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The public acceptance of Hydrogen Fuel Cell applications in Europe: results from a seven country survey

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Hyacinth

INTRODUCTION

CONTEXT

- Among the alternative technologies to generate low-carbon heat and electricity and to replace fossil-fuel based vehicles, **residential fuel cells** and **hydrogen fuel cell vehicles** (FCEV) are receiving support towards commercialization in many countries
- It is assumed that both applications have **mass-market potential** and will have a significant impact on reducing emissions and primary energy consumption (Ammermann et al., 2015).
- **Public and consumer acceptance** will likely play a role in the successful adoption of hydrogen and fuel cell applications



CONTEXT

- The objective of HYACINTH Project is to achieve a greater **understanding** of the **social acceptance** (stakeholder and public acceptance) of hydrogen and fuel cell technologies and applications at the European level

MULTI-COUNTRY SURVEY STUDY: OBJECTIVES

- To examine **public awareness**, familiarity, perception of benefits and costs, global attitude and **acceptance** of FCH technologies
- To identify key individual and social **determinants** of public awareness and acceptance of FCH technologies
- To report on **cross-country comparisons** in public awareness, attitudes and acceptance towards FCH technologies

Table . *Studies on hydrogen public acceptance published in the last five years and based on survey research with representative samples at the country or region level*

Ref.	Year	Country	Data collection	Research question or focus	Population and sample
Achterberg et al.	2010, 2014	The Netherlands	Data gathered in 2008 through an online survey questionnaire	The relationship between the information one has about the hydrogen technology, how one is culturally predisposed and the way one judge's hydrogen technology.	Representative sample of the Dutch population (n=2121)
Tarigan et al. 2012	2012	Greater Stavanger, Norway	Data set collection through a random telephone survey to 1270 phone numbers and interviews	The effect of knowledge and environmental attitude on the likelihood of supporting the introduction of hydrogen vehicles and refuelling stations, the use of hydrogen vehicles in the future and willingness to pay more for hydrogen fuel.	Sample of the general population. Two groups (back yard and general population) n=1000
Zimmer and Welke	2012	Germany	Survey questionnaire based on interviews and focus groups.	Understand how people perceive hydrogen technologies and which opinions, mental images and attitudes toward hydrogen technologies they have.	General population (1011 people were interviewed).
Huijts et al.	2013	The Netherlands	Online questionnaire (action-related items)	Knowing what motivates citizens intention to act in favour of or against hydrogen refuelling facilities	Dutch citizens: Informed group / group control (no information) persons living less than 500m from a refuelling station were oversampled n=800

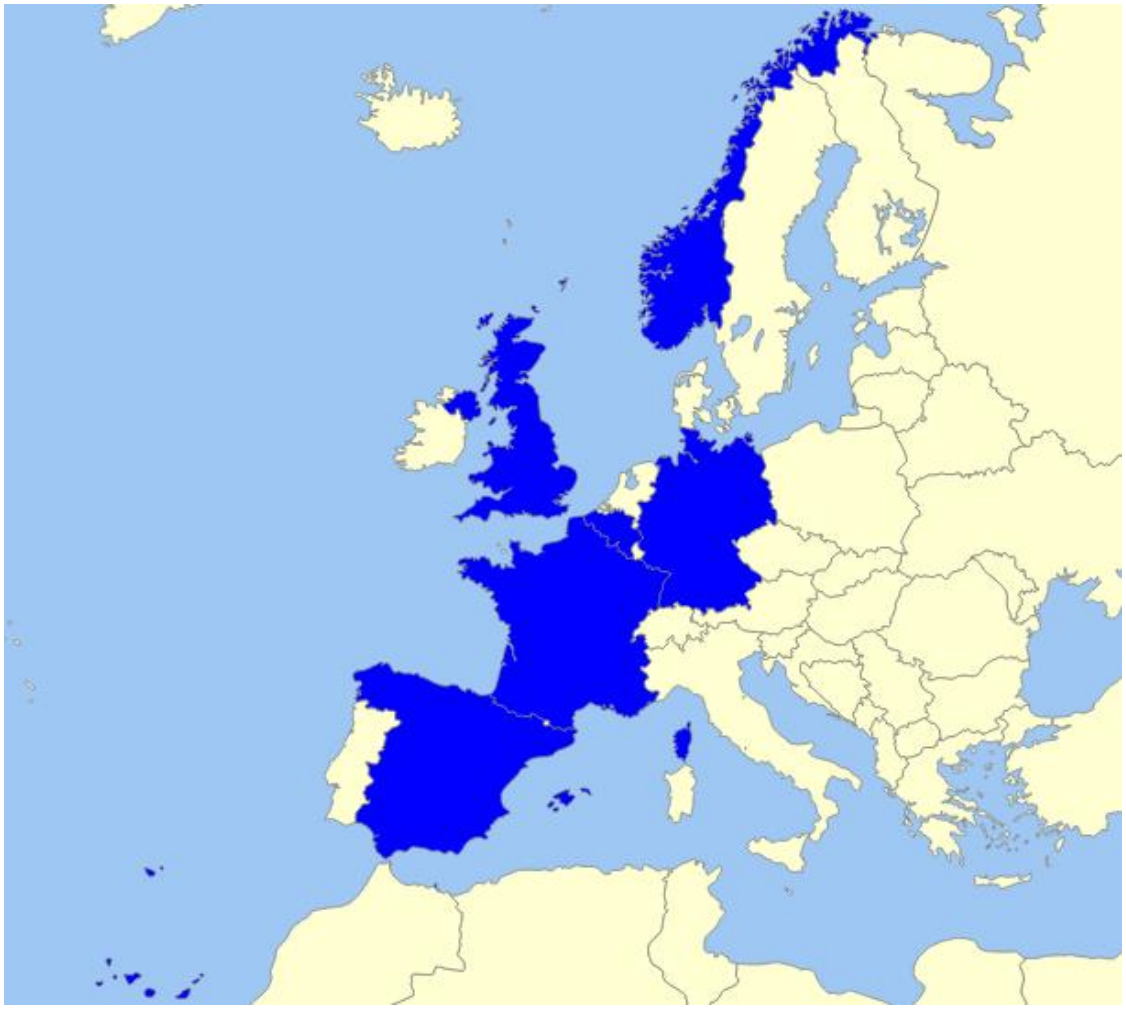
DESIGN OF THE STUDY

METHOD

- Questionnaire survey
- Population: General population (aged 16 and more) in seven countries
- Implementation: Online panels (by Norstat)

