



European R&D actor expectations of hydrogen fuel cells for transport, heat and power

Prof Paul Upham, University of Leeds and Leuphana

Presentation for ILMO/SYKE, Helsinki, Nov 4th 2016

- Project context and design
- Policy and theoretical context
- Interviewee sample description
- Overview of perceptions and expectations
- Exemplar quotations
- Summary

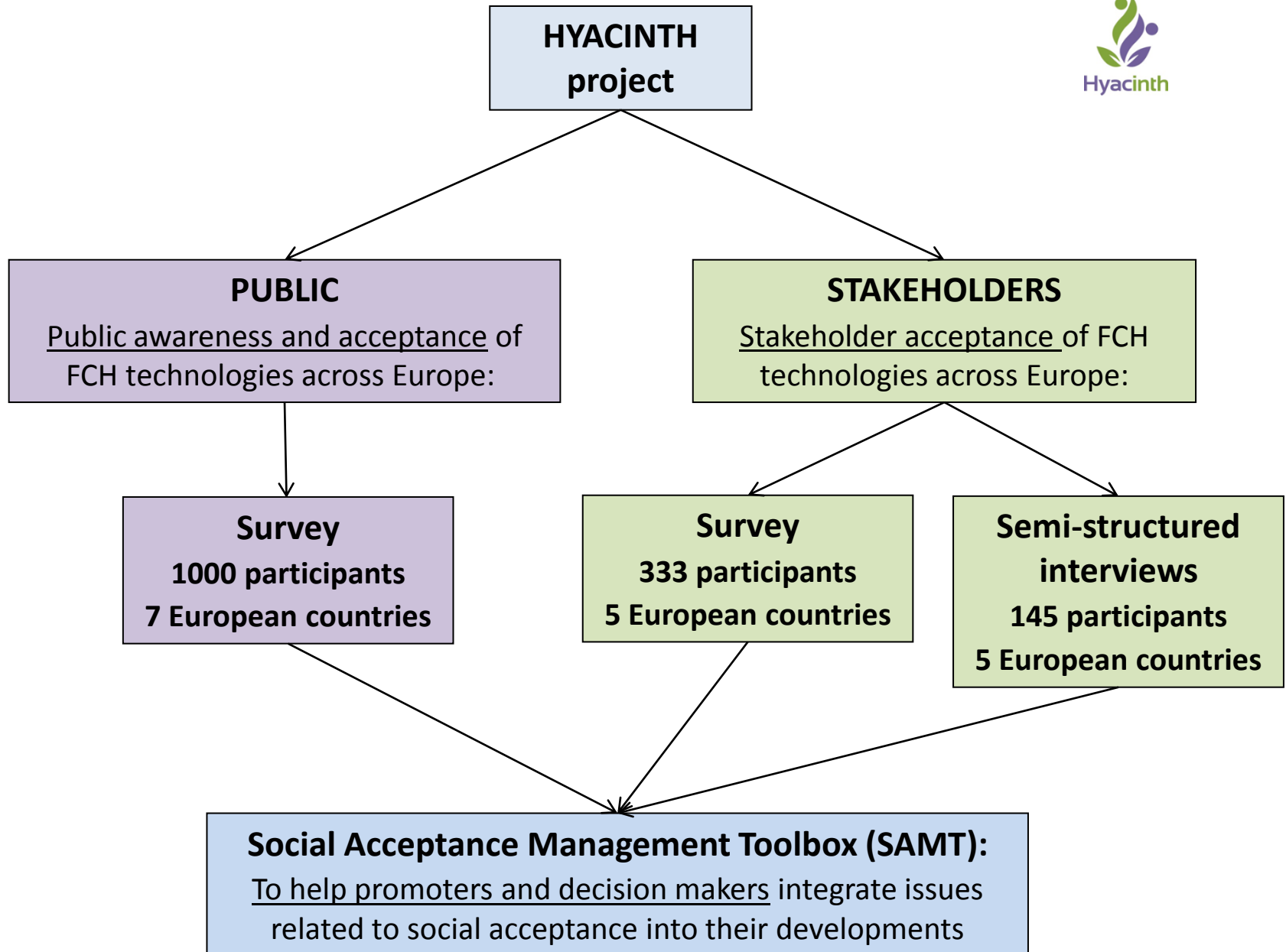
- **Project Title:** "Hydrogen acceptance in the transition phase (HYACINTH)"
- **Call:** FCH-JU-2013-1 (FP7)
- **Period:** September 2014 – February 2017
- **Funding Agency:** Fuel Cell and Hydrogen Joint Undertaking 
- <http://www.fch.europa.eu/> and <http://hyacinthproject.eu/>

