Informed Public Attitudes towards Fusion Energy in Europe

Report

Socio-Economic Studies on Fusion

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Important disclaimer

Contents

Introduction

Assessing public attitudes towards fusion energy and research is a relevant issue for the fusion community and the broader energy policy community in Europe. How familiar are the European citizens with fusion energy? How do the general public in Europe perceive the potential benefits and costs of fusion? Do they accept and support further fusion developments in their country and the European Union? These and other related questions are the objective of this research report developed in the context of the SES Programme within EUROFUSION.

Social research within SES has previously addressed these topics in a number of qualitative and survey studies (see for instance Prades et al., 2009; the SCK•CEN Barometer, 2015 or the study by Sarah Medley, Christopher Jones and Sophie Yardley (2017). However, cross-country in-depth survey research into public attitudes and acceptance of nuclear fusion in Europe was lacking. This report is the result of a research carried out in 2018 to collect cross-national data on public attitudes towards fusion energy and research. The basis for this research were stablished in the preparatory work carried out within SES in the period 2014-17 which pointed out some possible research paths that could be followed in the next years.

Survey research has been widely used to assess public attitudes on emerging technologies (Gupta, Fischer, and Frewer 2012). A key issue when assessing public acceptance of energy technologies is the fact that, often, they are not well known yet, which produces the problem of "pseudo opinions" and "non- attitudes"(De Best-Waldhober & Daamen, 2006). For instance, it is common that despite the fact that survey participants know little about some technology (like CCS, GM food or hydrogen), they express an opinion. Consequently, their views tend to be unstable and very sensitive to contextual change. Given the public's limited awareness and lack of knowledge about fusion (Prades et al, 2008), this is an essential methodological challenge that has to be taken into account in researching public attitudes towards fusion energy.

Research objectives

The specific objective of this research was to develop and implement a cross-sectional survey with members of the public to gather data on current public attitudes towards fusion energy and research in Europe. The specific objectives of the study were:

1. To estimate levels of public awareness, familiarity, perception of benefits and costs, global attitude, acceptance, support and related attitudinal dimensions (affect, norms, trust) regarding fusion energy
2. To identify key individual, attitudinal, socio-demographic and contextual determinants of public attitudes and acceptance of fusion energy and research;
3. To examine the individuals' attitudes after having received and evaluated expert information on the consequences of fusion energy
4. To report on cross-country comparisons in public awareness, attitudes towards and acceptance of fusion;

Overview of the study

Design

A nationally representative, self-administered cross-sectional survey was conducted in 21 European countries to gain insight into the public attitudes towards fusion research and fusion energy. Our research design entailed the development of a specific questionnaire and the data collection via online panels in several European countries.

Questionnaire

The design of the questionnaire was based on the technology acceptance model (Huijts, Molin, and Steg 2012), an analytical psychosocial framework explaining public acceptance of energy technologies, previous studies on public acceptance of energy technologies (Gupta et al., 2012), and the Information Chocie Questionnaire (De Best-Waldhober & Daamen, 2006). Specific questions and items were derived from previous studies, when possible, in order to ensure the validity and reliability of the measures. Other items were specifically developed for this questionnaire in order to measure specific dimensions related to public attitudes towards fusion energy.

Structure

The questionnaire combined the presentation of information with items measuring the various studied dimensions. After an introduction to the study, the first questions measured a number of prior attitudes (problem perception, prior knowledge, attitude towards nuclear energy, attitudes towards science, etc.) that might influence acceptance of fusion energy.

After this, respondents were provided with very brief information about fusion energy and the objectives of the study and were asked about their level of *awareness* and *familiarity* about fusion. An experimental manipulation was conducted in this section. A small sample of participants read a text emphasizing the words "*nuclear* fusion" instead of "fusion energy". This was aimed at examining the effect of the nuclear brand on the uninformed evaluation of fusion.

After this set of questions, background neutral information on fusion was provided to the whole sample of participants (around 300 words). Then, all participants went through section B, including questions measuring *initial evaluation* of fusion energy, *feelings* and *beliefs*, and *epistemic trust*.

After this section, an exercise consisting on an evaluation of the various consequences of fusion energy was conducted. We provided participants with expert information about six potential consequences of the development of fusion energy. To stimulate information processing and to help respondents reach a more stable attitude, they were requested to give a quantitative evaluation of each consequence. An experimental manipulation was conducted in this section. A small sample of participants read, instead of the potential consequences of the development of fusion energy, a text with a short description of the viewpoints of the key relevant actors (government, industry, NGOs).

After this, participants answered questions measuring *global evaluation of fusion energy*, *acceptance*, *support* and *preference for alternative options*. Finally, all participants were asked about their level of trust in fusion research decision makers.

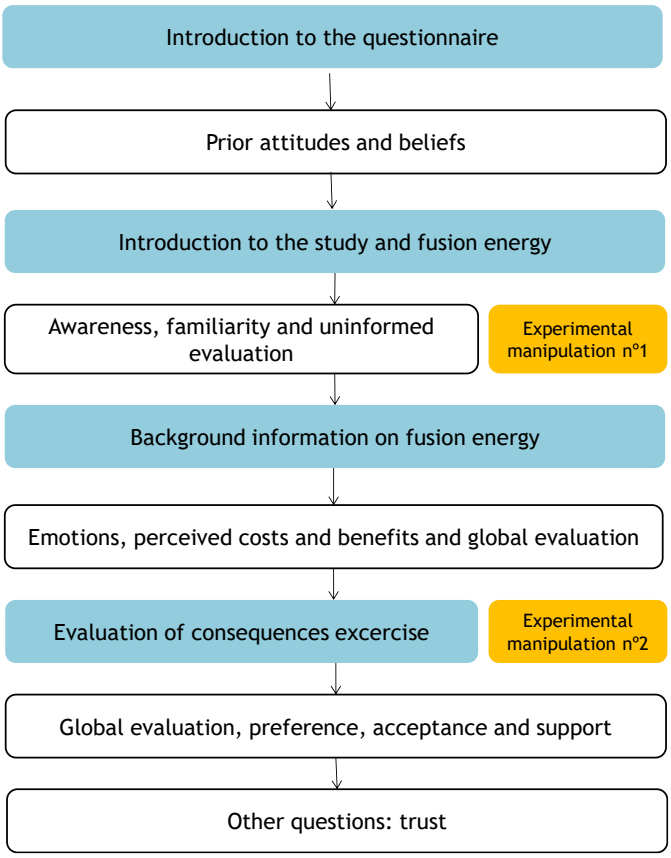


Figure 1. *Design of the questionnaire*

Variables

Some of the variables included in the questionnaire were derived from the dimensions shown in Table 1. For a full version of the questionnaire, see Annex 3.