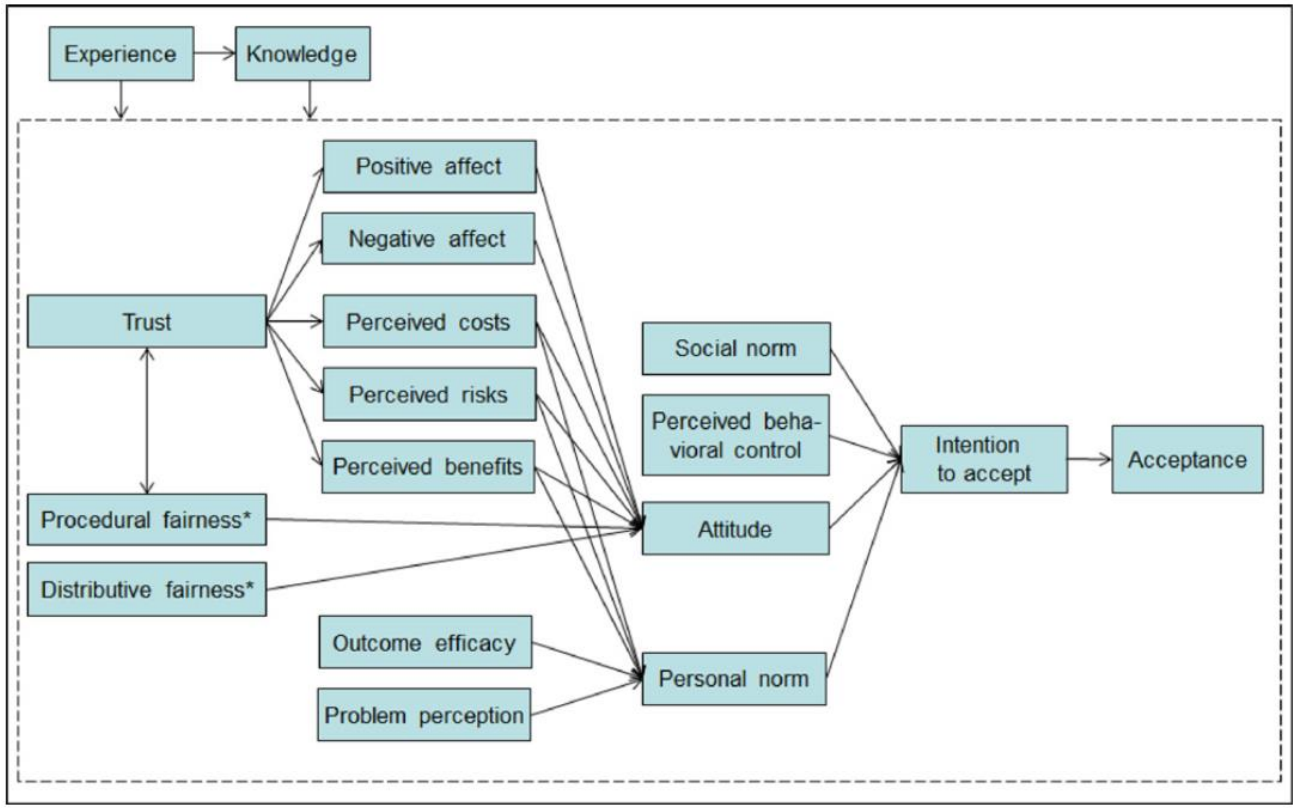
STUDIED COUNTRIES

PUBLIC ACCEPTANCE STUDY



ANALYTICAL MODEL

- The final questionnaire draws partially on the **technology acceptance model** (Huijts, Molin, & Steg, 2012), recent empirical studies on public acceptance of hydrogen technologies (Achterberg, 2014; N. M. a. Huijts, Molin, & van Wee, 2014) and Information Choice Questionnaire (ICQ) (Best-waldhober & Daamen, 2006)



Technology Acceptance Model (Huijts, Molin and Steg, 2012)

STUDIED DIMENSIONS

Dimension	Definition	Studies
Awareness	Degree to which individuals are conscious, know, have heard of specific technologies or developments	Zimmer and Welke (2012)
Familiarity	Subjective knowledge and familiarity with the technology	DOE survey
Experience	Direct personal contact with hydrogen applications	Zimmer and Welke (2012)
Uninformed evaluation	Personal evaluation of the technology before being informed about potential consequences	De Best-Waldhober et al., 2008
Affect	Degree in which the technology generates various emotions in participants	Midden and Huijts, 2009
Perceived impacts	Beliefs regarding the potential consequences of the technology	Huits et al., 2014
Evaluation of consequences	Degree to which individuals consider potential consequences an advantage or a disadvantage	De Best-Waldhober et al., 2008
Global attitude	Personal evaluation of the technology	De Best-Waldhober et al., 2008
Acceptance and Support	Degree in which the individual accepts and supports (attitudinal and behavioural acceptance) further developments in the technology Comparison with other technologies??	Achterberg, 2014
Trust	Trust in industry and governments to make good decisions and to succeed	Midden and Huijts, 2009
Other variables	Pro-environmental self-identity Involvement, interest in technology Lifestyle practices; Sociodemographics	Huijts (2012) Axsen et al. (2012); Whitmarsh & O'Neill, (2010)

DESIGN OF THE QUESTIONNAIRE

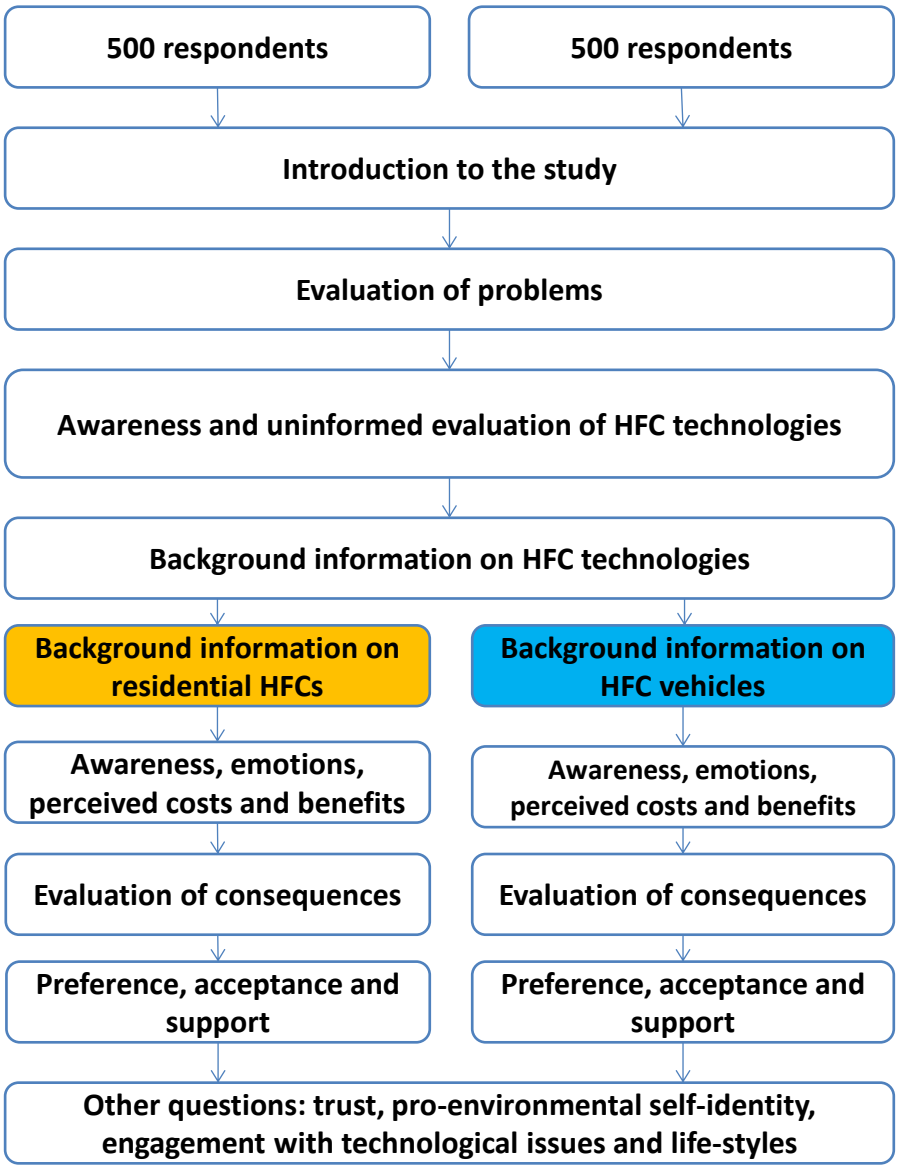


Figure 1. *Summary of the design of the questionnaire*

SAMPLE

Distribution of the sample per country studied

Sample		BE (%)	FR (%)	DE (%)	NO (%)	SL (%)	ES (%)	UK (%)
N		1021	1022	1011	1033	1014	1034	1013
Sex (male)		47%	48%	49%	49%	49%	49%	52%
Age group	18-34	27%	28%	23%	28%	27%	29%	28%
	35-44	18	18	18	19	19	21	18
	45-54	19	17	19	18	18	18	17
	55+	36	36	40	35	35	32	37
Education	Primary	13%	24%	0.3%	8%	5%	8%	9%
	Secondary	46	25	75	40	60	31	30
	Tertiary (or higher education)	41	51	25	52	35	61	61
Size of place of residence	<2.000	9%	21%	8%	12%	27%	6%	12%
	2.000-20.000	46	33	31	29	38	19	23
	20.001-199.999	32	27	29	35	18	31	32
	200.000-1.000.000	7	10	19	17	14	23	17
	>1.000.000	5	9	13	6	2	21	16

Jump to:

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Over the last decades, hydrogen (H2) has gained increasing attention as a fuel and for energy storage. Governments and companies across Europe are devoting efforts to the development and implementation of fuel cells for *power generation* and *residential heating* and *fuel cell vehicles* (FCVs). The main reasons for this include the need to reduce air pollution in towns and cities and to reduce reliance on fossil fuels.

Photo: H2, the chemical formula for hydrogen gas

A hydrogen fuel cell is an electrochemical device (like a battery) that combines hydrogen and oxygen to produce electricity. Fuel cells and batteries are similar because they use a chemical reaction to provide electricity. But fuel cells differ from batteries in that they produce electricity whilst batteries only store electricity. Small fuel cells can power devices such as phones or laptops, while larger fuel cells can provide energy for homes, buildings, industry as well as to power vehicles.

A fuel cell will produce electricity as long as it has a fuel supply (hydrogen). Although hydrogen is the most common of all elements in the universe, energy has to be used to generate hydrogen. Hydrogen can be produced from any primary energy source. Currently, most hydrogen is produced from natural gas. But also wind power can be used to separate hydrogen from sea-water. The hydrogen then acts as a store of energy that can be transported and used in different ways. In other words, hydrogen is not an energy source but an energy carrier.