PROJECT DETAILS - PARTNERS



- Centro Nacional del Hidrógeno (CNH2) – Spain
- I PLUSF France – France
- Fraunhofer-Institut für System- und Innovationsforschung ISI– Germany
- Aberdeen City Council– United Kingdom
- University of Sunderland– United Kingdom
- Centre for Energy, Environment and Technology (CIEMAT) – Spain
- Sustainability Research Institute (SRI), University of Leeds - United Kingdom
- CIDAUT Foundation– Spain
- Razvojni Center za Vodikove Tehnologije (RCVT) – Slovenia
- NORSTAT Services GmbH (NORSTAT) – Germany
- I PLUSF España – Spain





- Directive 2014/94/EU on the deployment of alternative fuels infrastructure supports the development of low carbon transport, inc. min requirements for alternative fuels infrastructure
- Article 5 “Hydrogen supply for road transport” requires the circulation of hydrogen-powered motor vehicles within national networks with cross-border links by 31 December 2025.
- Only Germany has a dedicated national hydrogen implementation plan. Launched in 2006 with an expected lifetime of 10 years, the “[Nationales Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie – NIP](#)” (National Hydrogen and Fuel Cells Innovation Program) is a public-private partnership across several ministries and regions, with an initial, planned budget of €700m from each of government and industry (€1.4bn total).
- [NOW GmbH](#) (National Organisation Hydrogen and Fuel Cell Technology) was created to manage this

- Of the remaining countries, France has the strongest level of financial support from government, with the “Mobilité Hydrogène France” (Hydrogen Mobility France) initiative / consortium
- The estimated funding needed until 2030 to implement about 600 HRS and more than 800,000 FCEV is about €586m
- The UK, Spain and Slovenia all have project-based hydrogen and HFCEV activity. Some of this is relatively substantial in scale: e.g. Aberdeen’s the largest hydrogen bus fleet within Europe
- However, in terms of *national* private and/or public sector commitments to financial investment and infrastructure deployment, Germany is primary in terms of scale, France second and the UK a more limited third.
- This in turn plays a role in the nationally situated expectations of the interviewees

SOCIOLOGY OF EXPECTATIONS

- When technologies or scientific capabilities do not yet exist, or are primarily at a demonstration stage, advocates generally solicit support on grounds that lie beyond evidence of technical progress.
- Such grounds have been theorised as technological expectations, i.e. 'real-time representations of future technological situations and capabilities' (Borup et al. 2006).
- In very many cases, alternative futures and their technological trajectories compete for support. In both innovation systems and sociotechnical transitions theory, expectations are viewed as playing a *performative* role: widely shared expectations attract investment, strengthen functional networks and are thus more likely to become a reality
- With advanced technological change having become a strategic focus for governments, fostering shared expectations has become an important feature of 'communication and interaction across institutional and epistemic borders.' (Borup et al, 2006, p. 286).

COLLECTIVE VS INDIVIDUAL EXPECTATIONS

- The results illustrate the thesis that expectations are ubiquitous (e.g. Berkhout, 2006)
- They also illustrate Borup's (2012) observation that formal, collective visioning exercises need to: "navigate a sea of expectations"
- An example of a collective vision that would need to navigate this sea is the OECD/IEA (2015) Technology roadmap: hydrogen and fuel cells
- This envisages a strong decarbonisation scenario consistent with 2°C (50% chance), demand reduction and efficiencies, high carbon emission prices and rapid deployment of HFCs that quickly reduces costs through scale-up of both supply and demand



Technology Roadmap
Hydrogen and Fuel Cells

EXPECTATIONS ARE SITUATED

- Berkhout (2006, p.300) argues that 'private expectations are to a large extent shaped by socially-distributed rhetorics about the future, as well as by the inertias represented by material conditions'
- We see this, but we can also ask 'which rhetorics in particular?'
- For our interviewees, the most potent influences are the national policy contexts and the experience of demonstration projects
- To the extent that deliberately ambitious visions are attempts to persuade and hence are in part rhetorics, then these appear more remote
- Ambitious roadmaps may not sink in the sea, but they have a rough journey!