Table 1. *Dimensions included in the questionnaire*

Dimension	Definition	Studies
Awareness	Degree to which individuals are conscious, know, have heard of specific technologies or developments	Zimmer and Welke (2012)
Familiarity and experience	Subjective knowledge and familiarity with the technology and direct personal contact with the technology	DOE survey Zimmer and Welke (2012)
Uninformed evaluation	Personal evaluation of the technology before being informed about potential consequences	De Best-Waldhober et al., 2008
Perception of benefits and costs	Beliefs about the potential benefits and costs of fusion energy in a number of dimensions (from economic to environmental or social)	Visschers and Siegrist, 2008

Affect	Degree in which the technology generates various emotions in participants	Midden and Huijts, 2009
Evaluation of consequences	Degree in which individuals consider potential consequences an advantage or a disadvantage	De Best-Waldhober et al., 2008
Overall 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	Achterberg, 2014
Preference for alternatives	Evaluation of different energy alternatives Preference for investment in different options	
Trust	Trust in industry and governments to make good decisions and to succeed	Midden and Huijts, 2009
Other variables	Epistemic trust NEP Attitudes towards new Energy technologies Attitudes towards nuclear energy Sociodemographics	Huijts (2012) Axsen et al. (2012); Whitmarsh & O'Neill, (2010) Sjoberg, L., & Herber, M. W. (2008).

Provision of information

The provision of information was a key element in the building of the questionnaire. We provided to respondents three pieces of information:

- Information introducing the main characteristics of fusion energy. This information was provided after the introduction of the study and the first questions measuring awareness and familiarity with fusion energy. This background information was based on a selection of information materials from websites and newspapers information and tried to represent actual information that a citizen could acquire through the media, factsheets and websites.
- Information on the potential consequences of fusion (including costs, risks and benefits). The information on the potential consequences of fusion energy was produced together with experts from Eurofusion to guarantee that the information provided is valid and balanced. Three fusion experts checked the final document with all information (background information and information about the consequences). Participants were asked to evaluate the importance of each of the consequences.
- Information on the viewpoints of stakeholders. Information on how the various stakeholder groups perceive fusion energy. This information was provided only to 10% of participants in the survey with the aim of evaluating the effects of this information compared to the evaluation on the consequences.

Sample

The total research sample consisted 19970 European citizens, ages 16 and older. Samples of the general population- citizens aged 16 and older- were recruited from large national panels in the studied countries (see table 1) in November 2018. The use of panels allowed achieving a representative sample of the general population in terms of sex and age. Other quota (region and education) were taken into account as soft quota (see annex 1 for more details on the sample at the country level).

Table 2. *Characteristics of the sample*

Id	Country		Sample (aprox.)	Date of fieldwork
1	Austria	AT	950	Nov-2018
2	Belgium	BE	950	Nov-2018
3	Bulgaria	BG	950	Nov-2018
4	Czech Republic	CZ	950	Nov-2018
5	Denmark	DK	950	Nov-2018
6	Finland	FI	950	Nov-2018
7	France	FR	950	Nov-2018
8	Germany	DE	950	Nov-2018
9	Greece	GR	950	Nov-2018
10	Italy	IT	950	Nov-2018
11	Latvia	LV	950	Nov-2018
12	Lithuania	LT	950	Nov-2018
13	The Netherlands	NL	950	Nov-2018
14	Poland	PL	950	Nov-2018
15	Portugal	PT	950	Nov-2018
16	Romania	RO	950	Nov-2018
17	Slovenia	SI	950	Nov-2018
18	Spain	ES	950	Nov-2018
19	Sweden	SE	950	Nov-2018
20	Ukraine	UKR	950	Nov-2018
21	United Kingdom	UK	950	Nov-2018

Results

Awareness and personal relevance

On average, five out of ten respondents (48%) reported having heard about fusion energy before participating in the study. Awareness of fusion energy ranged from countries like Czech Republic, France or Germany where around three out of ten respondents reported having heard about fusion to countries like Sweden, Poland, Romania or Ukraine, where more than five out of 10 respondents reported having heard about fusion[1]. Among those who had heard of fusion energy, the majority of them considered themselves only slightly familiar with fusion (they have heard about fusion power, read an article or watched a television feature about the technology). Only 7% of respondents considered themselves "familiar" with fusion energy, meaning that they have some experience with fusion power, researched the subject for school, work, or personal interest.

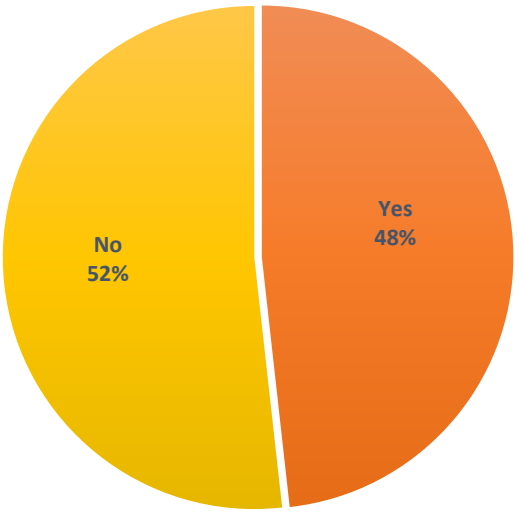


Figure 2. *Have heard of fusion (in %, total sample, n=19970)*

Altogether, 36% of respondents in the total sample considered fusion energy as personally "important" or "very important" and 40% as "somewhat important". Personal relevance associated with fusion energy varied from countries like Latvia, where only 20% of respondents considered fusion to be important or very important, to countries like Romania or Portugal, where almost 50% of respondent considered fusion important or very important (see figure 3).

[1] Results for awareness in some countries might be subject to acquiescence response bias as well as sampling bias.