Question: q11ax2

q11ax2

They would reduce CO_2 emissions

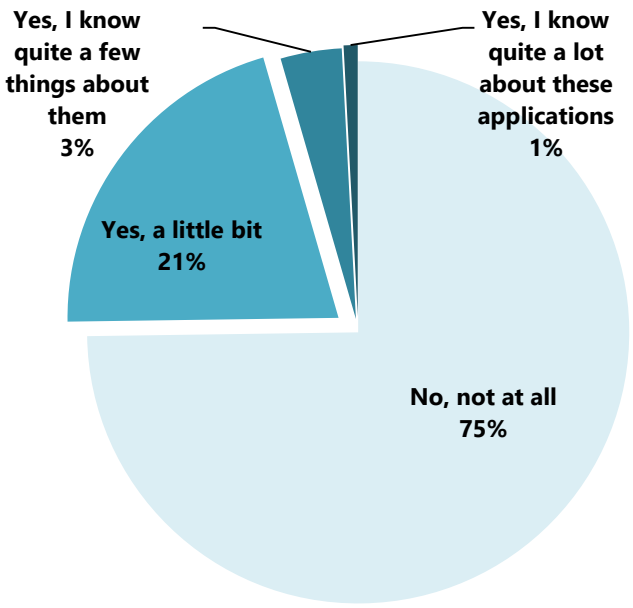
A typical fuel cell micro combined heat and power system, using natural gas as the hydrogen source and comprising a fuel cell unit, peak load boiler and hot water tank, can reduce CO_2 emissions by up to 50% compared to the separate generation of heat and power.

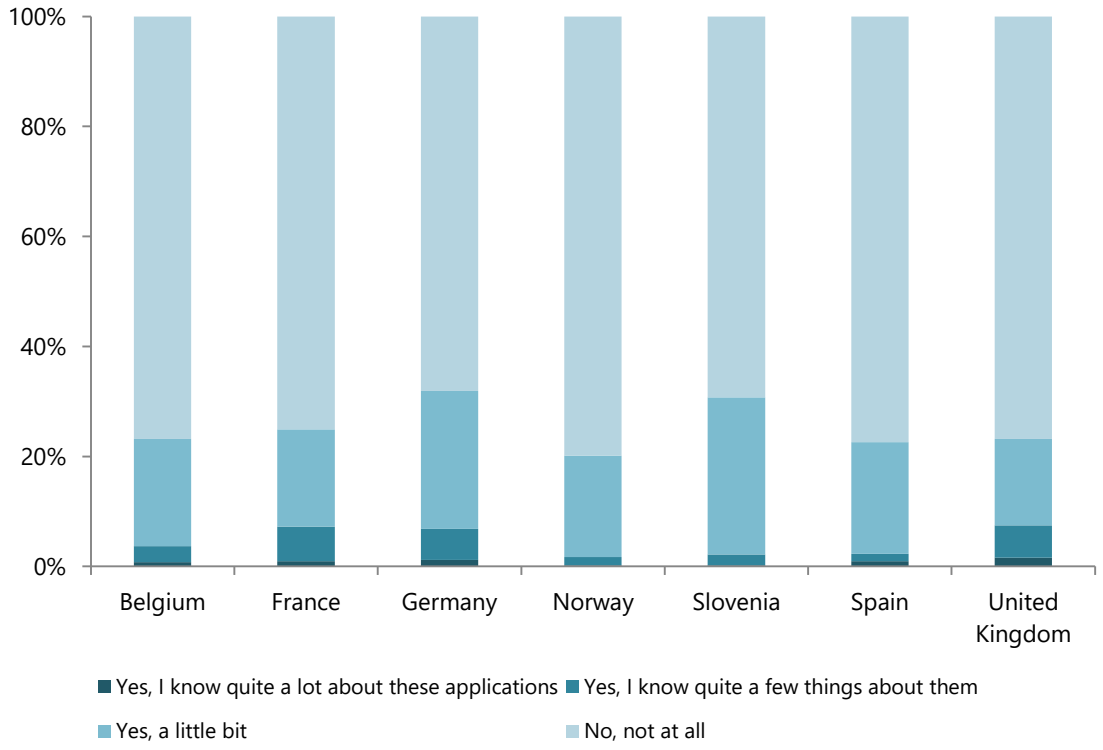
Do you consider this consequence as…

very negative		not important		very positive
1	2	3	4	5

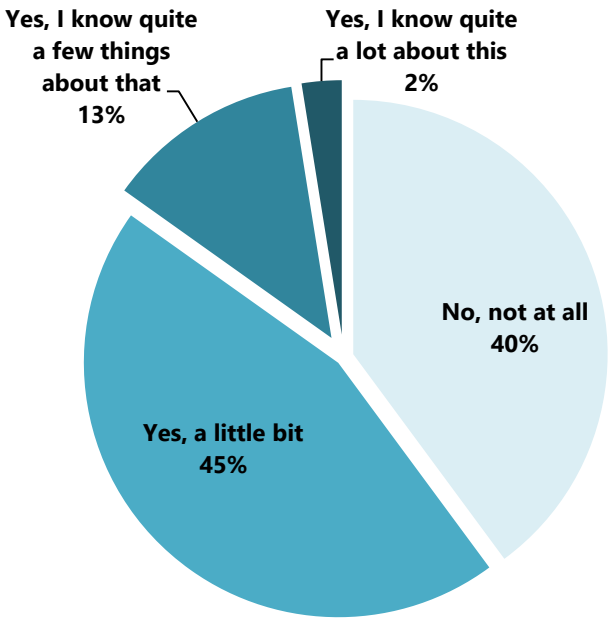
RESULTS

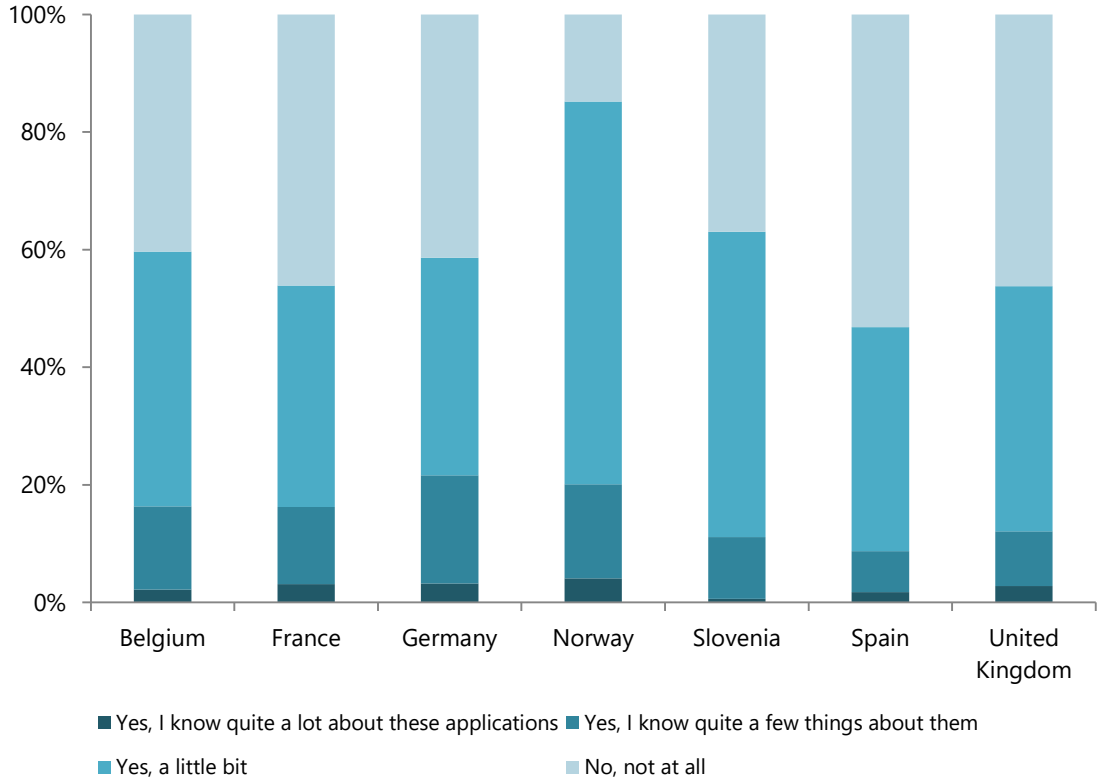
Awareness of residential hydrogen fuel cells



