologies to generate low-carbon heat and electricity and to replace fossil-fuel based powertrains, hydrogen fuel cell (HFC) technologies, including fuel cell micro-CHP, hydrogen based back-up or prime power systems, and hydrogen fuel cell electric vehicles (FCEV) are receiving support towards commercialization. It is increasingly understood that the success of innovative energy technologies is dependent not only upon the technical characteristics of those technologies, but equally on supportive social, political and economic contexts (EC, 2013 and 2014; OECD, 2014). In our study we therefore address the social acceptance of hydrogen technologies from a stakeholder point of view. This implies that social acceptance is here understood in the broad sense of societal embedding and adoption of technology, which involves many societal groups and not only the public.



The Hyacinth Project, funded by the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) has worked to increase the understanding of cross-country differences and similarities in public and stakeholder awareness and attitudes in relation to hydrogen and fuel cell applications. The primary aim of Hyacinth has been to assess levels of awareness, understanding and acceptance of FCH technologies in various EU countries with different levels of market penetration and government support. In parallel to the stakeholder study which is summarised in this document, a study of public acceptance across Europe was also conducted to cover all relevant groups (see Oltra et al., 2016 for results).

The study: survey and interviews

A mixed-methods study, based on a questionnaire-survey and qualitative semi-structured interviews, was designed and implemented to collect data on stakeholders' acceptance, expectations and views of FCH applications. An overview of the study design for the two studies is given in the following table.

	SURVEY	SEMI- STRUCTURED INTERVIEWS
Participating countries	France, Germany, Spain, Slovenia, and United Kingdom	
Time period	March and June 2016	November 2015 to June 2016
Total sample	333 participants	145 interviews
Recruitment	Invitations were sent by the project partners in each country.	Interviews were conducted by the partners in each country.
Sampling	Energy stakeholders and hydrogen experts	Stakeholders from hydrogen and fuel cell projects
Procedure	The stakeholder survey was conducted using national versions of an online questionnaire.	Interviews were conducted by phone; (some face-to-face). The interviews were conducted in the local language and lasted around 30 minutes.
Data Analysis	The data was analyzed using SPSS software.	Qualitative data has been coded with MaxQDA.

Survey

A standardised questionnaire for the survey was developed by the researchers from the project team, i.e. CIEMAT, Fraunhofer and University of Leeds. It consisted of 16 questions measuring respondents' expectations about hydrogen fuel cell stationary applications for commercial and residential use and fuel cell transport applications, as well as their perception of the main challenges facing these applications and their overall attitude towards these applications. Stakeholders were also asked about their views and expectations of other actors, i.e. anticipated societal responses (including other stakeholders and the public). This includes measures of expected familiarity and acceptance for HFC technologies.

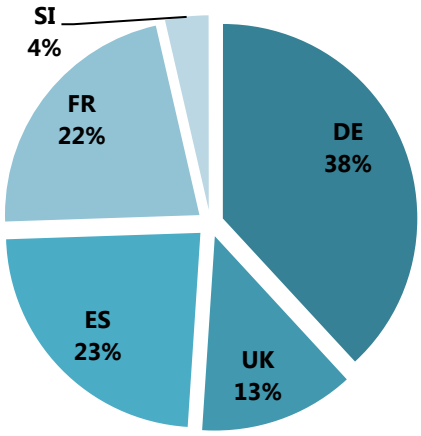


Figure 1: Survey sample size and country affiliation

In total, nearly 950 stakeholders were contacted by the project team, resulting in a sample of 333 participants. Invitations to take part in the survey were sent to participants by the project partners in each country. The stakeholder survey was conducted using an online questionnaire provided by the market research institute Norstat after being translated into national languages by the project partners. Data was collected from 30th March until 8th June 2016. Figure 1 provides the country affiliations of the respondents, who came from private companies, especially in France and Slovenia; but also from non-profit organizations and public companies – a background that applies to many German respondents. Education organisations were very relevant among UK respondents, but more generally all types of organisational affiliations were covered in all countries. Figure 2 provides information on the sectoral affiliations of the respondents.

With regard to the field of work or expertise, more than half of the respondents (53 percent) work in research on hydrogen and/or fuel cells. Nearly a third work in the field of hydrogen production and a quarter in systems integrations.

The surveyed stakeholders have plenty of experience in the field of hydrogen and fuel cells: more than a third of the respondents have been professionally involved in Hydrogen and/or Fuel Cell activities for 11 years or more, 21 percent for five to ten years and 26 percent for less than five years.