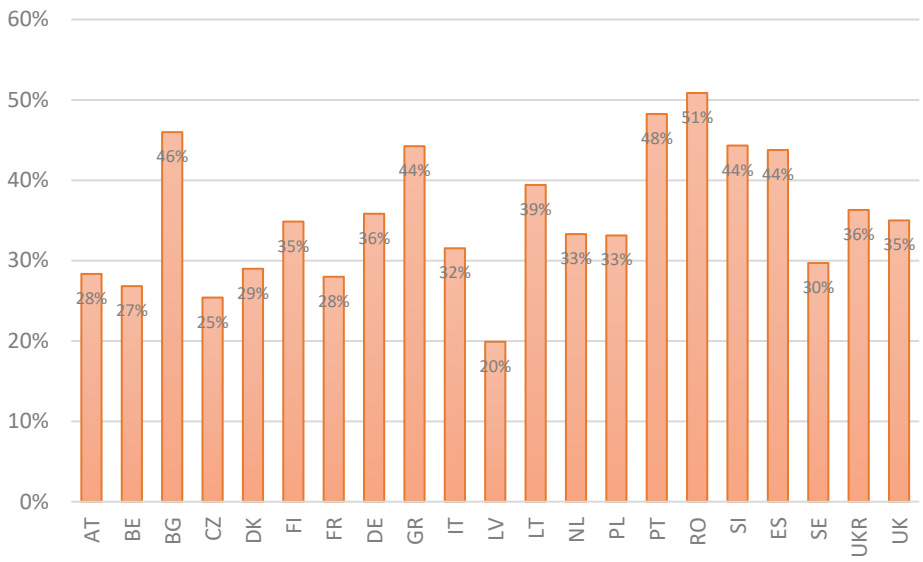


Figure 3. *Percentage of respondents that consider fusion energy personally "important" or "very important" (in %, by country)*

Initial evaluation and affects

After having read general information about fusion energy, we asked respondents to rate fusion as an energy option in a scale from 1-very poor to 5-very good option. This initial evaluation can be taken as a measure of how individuals, in general, evaluate fusion energy after having been informed about the main characteristics and challenges of fusion.

Generally, respondents reported a positive reaction to fusion energy. As shown in Figure 4, on average, respondents rated fusion energy as a fair option (the average evaluation for the whole sample was 3.48 in a 1 to 5 scale; and 45% of respondents rated fusion as fair). Considering the 21 countries, more than 40% of respondents rated fusion as a good or very good option, whilst less than 15% of consider fusion a bad or very bad option. The initial evaluation of fusion energy ranged from 2.98 in Austria to 3.88 in Romania.

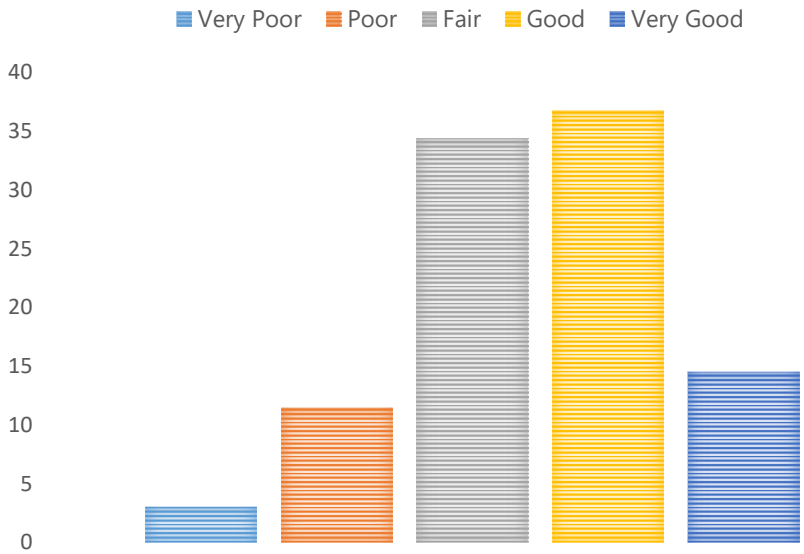


Figure 4. *Initial evaluation of fusion energy (in %, total sample, n=19970)*

Affective associations with fusion energy were generally neutral to positive among our studied population. In a scale from 1 to 5, we asked respondents to consider to what extent did fusion energy evoke various feelings in them (Worry or Tranquility; Aversion or Enthusiasm; Disinterest or Interest; Pessimism or Optimism). On average, respondents reported neutral feelings of worry-tranquility (3.00), slightly more enthusiasm than aversion (3.38), quite more interest than disinterest (3.71) and slightly more optimism than pessimism (3.49). Countries where respondents reported higher levels of interest about fusion were Romania (3.99) and Bulgaria (3.96), while the country were respondents reported more worry was Austria (2.63).

Beliefs about the benefits and negatives of fusion energy

Generally, fusion was perceived as having neutral to positive impacts on the energy system, the environment, public health and society. An important segment of respondents (around 40%) provided a neutral or undecided response when asked about their beliefs regarding fusion energy, meaning that they are unaware or unsure about the potential impacts of fusion. But generally, respondents hold positive beliefs about fusion energy: 48% believed that it will be technologically viable; 52% believed that it will have a positive impact on the energy system; and 45% believed that fusion will have positive impacts on society.

	-2	-1	0	1	2	
Technologically unviable	4%	10%	36%	32%	4%	**Technologically viable**
Cost too much develop	7%	16%	40%	25%	9%	**Have acceptable costs**
Contribute very negatively to the energy system	4%	8%	34%	34%	17%	**Contribute very positively to the energy system**
Very negative effect on the environment	7%	11%	37%	29%	14%	**Very positive effect on the environment**
Be very dangerous for human health	8%	13%	40%	26%	11%	**Be safe for human health**
Be economically not competitive	5%	12%	39%	28%	14%	**Be competitive**
Very negative social impacts	4%	9%	42%	31%	12%	**Very positive social impacts**

Figure 5. *Assessment of fusion energy based on pairs of benefits/costs (in %, scale from -2 to 2, total sample, n=19970)*

Overall, respondents were more optimistic about the contribution of fusion to the energy system (in terms of security of supply, diversification, etc.) and its technological viability, and less optimistic about its development costs and its potential safety risks. On average, all the criteria considered were rated as neutral to positive (between 3.14 and 3.55 in a 1 to 5 scale).

In some countries respondents were more optimistic about the characteristics and potential effects of fusion, like Bulgaria (average of 3.6), Romania (3.5) or Finland (3.5). Respondents were less optimistic about fusion energy in Austria (2.9) or Germany (3.0).

Evaluation of consequences of developing and implementing fusion energy

Table 3 below provides the average evaluation of each of the consequences of developing fusion (as provided to participants in the questionnaire), as well as the correlation between the evaluation of a consequence and the overall evaluation of fusion energy.

All these consequences were evaluated as moderate or large advantages. The consequences evaluated as more positive were the "contribution of fusion to climate change" and the "(less) dependence on scarce resources". The consequences evaluated as less positive were the "(long) time horizon to build the technology" and the "generation of radioactive waste". Interestingly, both consequences generate a larger amount of polarization among respondents, as shown by the SD.