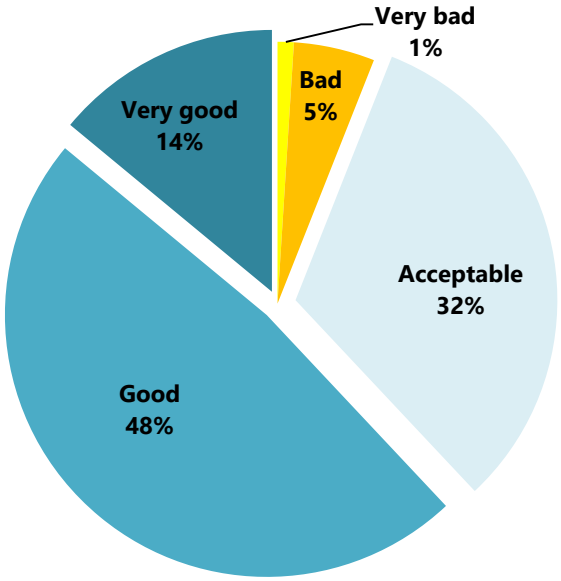


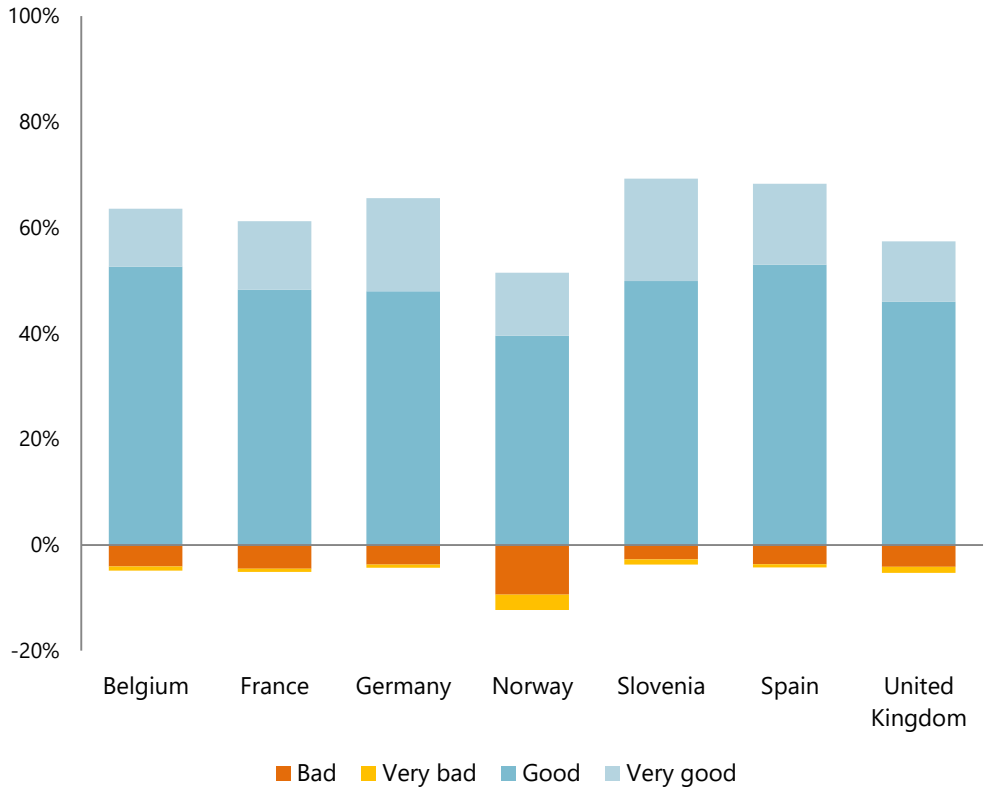
Awareness of HFCEVs





Informed evaluation/global attitude of home HFCs





Acceptance of home HFCs

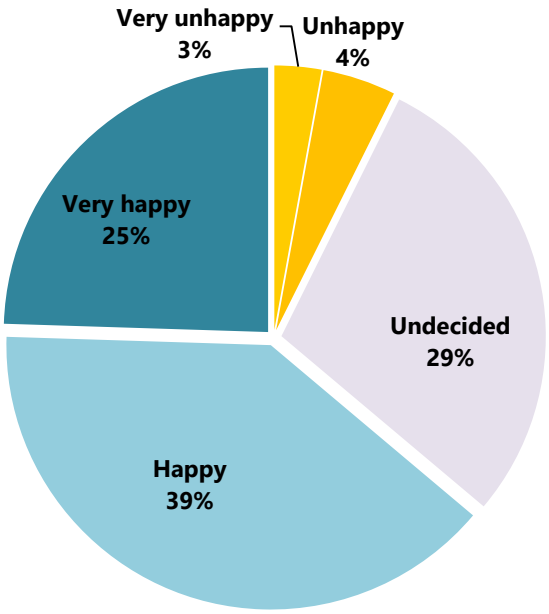
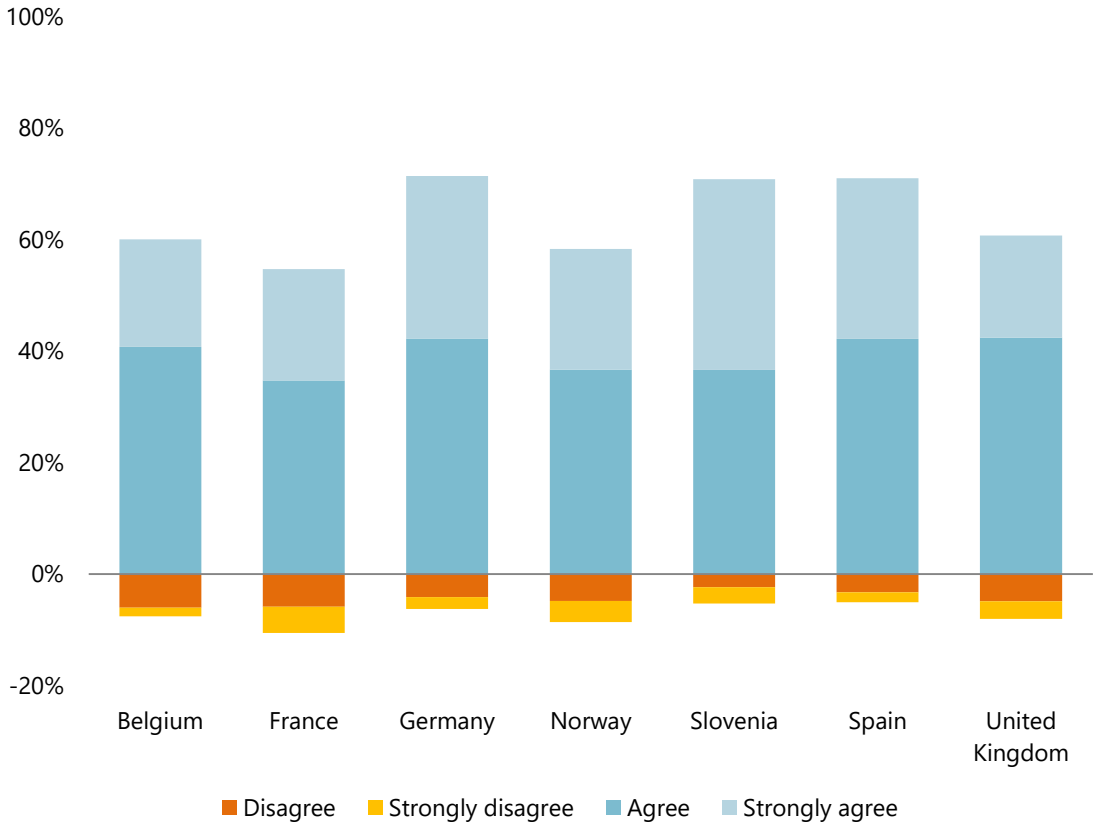
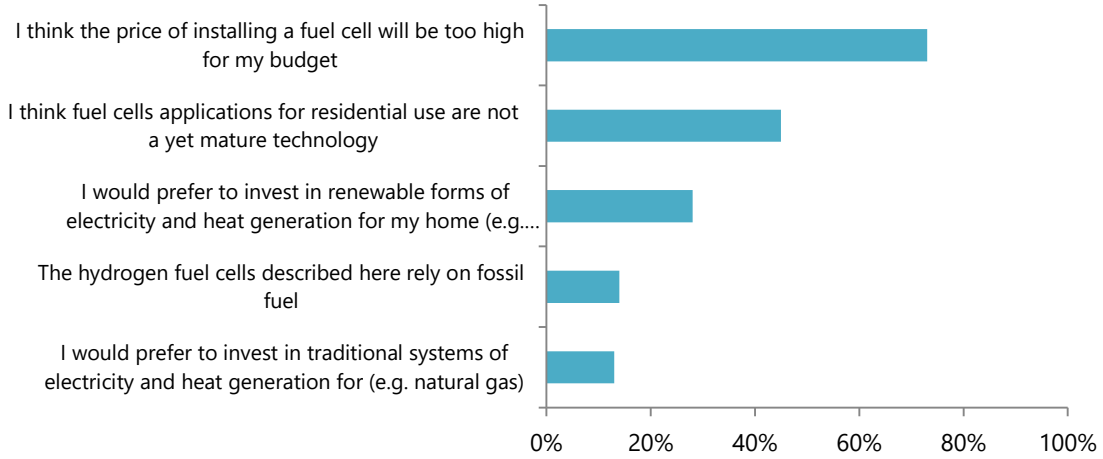
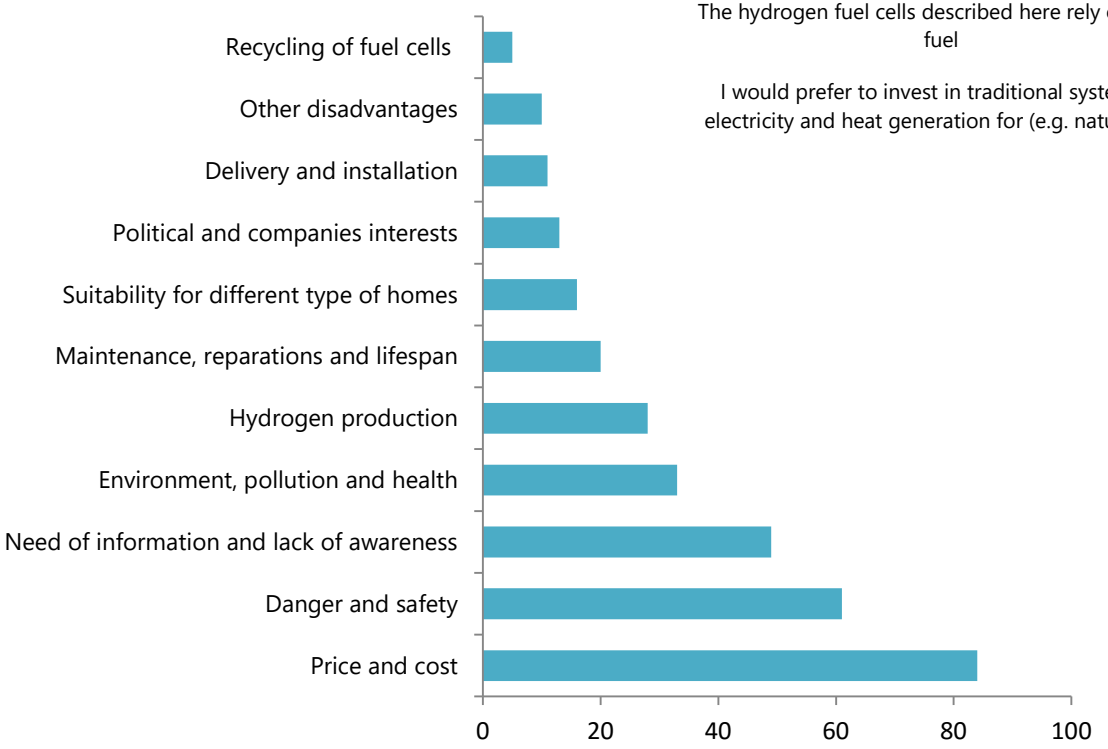