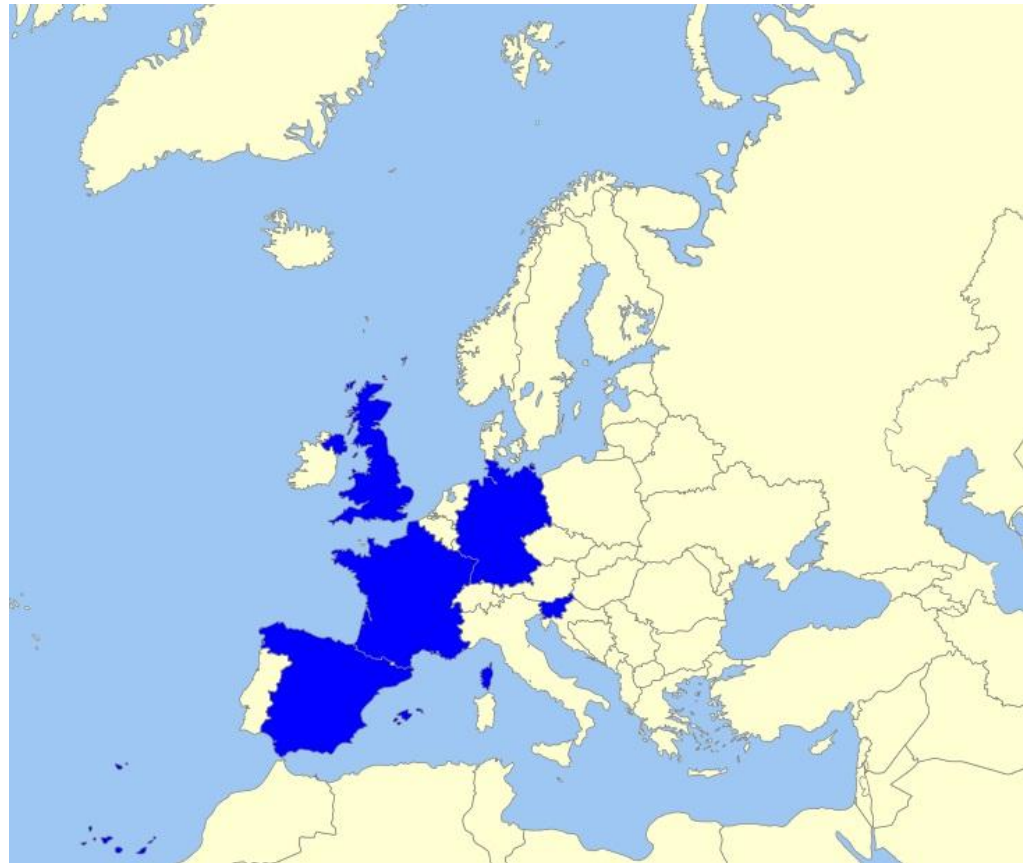
Technology Roadmap
Hydrogen and Fuel Cells

- **Semi-structured interviews** between November 2015 and June 2016
- Population: **selected stakeholders in 5 countries**
- Implementation: **telephone or face-to-face interviews**, recorded and summary transcripts