The "single" correlations between the evaluations of the consequences and the overall evaluation of fusion energy were medium to strong. The consequences that correlated highest were "price of electricity generated" (r = .56) and "generation of radioactive waste" (r = .54) indicating that these consequences had the most influence on the overall evaluation of fusion. The consequence that correlated lowest with the overall evaluation was the "(long) time horizon to build the technology" (r = .36). This indicates that this consequence had very little influence on the overall evaluation. This consequences was evaluated as less positive than other consequences, but did not influence the overall rating of the option.

Consequence	Average evaluation (1 to 5)	Correlation (-1 to 1)	Average overall evaluation of fusion
It will take years to build the technology	3,10	,366	3.50
Less dependence on scarce resources.	3,88	,526	
New installations are needed.	3,45	,504	
Radioactive waste	3,12	,545	
Contribution to climate change.	3,90	,513	
Price of electricity	3,64	,556	

Table 3. *Evaluation of the consequences of developing fusion and correlation with overall evaluation ((mean, n=19970*

Overall evaluation of fusion

Respondents evaluated fusion energy above the midpoint of the scale, grading it with a 3.50 in a 1 to 5 scale. This indicates that respondents considered that nuclear fusion is a fair option for energy generation. Altogether, 54% of respondents rated fusion energy as a good or very good option, 31% as a fair option and 15% as a poor or very poor option. When comparing among countries, the evaluation of fusion ranged from 2.97 in Austria to 3.86 in Romania.

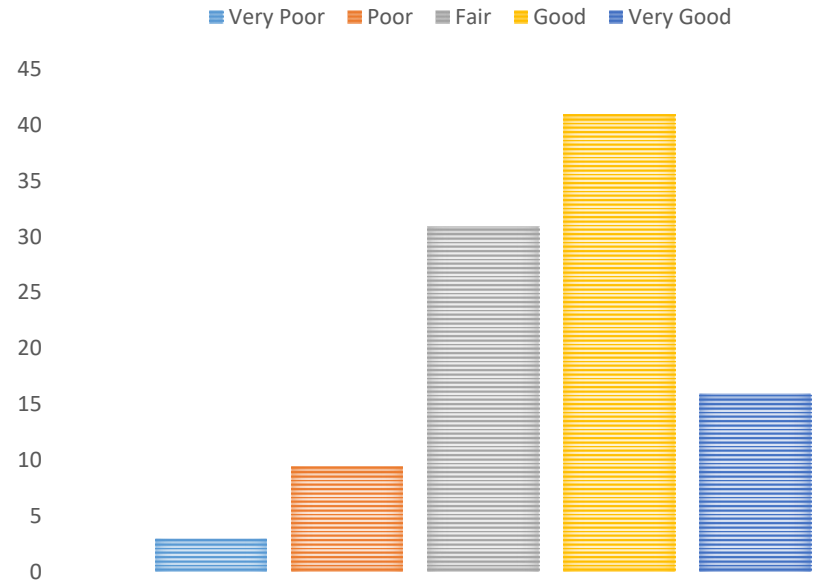


Figure 5. *Overall evaluation of fusion energy (in %, total sample, n=19970)*

The evaluation of fusion also varied according to socio-demographics. Overall evaluation of fusion was significantly more positive among male respondents relative to female respondents, those living very comfortably on current income relative to those finding it very difficult to live on current income, those who positioned themselves as right-wing relative to those who positioned themselves as left-wing. There were non-relevant differences in overall evaluation of fusion for age, educational level or size of residence (Table below).

Variable	Category	Overall evaluation (mean)
Sex	Female	3,3
	Male	3,7
Age	18-29	3,5
	30-39	3,5
	40-49	3,5
	50-64	3,5
	65 and above	3,5
Education	None completed	3,2
	Degree level or higher	3,5
	Up to GCSEs/O level or equivalent	3,3
	Up to A levels or equivalent	3,5
	Other qualifications/apprenticeships	3,4
	Undergraduate (not a Bachelor's degree)	3,5

	Graduate (Bachelor's degree)	3,6
	Postgraduate (master, doctorate, PHD etc.)	3,6
Size of place of residence	Less than 1,000 inhabitants (village)	3,4
	Between 1,000 and 20,000 (town)	3,4
	Between 20,000 and 100,000 (town, small city)	3,5
	Between 100,000 and 300,000 (city)	3,6
	Between 300,000 and 1 million (medium sized	3,6
	More than 1 million inhabitants (big city)	3,5
Income	Finding it very difficult to live on current income	3,2
	Finding it difficult to live on current income	3,4
	Coping on current income	3,5
	Living comfortably on current income	3,6
	Living very comfortably on current income	3,7
Political orientation	1 = extremely left	3,3
	2	3,4
	3	3,4
	4	3,4
	5	3,7
	6	3,8
	7 = extremely right	3,7

Table 4. *Overall evaluation of fusion according to socio-demographics (mean, n=19970)*

Attitude towards fusion

In order to categorize the attitude towards fusion energy, we provided respondents with three statements about nuclear fusion and asked them to select which best represented their view about fusion. As shown in the figure below, a majority of respondents (47%) reported a neutral or ambivalent position towards fusion energy. They considered that "Fusion might or might not be a viable source of electricity, so we should keep research on fusion energy but prioritize other sources of energy". 43% of respondents reported a positive attitude towards fusion and considered that "fusion power might be an important source of electricity in the future, and interested countries should fund research on fusion". Finally, 10% of respondents considered that "fusion power is unnecessary and dangerous: we should reduce or cancel the nuclear fusion program and invest on other energy sources or alternative programs".

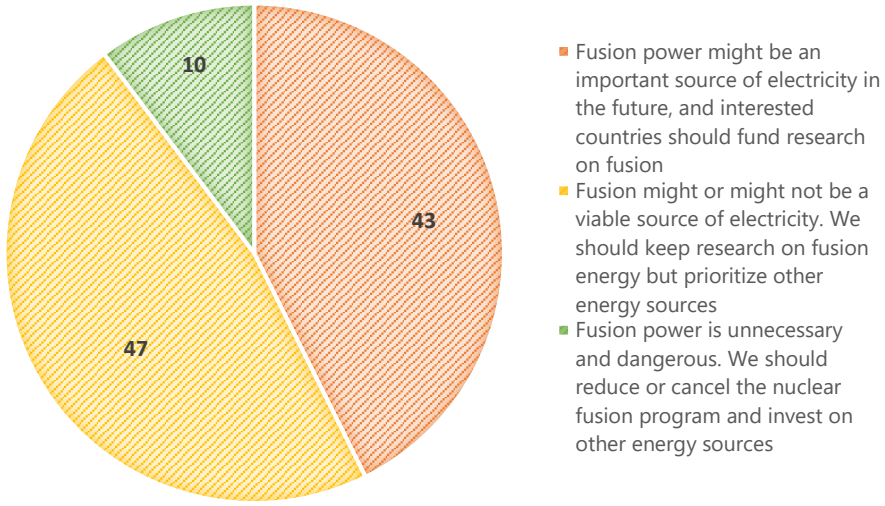


Figure 6. *Attitude towards fusion energy (in %, total sample, n=19970)*

Respondents were more positive about fusion in Romania, Bulgaria and Ukraine, where more than 55% of respondents agreed that fusion power might be an important source of electricity and research on it should be funded. The percentage of respondents with a negative attitude towards fusion energy was higher in Austria, where 25% of respondents considered that fusion power is unnecessary and dangerous.