Figure. *% of respondents in the total sample that would like to have a hydrogen fuel cell system in their home*

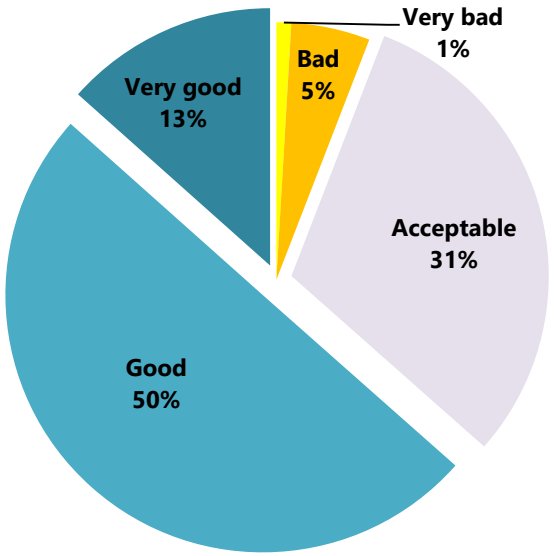


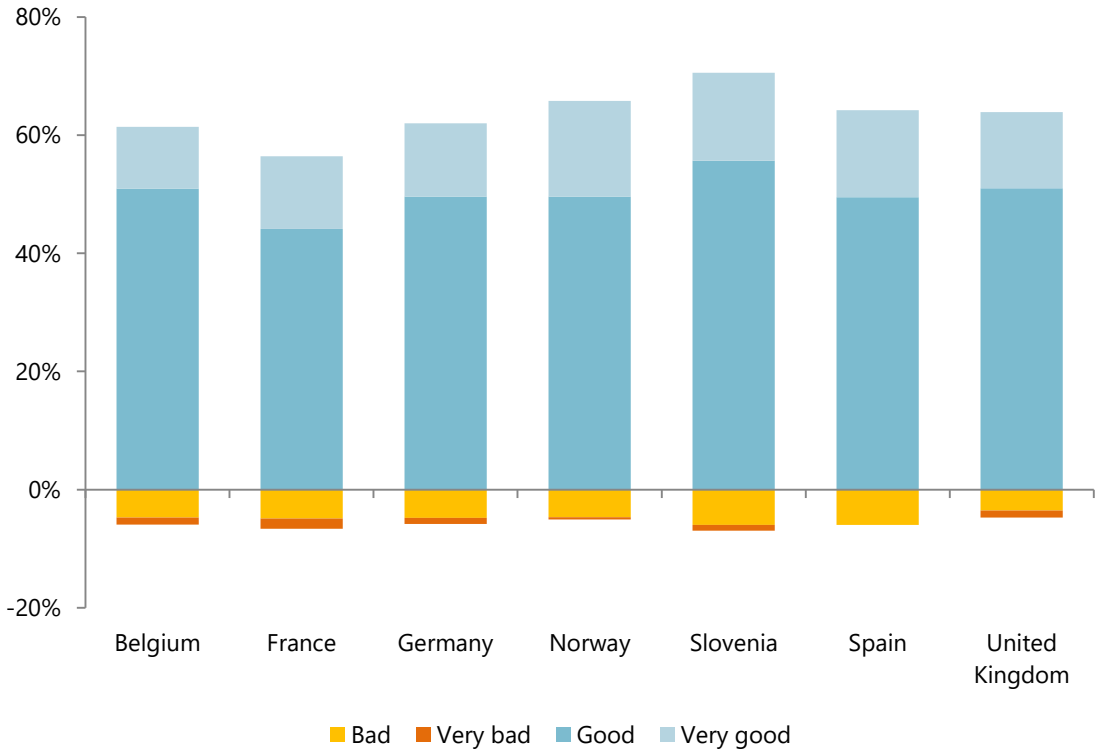
Respondents' reasons for not willing to buy a home HFC