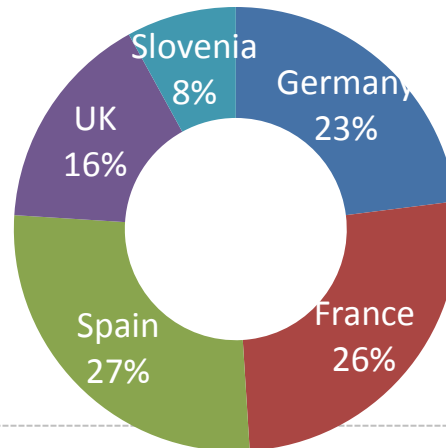
STAKEHOLDER ACCEPTANCE STUDY

France
Germany
Slovenia
Spain
United Kingdom

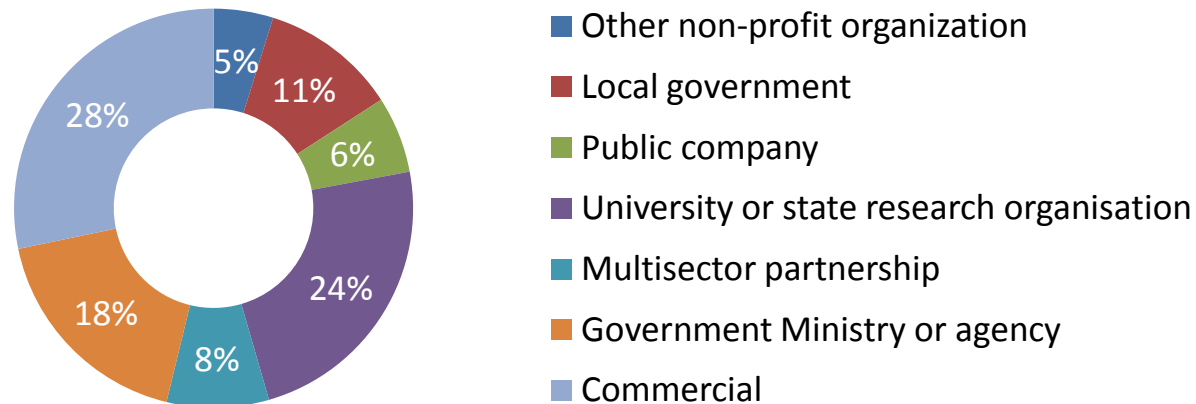
145 interviews



■ Interviewee percentage by country



■ Interviewee percentage by affiliation



Stakeholder interview results – a quick overview

Note: we divided the perceptions into three object-reference categories:

1. Hydrogen supply and use
2. Stationary applications (heat and power)
3. Mobile applications (vehicles)

■ Perceptions of hydrogen supply and use

- Strengths:
 - **Environmental performance of hydrogen** (despite the scepticism of the inefficiency of combining multiple conversion processes)
 - **Versatility:** energy storage vector for renewable energy supply (per se and in relation to electrical grid balancing)
- Weaknesses:
 - **Cost**
 - **Limited awareness** among regulators and government;
 - **Inadequate or excessive regulation** (if bracketed with the former, this would exceed cost as a perceived problem)
 - **Competition from alternative technologies**
 - **Lack of commercial support** and lack of markets
 - **Product unreliability**
 - **Immaturity and durability**
 - **General lack of infrastructure**
 - **Perceived safety issues**