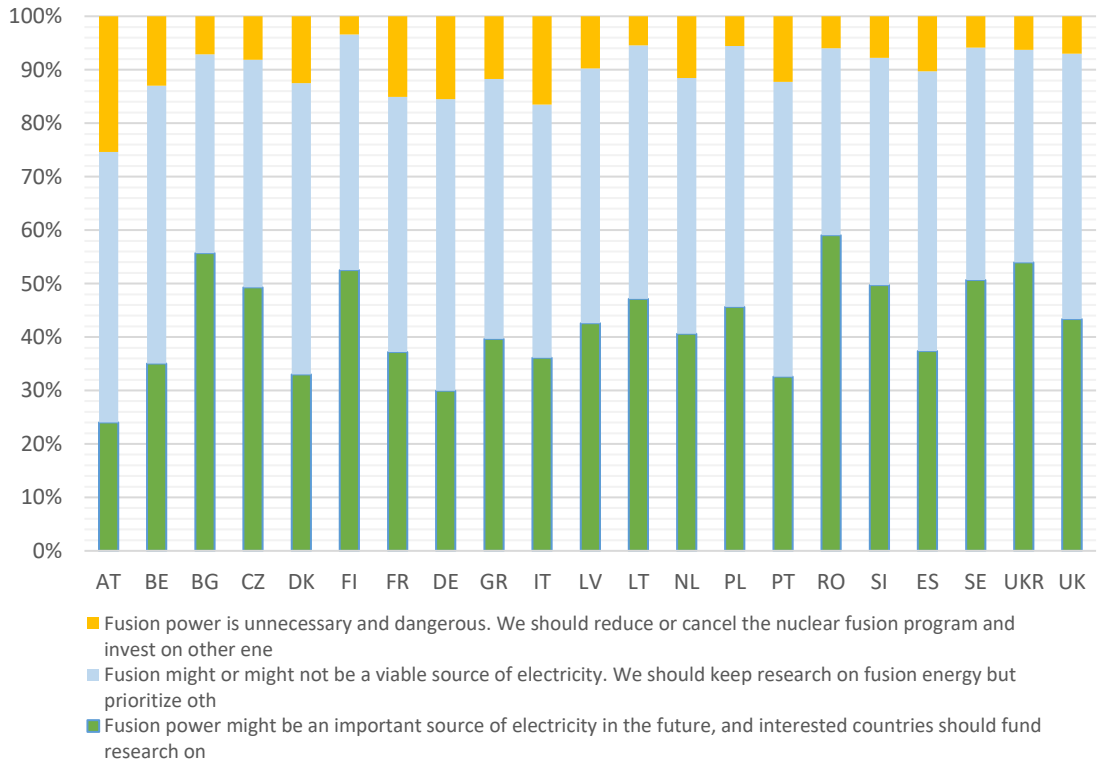


Figure 7. *Attitude towards fusion energy (in %, per country)*

Acceptance and support

Overall, the majority of respondents considered the development of fusion power acceptable: more than 65% of the studied population considered the development of fusion as "acceptable" or "totally acceptable". 24% of participants were unsure or undecided and less than 10% considered that the development of fusion is unacceptable.

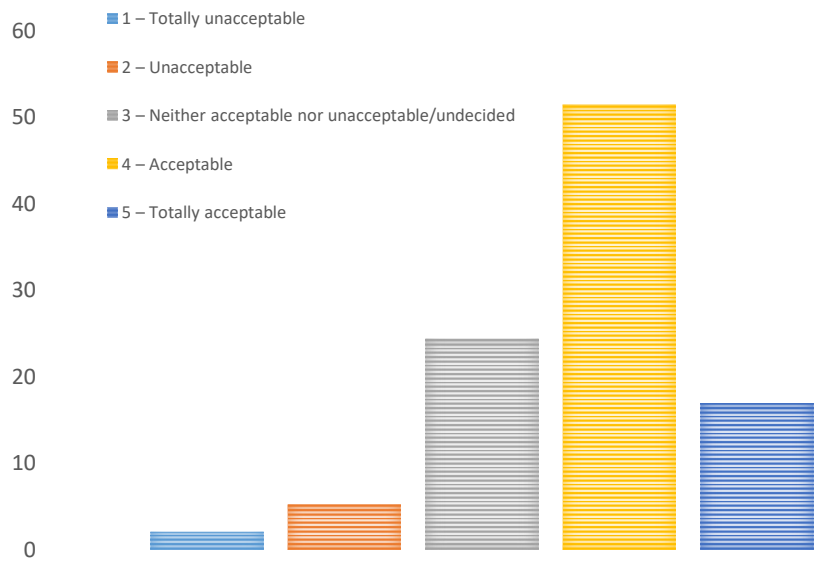


Figure 8. *Acceptance of fusion energy (in %, total sample, n=19970)*

The level of public acceptance of fusion ranged from 54% in Austria and Belgium to 80% in Romania, Ukraine, Bulgaria or Finland.