Informed evaluation/ global attitude of HFCEV





Acceptance of HFCEVs

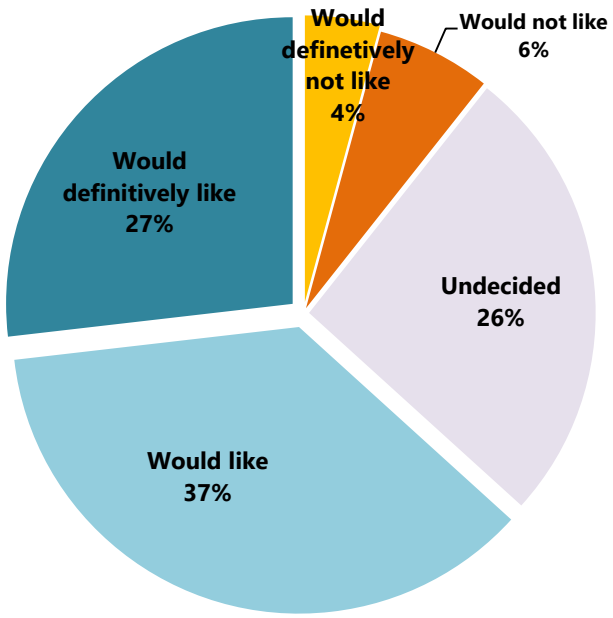
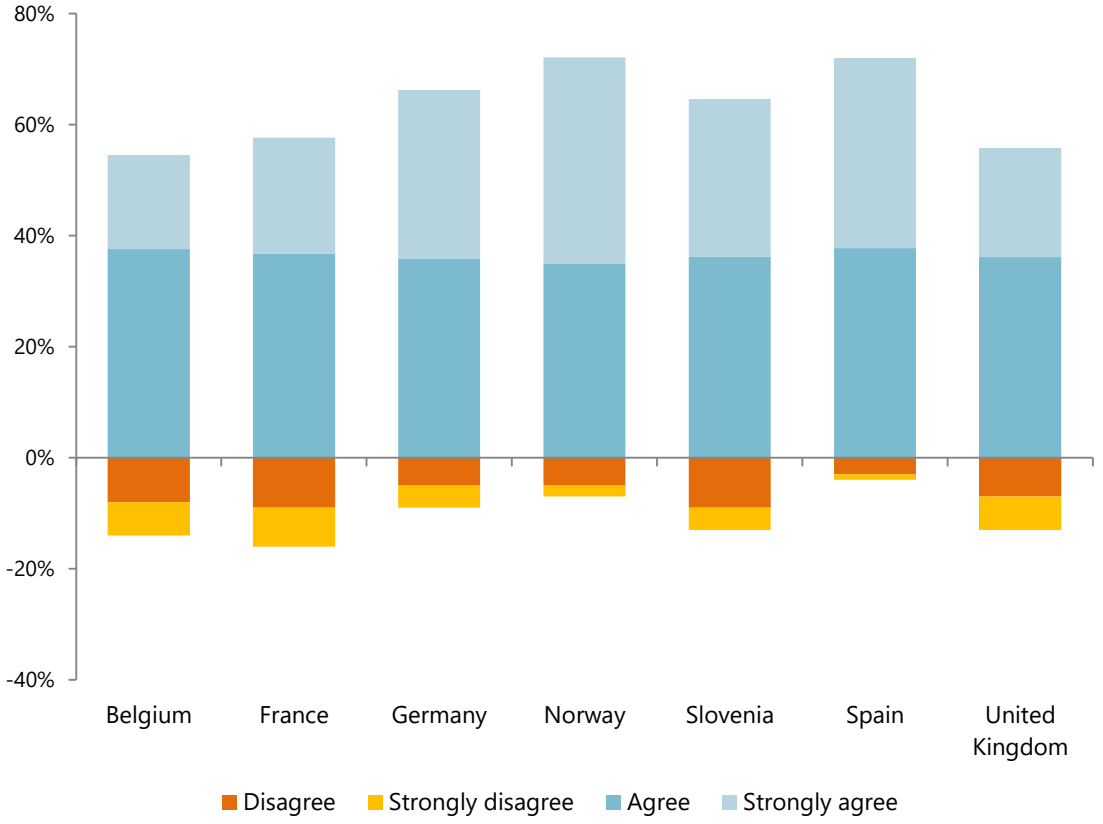
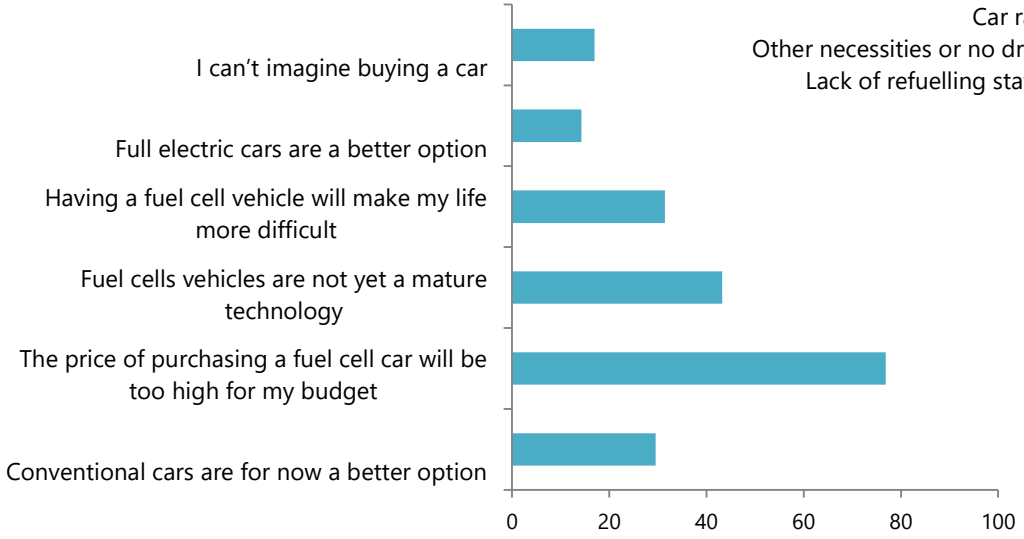
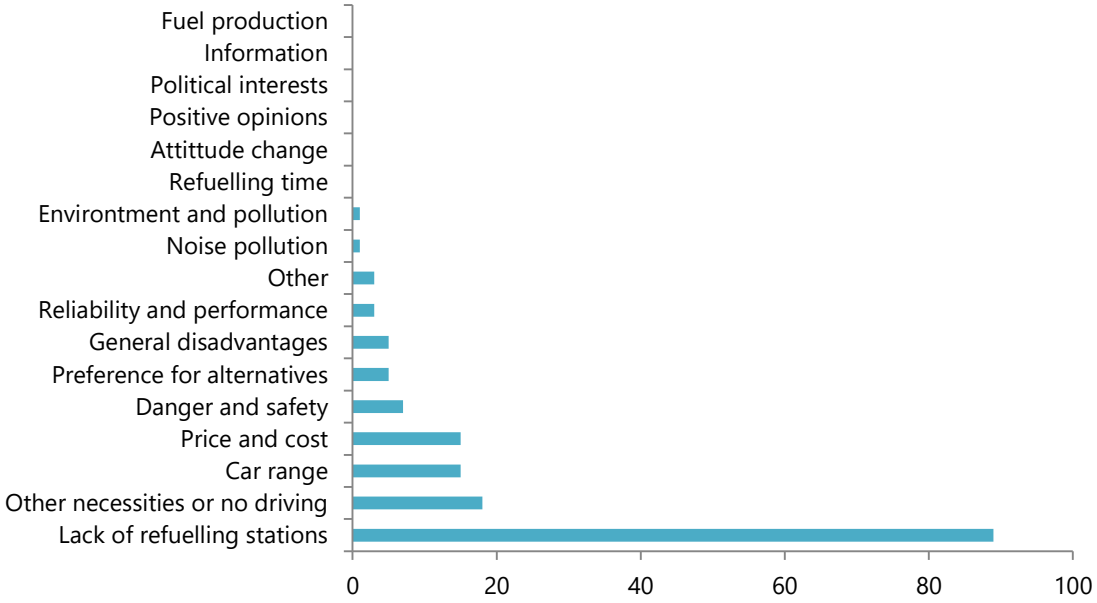


Figure. *Acceptance of HFCEVs (% of respondents that would like to have a HFCEV, all the countries)*