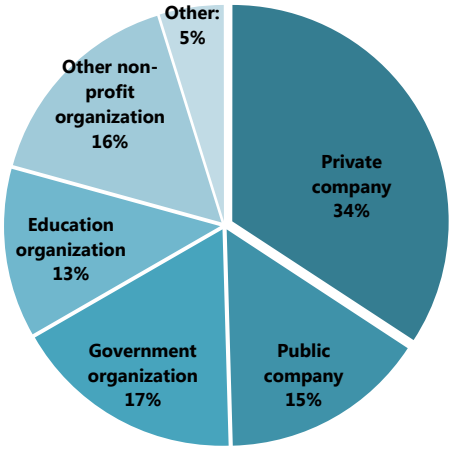


Figure 2: Type of organizations of stakeholders

Semi-structured interviews

Semi-structured interviews with stakeholders were carried out by the partners in each country between November 2015 and June 2016. For this purpose a guideline including a fixed set of questions was developed by the research partners from the project team , CIEMAT, Fraunhofer ISI und University of Leeds which served as a basis for the interview ("semi-structured"). Most of the interviews were conducted by phone and some face-to-face and lasted between 15 and 90 minutes. Based on a purposive sampling design, a total of 145 interviews were carried out. All interviews were recorded and summarized afterwards. Qualitative data was coded with MaxQDA, software intended for the purpose. The coding approach used here is both quantitative and qualitative.

Main results

In this section, the findings from the survey are summarised first, followed by an outline of the results from the interviews.

Stakeholder survey

- Of the participating stakeholders, 88 percent think that HFC technologies are a good or a very good solution for energy and environmental challenges. This view is shared across the countries surveyed.
- Regarding specific HFC technologies and applications, the most positive expectations are for H2-buses and H2 as a means of storage for renewable energy, followed by H2-based back-up power systems. Least positive prospects are for large scale systems for prime power. Stakeholders were then asked about the prospects for HFC technologies in their country. Respondents from France are most positive about this on average across technologies, followed by the UK and Germany, with Spain and Slovenia the least positive. Figure 3 provides more detail and some of these differences are statistically significant often

confirming more positive attitudes in Germany or France compared to Spain or Slovenia. Overall participants from all countries favour further governmental support and, as detailed below, the qualitative interviews suggest that the level of national policy support plays a notable role in stakeholders' level of optimism.