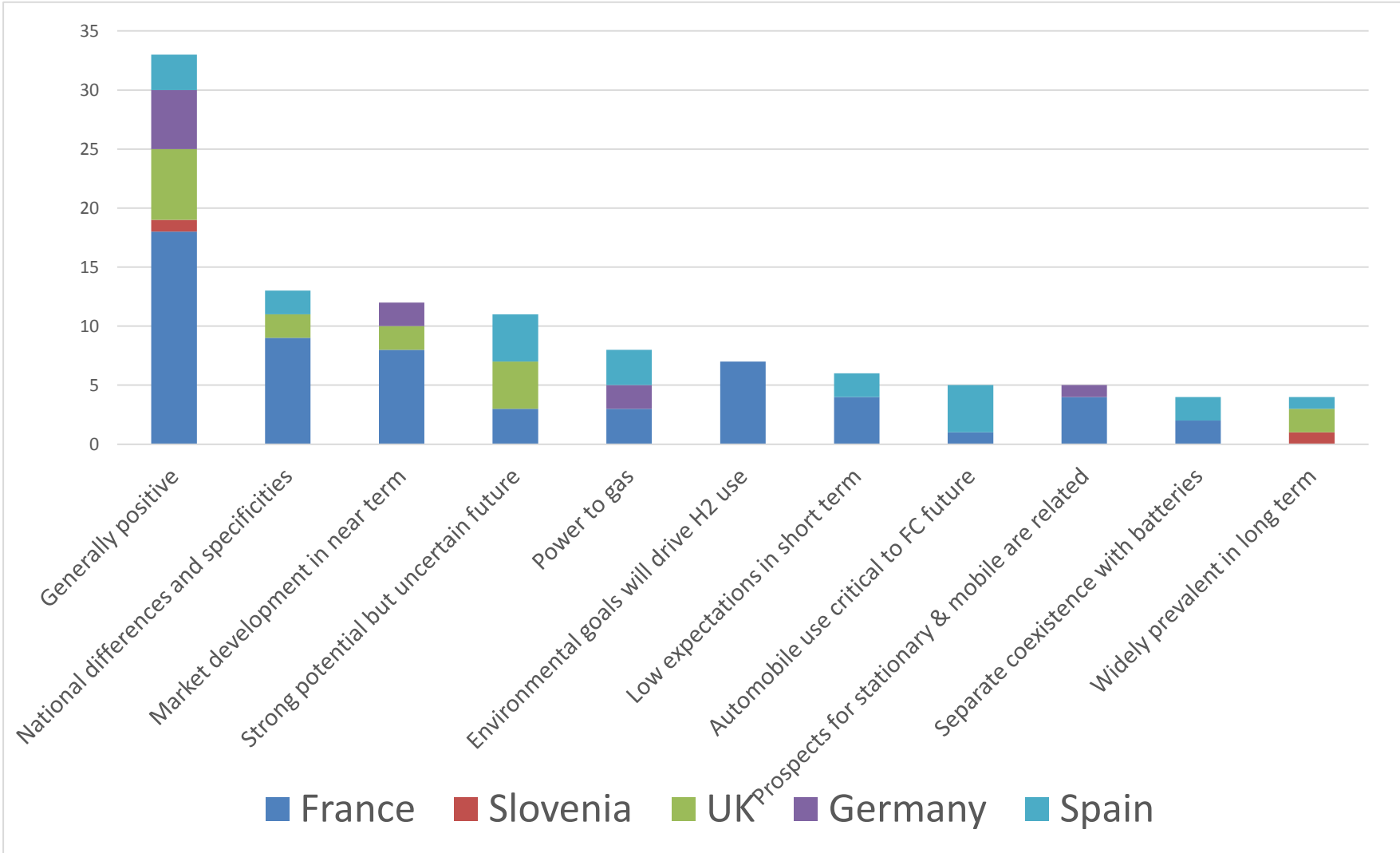
■ Perceptions of hydrogen supply and use

- Key expectations (mixed):
 - Positive view: **market development** expected by many stakeholders in the relatively **near term** (albeit with national differences and specificities).
 - **Uncertain future** for hydrogen and a high degree of **conditionality on government policy support**.
- Recommendations:
 - More **government and political support** is required
 - Need to **inform** and **engage stakeholders**
 - Additional **R&D** to **reduce costs**

STAKEHOLDER INTERVIEWS - RESULTS



Hydrogen supply and use: expectations (higher incidence)



■ Perceptions of static applications

- Strengths:
 - H2FCs for **portable power** (could also be bracketed with the potential for uninterruptible power)
 - **Integration** with **existing infrastructure** (UK respondents only)
 - **Efficiency** of fuel cells (reducing the pressure on the electrical network)
 - The capacity to offer **domestic** and **non-domestic CHP**, power and heat, including high power.
- Weaknesses
 - **Cost**
 - **Complexity** of the **system** and its **components**
 - Perceived and 'actual' **safety**
 - **Competition** from **alternative technologies**
 - The challenge of finding **commercial partners**
 - **Investment costs**
 - Perceptions of **technological inefficiency** on a system level.