Respondents' reasons for not willing to buy a home HFC



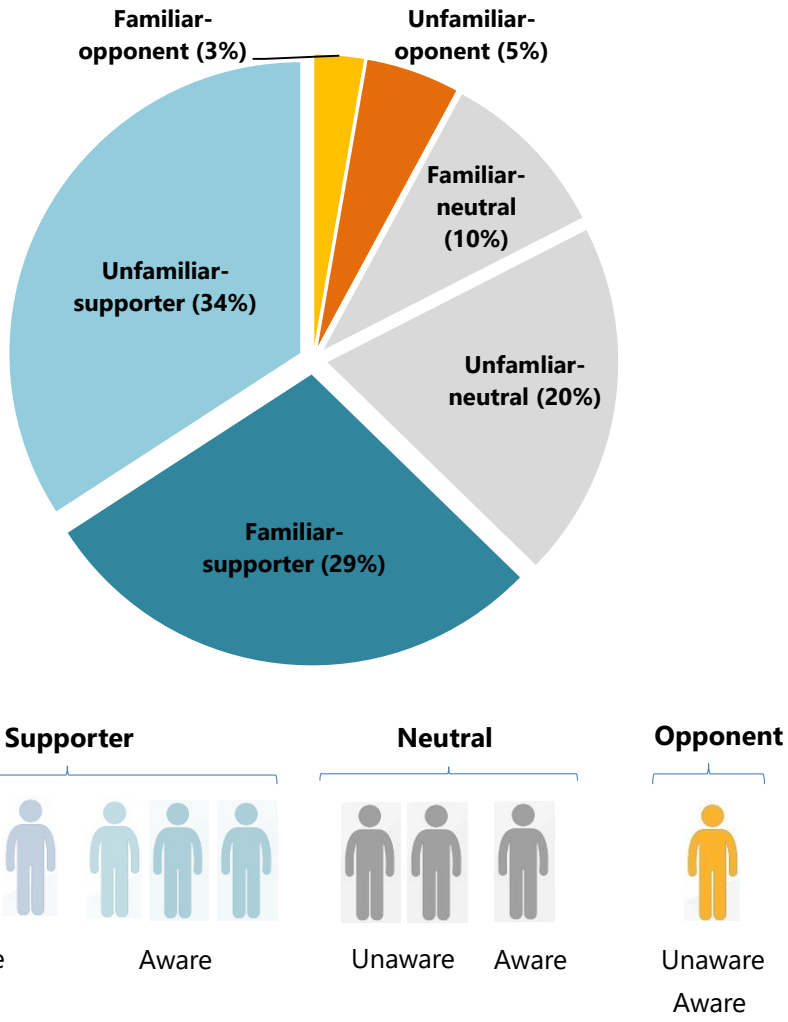


Differences across countries in the main studied dimensions

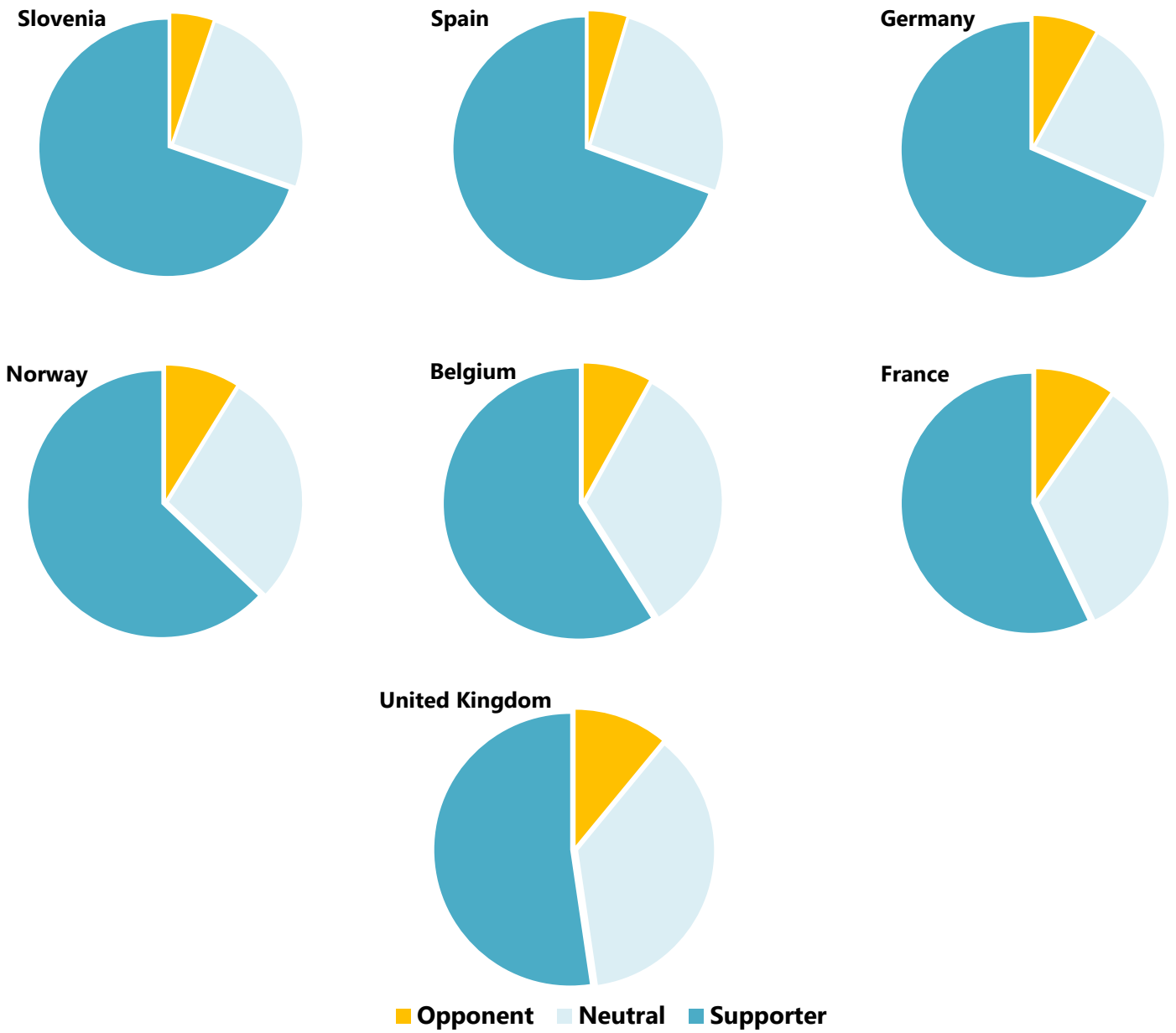
	Strength of the difference (eta)
Awareness of HFCs	0.12 (Cramer's V)*
Initial evaluation of HFCs	0.11*
Residential HFC	
Informed evaluation of home HFC	0.14*
Acceptance (willingness to adopt)	0.15*
Support to public funding of residential HFC	0.20*
HFC vehicles	
Informed evaluation of HFEV	0.07*
Acceptance (willingness to adopt)	0.19*
Support of HFCE buses in cities	0.11*
HFC Infrastructures	
Acceptance of HFC power plant	0.16*
Acceptance of H2 refuelling stations	0.05

** the difference is significant (p value <0.05; Brown-Forsythe test)*

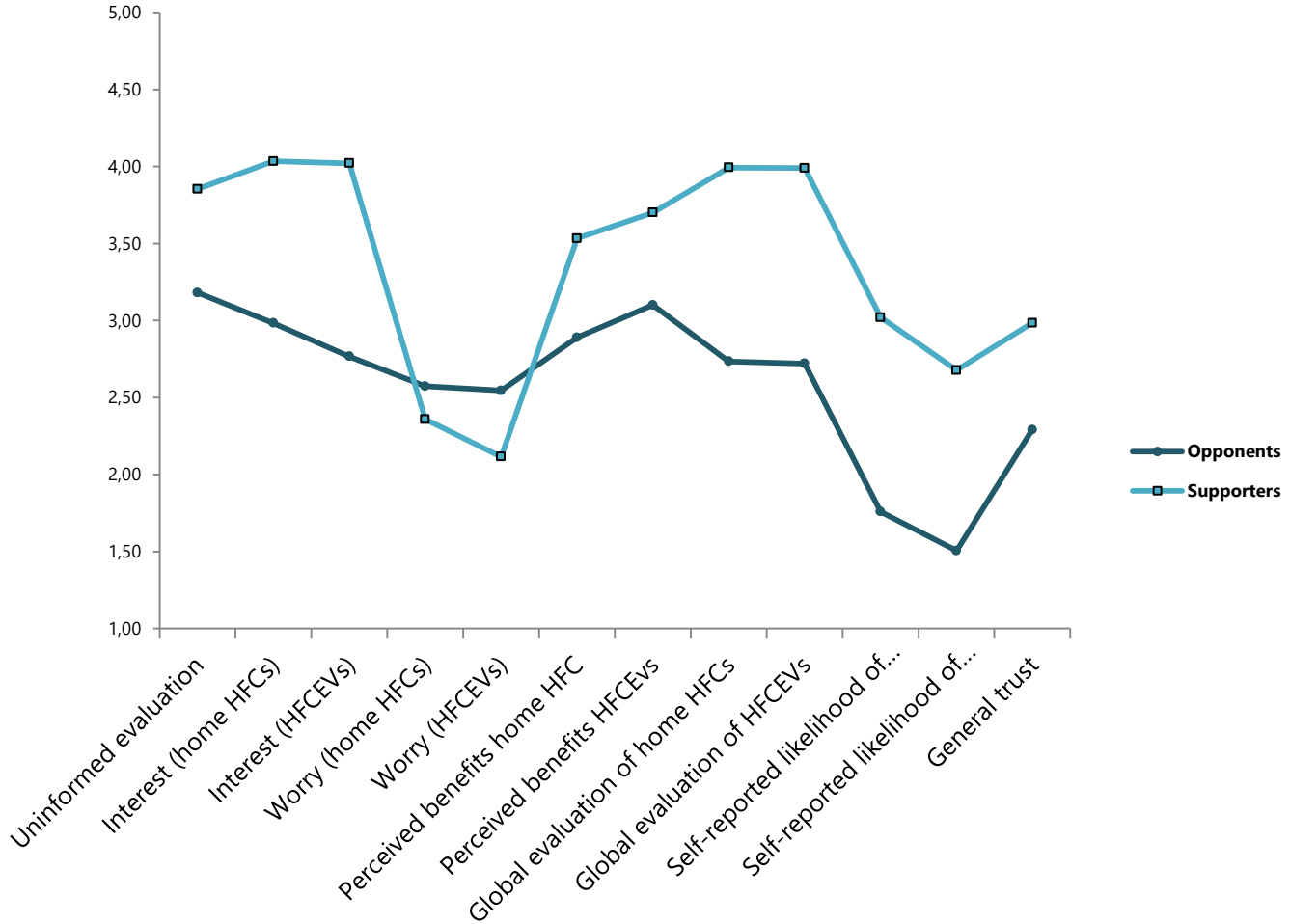
Supporters and opponents (all countries)