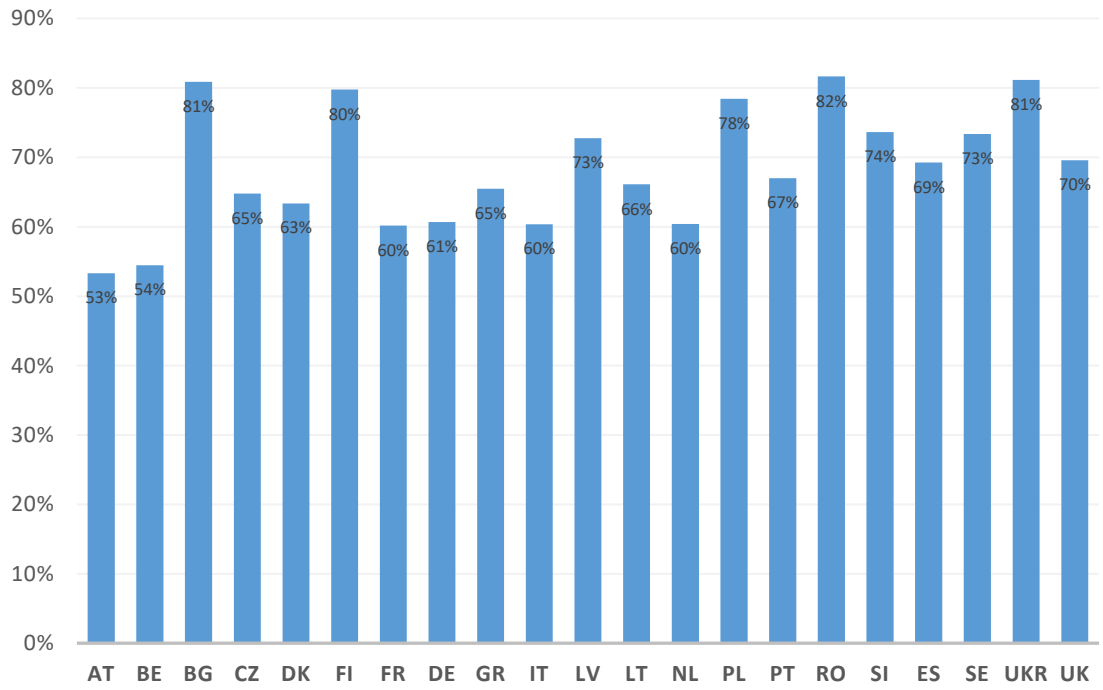


Figure 9. *Acceptance of fusion energy (per country, in % of respondents that consider fusion acceptable or totally acceptable)*

Support for public investments in the nuclear fusion research programme was also relatively high among the study population, with 52% of respondents supporting public investments on fusion in their own country and 61% supporting public investments at the EU level.

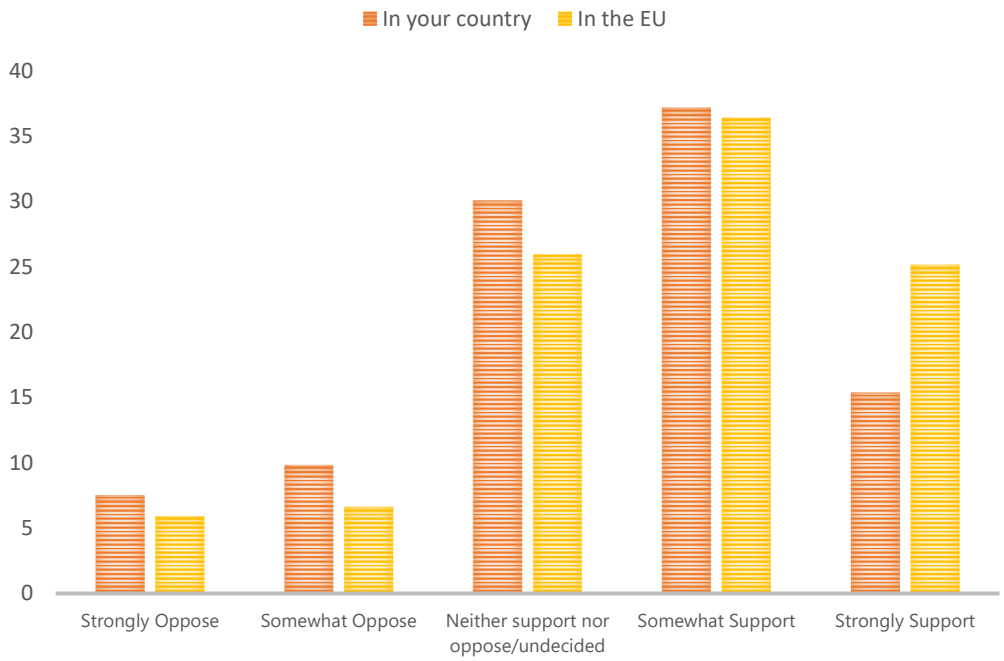


Figure 10. *Support for fusion energy research (in %, total sample, n=19970)*

Support for investments in the national level ranged from 33% in Austria to 68% in Romania. Support for investments in fusion in the EU level ranged from 38% in Austria to 77% in Bulgaria.

Attitudes towards ITER

The majority of respondents in the 21 countries was not aware of the existence of ITER: only 15% of the study population reported having heard about ITER before this study. The level of awareness about ITER ranged from 7% in Denmark to 24% in France and Romania.

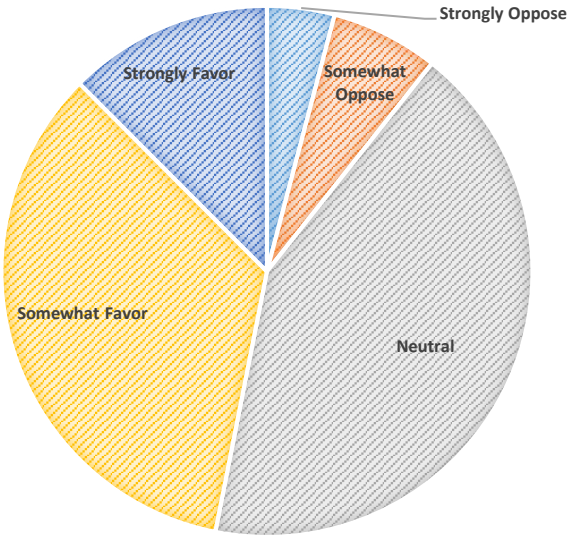


Figure 11. *Support investments in ITER (in %, total sample, n=19970)*

Regarding the investments in ITER, the majority of respondents was neutral to positive about it. Around 40% of respondents reported a neutral position about investments in ITER, whilst 34% considered themselves somewhat in favour of investments in ITER and 12% totally in favour. Support to investments in ITER ranged from 31% in Belgium to 66% in Bulgaria.

Preference for other energy technologies

In order to gauge individuals' preferences for alternative (to fusion) technologies, we first asked respondents whether we should focus in other energy technologies (renewables, energy saving and conventional technologies) instead of investing in fusion. Second, we asked them to distribute 100 units among the various energy technologies available, including fusion power.

As shown in the figure below, around 50% of respondents agreed that we should focus on renewable technologies like solar and wind instead of fusion while 37% expressed a neutral position towards this idea. Around 42% of respondents agreed that we should focus on energy efficiency and saving instead of fusion, while 40% expressed a neutral position towards this. Finally, around 15% of respondents agreed that we should focus on conventional fossil fuel technologies instead of fusion, while 32% expressed a neutral position towards this idea.