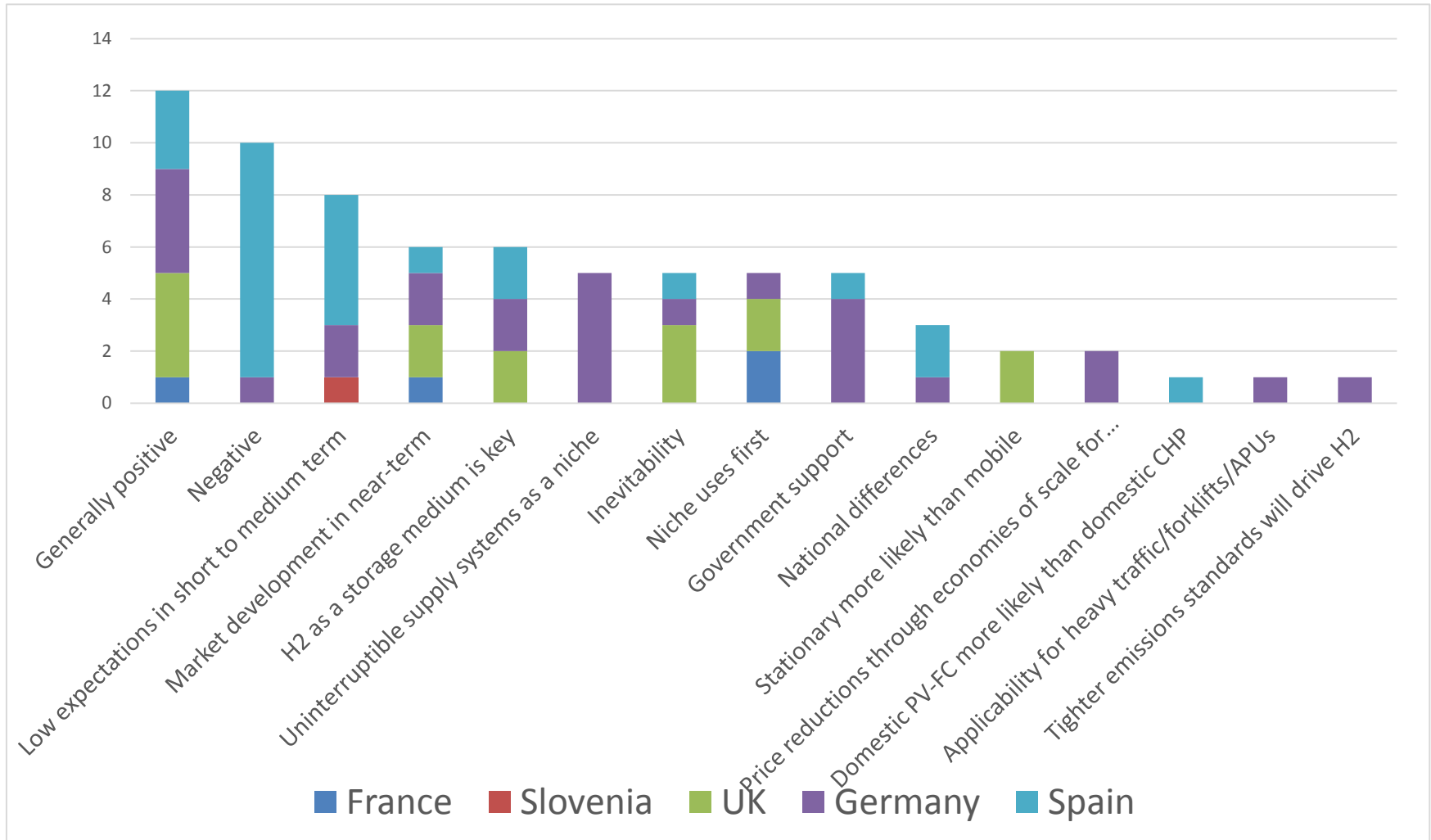
■ Perceptions of static applications

- Key expectations (very mixed):
 - **Negative expectations** by **Spanish** (largest single fraction of the total)
 - Positive expectations (second largest fraction)
 - Low expectations (in the short to medium term)
 - Expectations expressing a positive inevitability for the technology
 - **Expectation of niche uses first**
 - **Uninterruptible supply systems** as one such niche (German respondents only)
 - **Stationary uses** being more likely than mobile uses (UK respondents only)
 - Hydrogen being used as a **storage medium** as key to the take-up of static applications (UK respondents only)
- Recommendations:
 - More **sustained** and **coherent Government** (including European-level) support.
 - **Government support**
 - **Regulatory** and **public support** and understanding
 - **Regulatory support** particularly relating to issues of **safety**