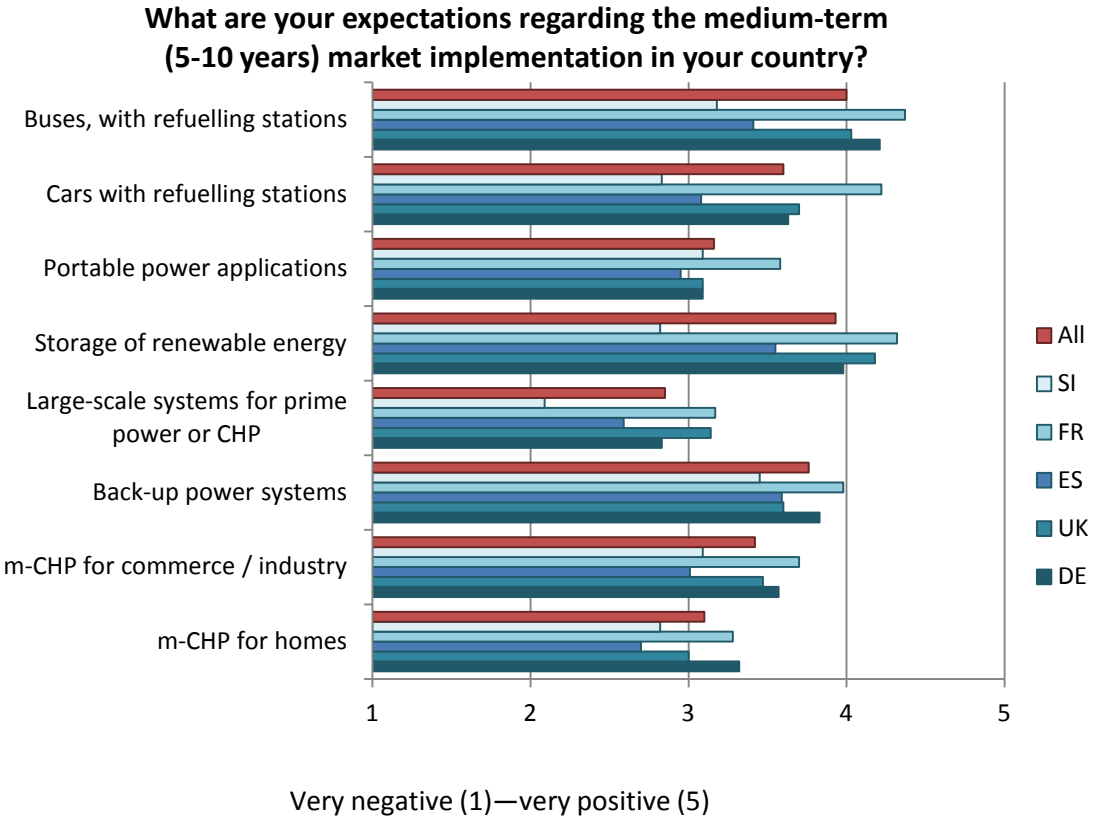


Figure 3: Future expectations for HFC technologies

- For the remainder of the questionnaire, participants had to choose between answering further questions either on HFC stationary applications or on H2 powered vehicles (FCEVs). In all countries but Slovenia, the majority of participants chose the mobile application, overall 72 percent.

Stationary applications

- Due to the limited sample size, cross-country statistical tests were not undertaken for this application type. Overall, respondents rate their familiarity with stationary applications as medium.
- Regarding challenges for stationary applications, safety issues and technological maturity are seen as minor challenges, with cost disadvantages as the major one. Other challenges such as awareness by different groups of actors, incentives, H2 production etc. were rated more moderately. Overall they were all rated around the scale mean, i.e. neither being an extremely serious issue nor a negligible one.

- In general, respondents expect that the environmental sustainability of H2 will influence public acceptance; that business models for an H2 distributions infrastructure are needed; and that air quality regulations may be a relevant driver of H2 use.
- Regarding public funding for FCH technologies, respondents were more positive about funding research and development than the funding for demonstration project and least positive about subsidies on purchase prices.
- Professionals from the same sector and researchers are rated as having a high familiarity with the technologies, significantly higher than all other groups. Politicians' and industrial/ commercial users' familiarity is regarded as higher than the general public's, which is rated lowest. Similarly, the attitude of both the research sector and professionals from same sector is regarded as more positive than the attitude of the other three groups. Familiarity and attitudes are rated similarly to some degree, i.e. in case of higher familiarity the rating of attitudes tends to be higher as well.
- Future market development: For stationary applications, the degree to which they are perceived to be able to compete with renewable electricity and heat technologies is most strongly related to the expected market development for HFC-systems. In addition to this, the implementation of air quality regulations and the development of business models for H2 distribution infrastructure are also associated with more positive market development.

Mobile applications: FCEVs

- Again, as for stationary applications, respondents rated their familiarity with FCEVs as medium.
- Providing a sufficient infrastructure of refuelling points is seen as the greatest challenge, followed by cost in general. Safety is rated as the least challenge. Other issues like technological maturity, regulation and H2-production rank in between. Some country differences are detected in the ratings of challenges; most often German participants evaluate a specific challenge as significantly less serious than participants from one of the other countries.
- Participants favour FCEVs over all other drive train technologies listed. However, the highest advantage is ascribed in comparison to conventionally powered vehicles and is smallest in comparison with BEVs. Country differences in ratings on this issue are small. Regarding state support for FCEVs, respondents rated the installation of hydrogen refuelling points as a top priority along with funding research and development; in the survey, demonstration projects were considered significantly less important and subsidies for the purchase of FCEVs even less relevant.
- The highest level of familiarity with FCEVs is ascribed to professionals from the same sector and researchers; the public is perceived to have the lowest level of familiarity. The automotive sector and politicians and regulators range in between. From an attitudinal perspective, the two groups most familiar are also perceived to have more positive attitudes than politicians and regulators, the general public and the automotive sector. Familiarity

and attitudes are rated similarly to some degree, i.e. in case of higher familiarity the rating of attitudes tends to be higher as well. Some country differences emerge, mainly including lower ratings from Spanish participants compared to some of the other countries.

- Five factors were expected to be influential on FCEV market development: being ready to compete with (1) alternative technologies, (2) full electric cars as well as (3) CNG / LNG cars, favourable attitudes of (4) professionals from the same sector and (5) from actors from the automotive sector. The more positive these five aspects were rated by participants, the more positive were their expectations about future market development for FCEVs.

Semi-structured interviews

During the analysis of the interviews three overarching categories became apparent as helpful in organising the material: (1) Perceptions of hydrogen supply and use, (2) perceptions of stationary applications, (3) perceptions of mobile applications. Within these categories the content from the interviews was organised along three dimensions, namely (1) perceived strengths and weaknesses, (2) expectations and finally (3) recommendations for each of the three main technology classes.