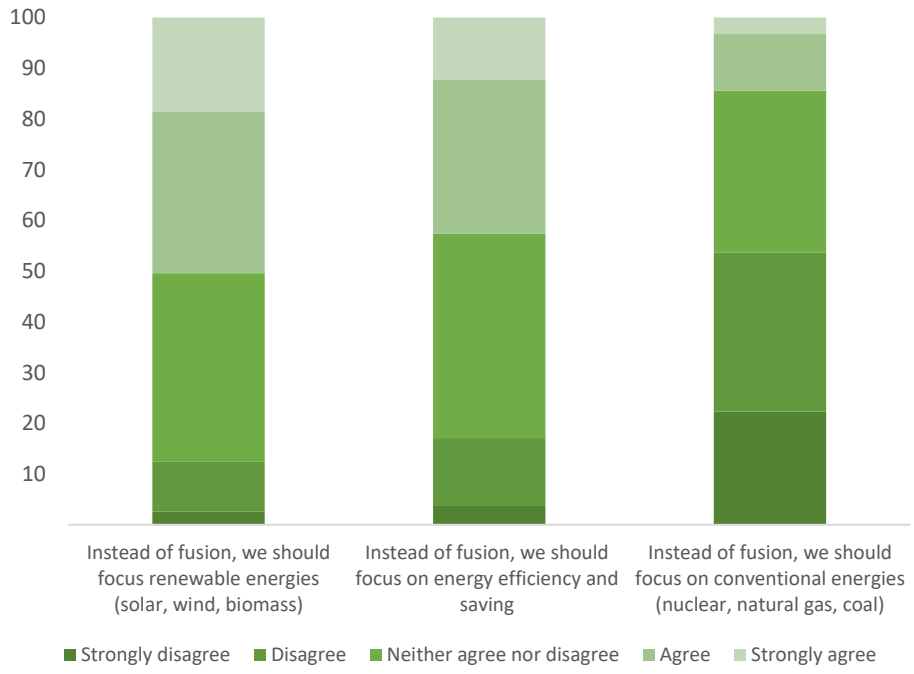


Figure 12. *Support for alternatives to fusion energy (in %, total sample, n=19970)*

Preference for investing in renewables instead of fusion ranged from 37% in Czech Republic and Bulgaria to 65% in Austria. Preference for investing in energy efficiency and saving instead of fusion ranges from 25% in Sweden and Bulgaria to 60% in Austria. Preference for investing in conventional fossil fuel technologies instead of fusion ranges from 7% in Denmark or Austria to 19% in Belgium or the Netherlands.

Investment preferences

We found similar results in the investment exercise. When asked to distribute 100 investment points in the research and implementation of various energy technologies, respondents tended to favour a mix of energy technologies and prioritize wind and solar, fusion power and energy efficiency and saving. Specifically, respondents invested, on average, around 34% of the total resources in wind and solar energy, 20% in fusion, 17% in energy saving and efficiency, 12% in bioenergy (biomass and biofuels), 7% in natural gas, 6% in nuclear fission and 2% in coal.

	N	Min	Max	Mean	Median	SD
Wind and solar energy	19970	0	100	34	30	26
Bio energy	19970	0	100	12	10	15
Energy efficiency and saving	19970	0	100	17	15	18
Nuclear (fission) energy	19970	0	100	6	0	12
Fusion energy	19970	0	100	20	15	22
Natural gas	19970	0	100	7	0	12
Coal	19970	0	100	2	0	7

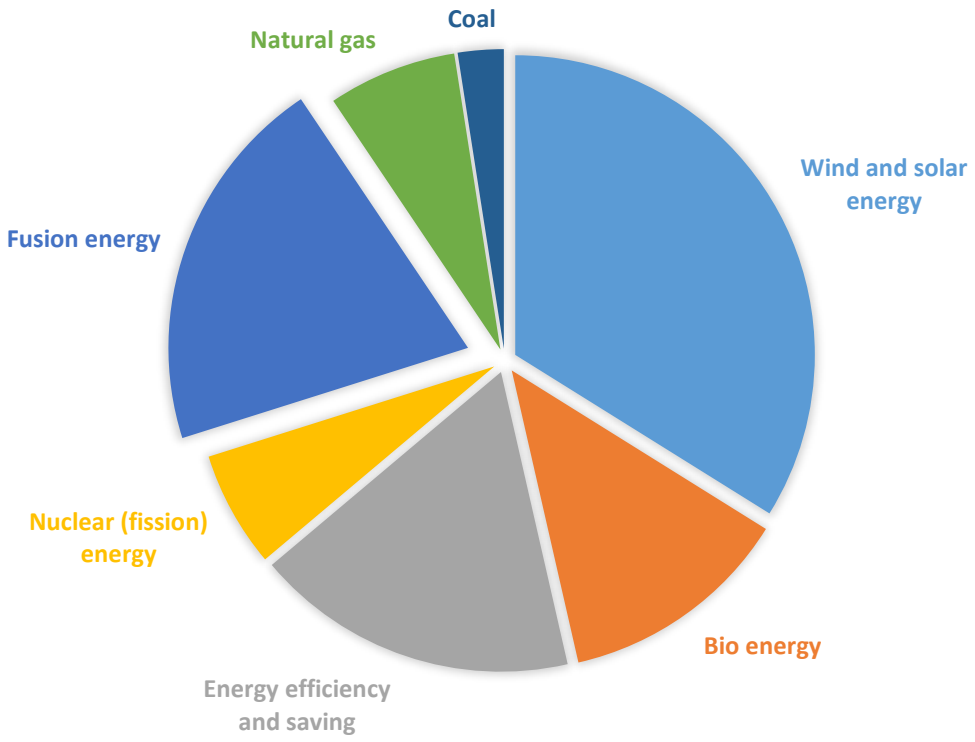


Figure 13. *Support for various energy alternatives (in % of 100 investment efforts, total sample, n=19970)*

The table below shows the correlation matrix among the investment options. The number (Spearman rho) indicates to what extent, investments in one technology are associated to

investments in another technology. If we focus on fusion, we can see that investments on fusion are substantially and negatively associated to investments in wind and solar, moderately and negatively associated to investments in energy efficiency and saving and weakly but positively associated to investments in nuclear fission.