STAKEHOLDER INTERVIEWS - RESULTS



Static applications: expectations



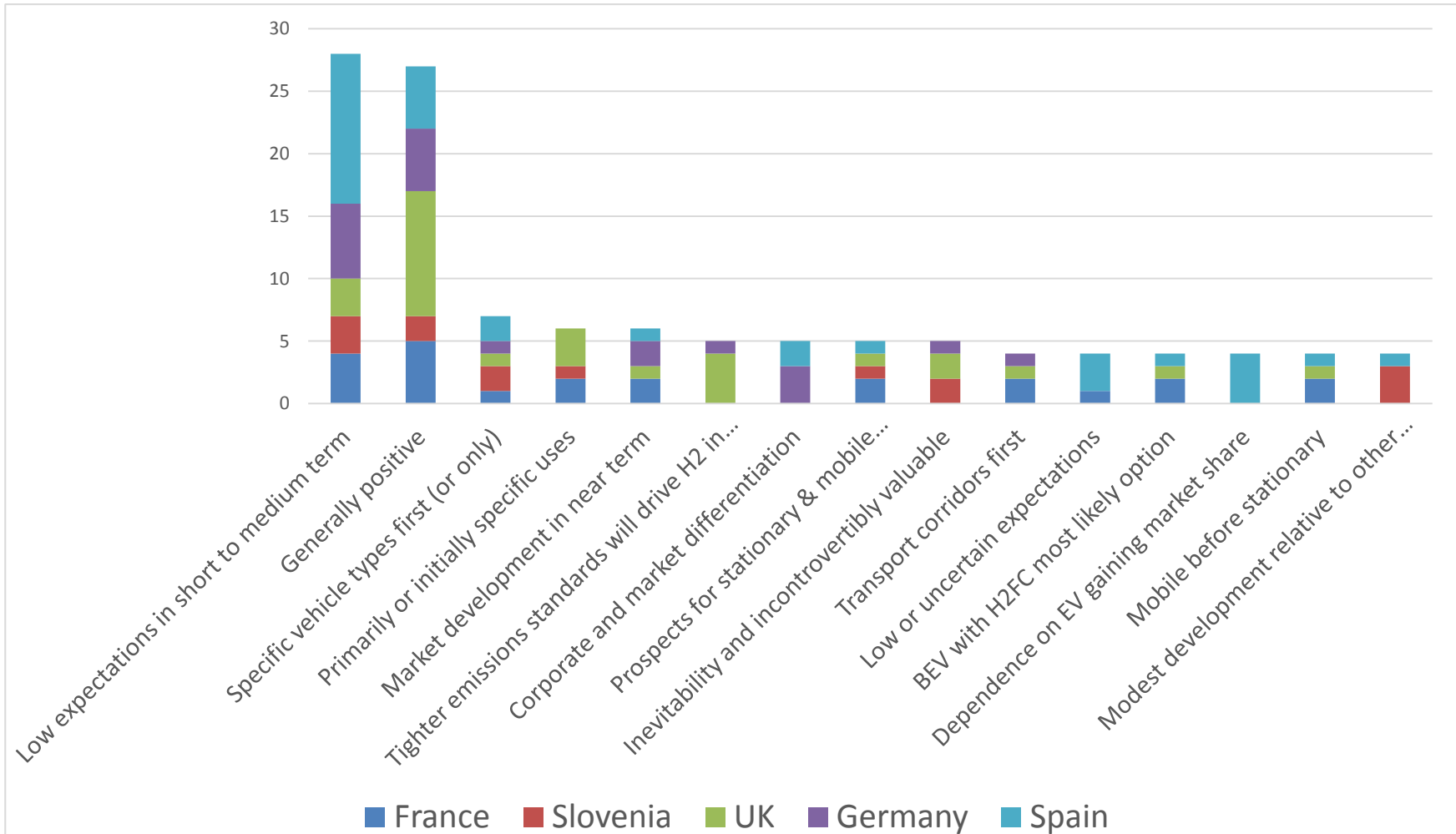
■ Perceptions of mobile applications

- Strengths:
 - **Operational performance:** long range, short refill times, high torque, strong performance generally and relative to alternatives
 - Ease of integration with **existing infrastructure**
 - Suitability for **specific fleets**
- Weaknesses:
 - **Financial cost**
 - ‘Actual’ and perceived **competition** with **other technologies**
 - **Lack of infrastructure** (including fuel)
 - **Limited awareness** and **support** by **regulators** and **government**
 - **Inadequate or excessive regulations, codes or standards**
 - **Safety** (‘actual’ and perceived)
 - **Technological unreliability/durability**
 - **Lack of markets**
 - **Lack of public awareness**