Perceptions of hydrogen supply and use

- The environmental performance of hydrogen is seen as the key strength, despite the scepticism of many regarding the inefficiency of combining multiple conversion processes. In addition, another dominant strength of hydrogen is perceived as its versatility, especially its utility as an energy storage vector for renewable energy supply, both per se and in relation to electrical grid balancing.
- The key perceived weakness of hydrogen is overwhelmingly seen as its cost, followed by inadequate or excessive regulation; lack of markets and market acceptance was also mentioned repeatedly.
- The key expectations for hydrogen were mixed: the majority of interviewees take a generally positive view of its prospects, with market development expected by many in the relatively near term, albeit with national differences and specificities. At the same time, however, a considerable number of interviewees perceive an uncertain future for hydrogen and a high degree of conditionality on government policy support.
- Interviewees who focused their comments on hydrogen supply and use made many recommendations, of which by far the most frequent was that more government and political support is required; followed by a perception of the need to inform and engage stakeholders, together with additional R&D to reduce costs.

Perceptions of stationary applications

- Interviewees strongly emphasised the utility of HFCs for portable / uninterruptible power as a key strength. To a lesser extent, reliability and efficiency as well as positive perceptions and environmental advantages were also emphasized as strengths, with German respondents being dominant in those categories.

- Interviewees overwhelmingly cited cost as the key weakness of stationary applications. Secondly, the complexity of the technical systems as well as limited awareness and support by regulators and governmental stakeholders were mentioned. These were followed by several perceived weaknesses at similar frequency of occurrence, including for example the inefficiency of hydrogen based systems, the challenge of finding commercial partners and perceived and 'actual' safety.
- The tone of expectations was mixed and seems to relate to the national policy environment. While unqualified positive expectations were voiced as often as negative ones, the unqualified negative expectations came only from Spanish interviewees, where interviewees feel unsupported by national policy, despite holding positive perceptions of the technologies per se.
- Interviewees' main recommendation was for more sustained and coherent Government (including European-level) support. With different scales of government bracketed together, this appeal for Government support dominates. Appeals for enhancing regulatory and lay public support and understanding follow in terms of perceived importance, along with regulatory support particularly relating to perceptions and issues of safety. In short, most of the recommendations are for supportive governmental action.

Perceptions of mobile applications: FCEVs

- The top strengths of mobile HFC applications are perceived as technical performance: long range, short refill times, high torque, etc. A further emphasis is on the lack of local emissions and that the technology is generally good also compared to alternatives.
- Financial cost dominates in terms of perceived weaknesses, followed by limited awareness and support by regulators and government and competition with other technologies; lack of infrastructure including fuel was also frequently referred to.
- Interviewees were divided in the tone of their expectations, with many expressing positive, general expectations but many also pessimistic in the short to medium term. Within these, UK interviewees expressed more general optimism than pessimism and Spanish interviewees the converse. More specific expectations all had – in comparison - very low incidental numbers.
- Interviewees again recommended governmental, political and regulatory support, including support leading to cost reductions; investment in refuelling infrastructure, together with more communication and engagement generally – including engagement of publics.

Conclusions

Across the full group of countries investigated, there are as yet no strong signals that HFC technologies have moved from their niches into the mainstream sectors of fuel supply, mobility, heat or power. However, stakeholder perceptions do vary in this regard between countries: expectations are to some extent associated with differing levels of government investment in R&D programmes, with Germany and Spain being at opposite poles in this regard.

Overall, while the stakeholders questioned have a strong positive appraisal of HFC technologies, they perceive cost and limited regulatory, political and commercial support in addition to competition from other technologies as key, inter-related obstacles. Consequently, again despite the perceived benefits of HFC technologies, stakeholders generally view these as likely to be realised in the medium to long term rather than near term.

Despite this, HFC technologies are also perceived as offering some realistic, specific niche potential in the shorter term, specifically for uninterruptible power, auxiliary power and high power demand uses, such as fork lifts and heavy goods vehicles. Moreover, lack of public support is not to be expected to become a major challenge if the framework conditions for the technologies develop in a supportive way.

This project has received funding from the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) under grant agreement Nº 621228

* To find more information about the results of the study, please go to http://hyacinthproject.eu/
The more extensive reports will be published soon.

References

OECD, 2014. System innovation (OECD STI Outlook), https://www.innovationpolicyplatform.org/content/system-innovation-oecd-sti-outlook

EC, 2013. Energy Technologies and Innovation. COM(2013) 253 final. Brussels: European Commission.

EC, 2014. Horizon 2020 Work Programme 2014-2015: 10. Secure, clean and efficient energy. Brussels: European Commission.

Oltra, C., Sala, R. (2017): General findings on public acceptance. Deliverable 5.2. http://hyacinthproject.eu/

Extensive report on study

Dütschke, E., Upham, P., Schneider, U. (2017): Report on results of the stakeholder survey. Deliverable 5.1. http://hyacinthproject.eu/