Supporters and opponents per country



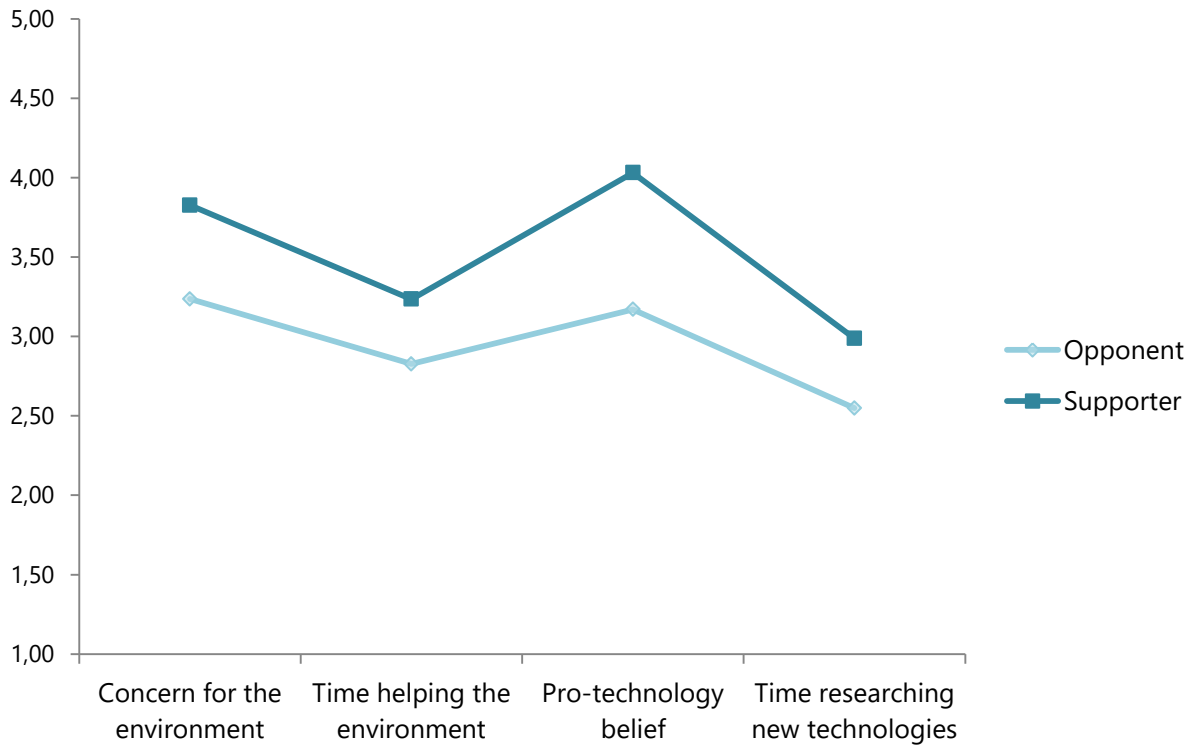
Differences between supporters and opponents in other dependent variables



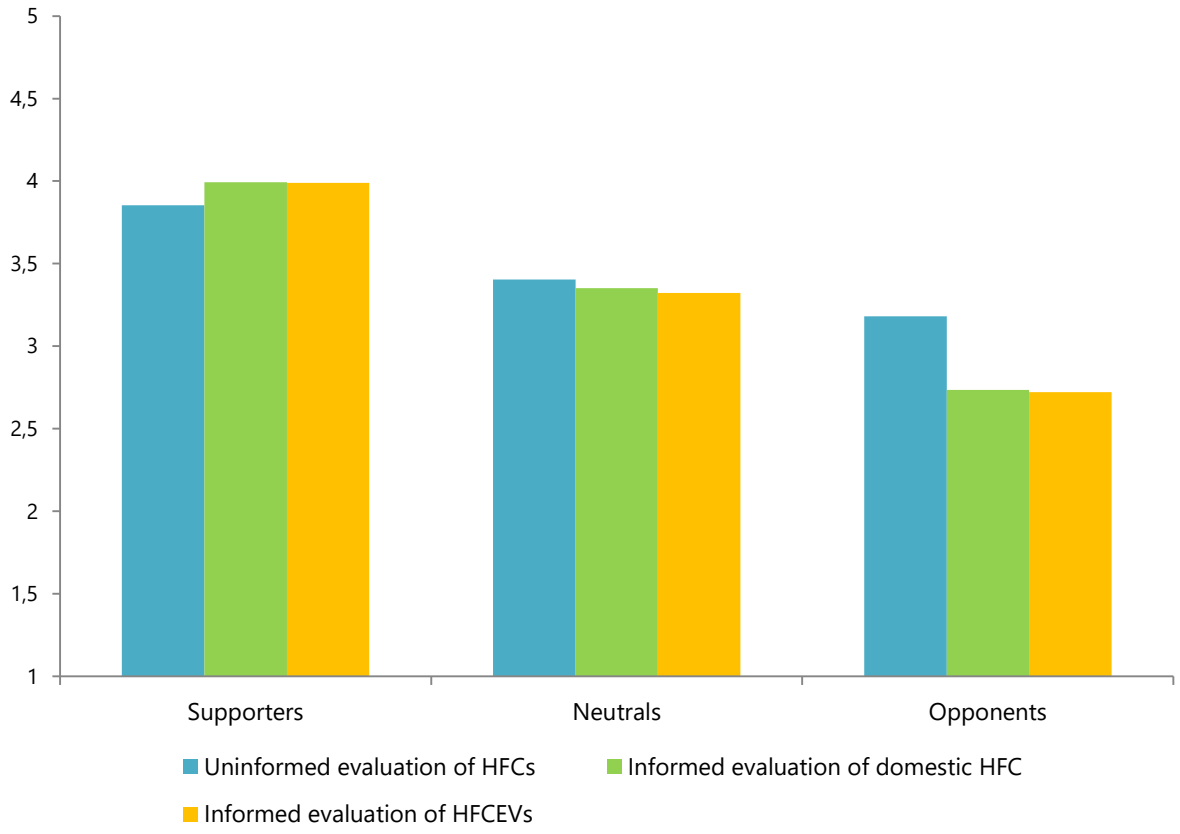
Sociodemographic differences between supporters and opponents

		Opponents (%)	Supporters (%)
Global (n=)			
Gender	Male	47	52
	Female	53	48
	Total	100%	100%
Age	18-34	19	28
	35-44	17	19
	45-54	18	18
	55+	46	36
	Total	100%	100%
Educational level	Non-university degree	78	75
	University degree	22	25
	Total	100%	100%
Size of residence	<20.000	48	44
	20.000 – 1.000.000	41	45
	>1.000.000	11	11
	Total	100%	100%
Status/income	Finding it difficult to live with current income	31	30
	Coping on current income	42	46
	Living comfortably	27	24
	Total	100%	100%

Differences between supporters and opponents in prior attitudes and habits



Change from uninformed evaluation to informed evaluation for supporters, neutrals and opponents (mean, seven countries)



CONCLUSSION

- Less than half of the population in the seven countries is aware of the existence of hydrogen and fuel cell technologies in the context of energy production.
- Public awareness is significantly lower for residential applications and higher for hydrogen fuel cell vehicles.
- The level of familiarity with both applications is low (less than 10% of respondents consider themselves familiar)
- The majority of the population in the seven studied countries have a positive initial attitude towards HFC technologies. The label associated to hydrogen and fuel cells seems to invoke positive feelings and thoughts among respondents.
- After processing relevant information, respondents in the seven countries are likely to accept and support the adoption of residential fuel cells and HFCEVs.
- Overall, the seven studied populations were similar in their attitudes towards HFC technologies. However, the results point to relevant differences in awareness and acceptance of HFC applications.

HYACINTH

Hydrogen Acceptance in the Transition Phase

Support & Coordinated Action

http://hyacinthproject.eu/

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