■ Perceptions of mobile applications

- Expectations:
 - **UK interviewees more optimistic** and Spanish interviewees **the converse**
 - **Specific vehicle fleets** being the first to use H2FC technology
 - **Niche uses first** or only
 - **Tighter emissions** standards driving H2FC use
 - **Battery electric vehicle (BEV)** with H2FC being the most likely option
 - **Transport corridors being first** to support H2FCs
 - Perception of H2FCs being **inevitable** or **incontrovertibly valuable**
- Recommendations:
 - **Governmental, political** and **regulatory support**
 - **R&D** to support **cost reductions**
 - **Commercial partner** support
 - More **communication** and **engagement** generally, including of publics
 - Investment in **refuelling infrastructure**

Mobile applications: expectations



STAKEHOLDER SURVEY - EXPECTATIONS



Differences on a country level between stated expectations about market development for several HFC technologies (n=333)

	Differences in ANOVA
m-CHP for homes*	DE > ES
m-CHP for commerce / industry*	DE, FR > ES
Back-up power systems	-
Large-scale systems for prime power or CHP*	FR > ES
Storage of renewable energy*	UK, FR > ES DE, UK, FR > SI
Portable power applications*	FR > ES
Cars with refuelling stations*	DE > ES FR > DE, ES, SI
Buses, with refuelling stations*	DE, UK, FR > ES DE, FR > SI
Tested with ANOVAS and post-hoc-tests.	

CONTEXTS AND QUOTATIONS

- Of the five countries considered here, although there is HFC related R&D activity in all, only Germany has a dedicated national hydrogen implementation plan (initial, budget of €700m from each of government and industry: €1.4bn total)
- "I do not have a crystal ball ... what is clear is that Spain is not in the game. When we want to do it, it will be already done. Germans and others will have already done it... It will happen as in the automotive sector, we are only good component manufacturers." *Spain, private sector*
- "I think there are opportunities for the countries that lead on these technologies. We see Germany going for hydrogen in a big way. Scotland has also done that. We've got clusters in Aberdeen, Orkney, and Fife. We are placing ourselves well. There will be jobs created and opportunities for providing services and exporting as well. These are all opportunities that will come." *UK, private sector*

CONTEXTS AND QUOTATIONS

- "As long as the (lithium-ion) battery remains with the current limitations... the fuel cell has a future. If in the future we have batteries that load quickly and with a highest energy density, I do not know if the hydrogen will have an application in the electrical world." *Spain, university*
- "When we talk about hydrogen today, we always think about fuel cells. This is fine but there are still very few HFCEVs, there is still no solution for heavy vehicles, etc. ... so then, we want to resume the tests done years ago to mix hydrogen and methane. You can propel a bus running on natural gas with a mixture of 20% hydrogen (you can reach even 25 to 26%) and the rest of natural gas. *Spain private sector*

CONTEXTS AND QUOTATIONS

- "On the producer side, the supplier side of the technology we do not have the necessary capacity that is needed. One major company is now consequently following this path and they expect it to be relevant on the medium term, but many others are still playing on a low level. You cannot make billions from it at the moment, the time span is more towards 2030." *Germany, state research organisation*
- "Of course the costs of the vehicles are still too high, sure there are a lot of problems to solve regarding the infrastructure (reliability, operating costs, the technology itself). [...] But in the long run there is no alternative in my view." *Germany, private sector*

SUMMARY



- R&D stakeholders have a strong positive appraisal of HFC technologies, but perceive significant limitations:
 - cost and limited regulatory, political and commercial support;
 - competition from other technologies and inter-related obstacles.
- Hydrogen and HFCs still seen as a medium to long term prospect rather than near term, except for:
 - Uninterruptible power, auxiliary power and high power demand such as fork lifts and heavy goods vehicles
 - Use of hydrogen as a constituent of largely fossil CNG and injected to the gas grid
 - Use of HFCs in battery electric vehicles, to extend range (as in e.g. France)
- Expectations appear nationally situated and influenced, with optimistic (high HFC) scenarios often acknowledged as possible and even necessary, but mostly considered unlikely in the short and medium term (if that)
- The sea of expectations for HFCs is still quite rough...



HYACINTH

Hydrogen Acceptance in the Transition Phase
Support & Coordinated Action

Contact for this presentation:
paul.upham@Leuphana.de



*This project has received funding from the
Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) under
grant agreement N° 621228*