	Wind and solar energy	Bio energy (biomass and biofuels)	Energy efficiency and saving	Nuclear (fission) energy	Fusion energy	Natural gas	Coal
Wind and solar energy		-,161	-,193	-,367	-,418	-,270	-,239
Bio energy (biomass and biofuels)			,064	,029	-,093	,104	,109
Energy efficiency and saving				-,043	-,122	,000	,005
Nuclear (fission) energy					,120	,275	,369
Fusion energy						-,064	-,043
Natural gas							.458
Coal							

Table 5. *Correlations between investment options (Spearman Rho, n=19970)*

Trust in fusion research decision makers

Trust in actors involved in the development of fusion energy varied significantly among countries. Altogether, trust was higher for nuclear fusion scientists (3.35 in a 1 to 5 scale) and lower for national decision makers (2.70). Specifically, we found that 45% of respondents expressed a high level of trust in nuclear fusion scientists, 39% in nuclear fusion research managers, 30% in EU decision makers and 22% in national decision makers. Trust in fusion scientists ranged from 2.87 in Austria to 3.8 in Bulgaria and Romania; trust in nuclear fusion research managers from 2.66 in Austria to 3.64 in Bulgaria, trust in EU decision makers from 2.55 in Austria to 3.64 in Romania; and trust in national decision makers from 2.37 in Italy to 3.08 in Romania.

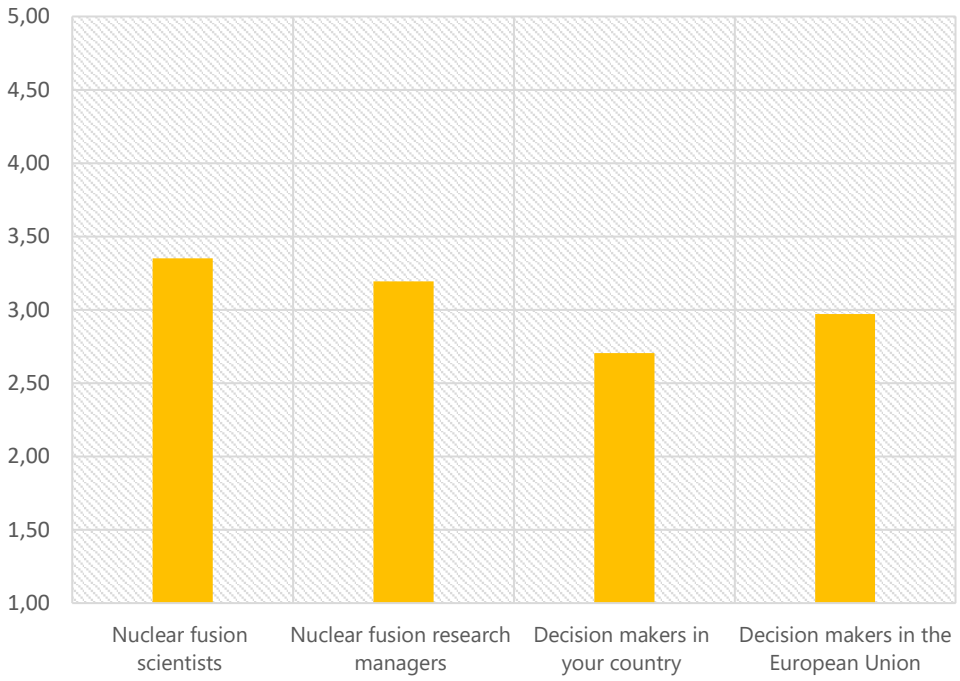


Figure 14. *Trust in fusion research actors (average, total sample, n=19970)*

Effects of information on evaluation of fusion energy

Initial evaluation vs evaluation after information about the consequences of fusion

Figure 12 shows the distribution of the evaluation of fusion energy in two moments: before receiving information about the general and specific characteristics of fusion energy (initial evaluation) and after the exercise on the evaluation of consequences of fusion (overall evaluation). The results show that the evaluation of fusion energy became slightly more positive after the evaluation of consequences exercise: the percentage of respondents that considered fusion a "fair" option decreased slightly, whilst the percentage of respondents that considered fusion a "good" option increased slightly. The average evaluation increased very weakly from 3.42 to 3.46. Application of the t-test shows that the mean values are significantly different (p=0.000).

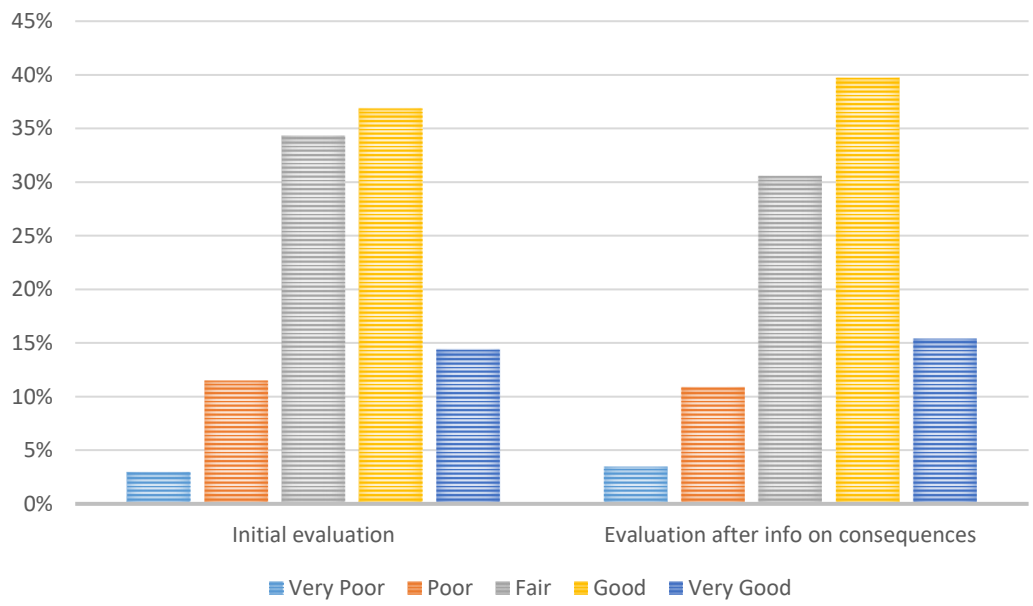


Figure 15. *Evaluation of fusion energy, before and after the evaluation of information on consequences (in %, total sample, n=19970)*

The results in Table 7 also show that the majority of participants tended to provide the same evaluation after the evaluation of consequences exercise. More than 60% of respondents provided the same evaluation (see the cells in grey). Second, the evaluation of fusion tended to become more neutral for participants that rated fusion as "very poor", "poor" or "very good" option, more positive for participants that rated fusion as "fair" option and both more neutral and more positive for participants that rated fusion as a "good" option.

Specifically, of the respondents that considered fusion a "very poor" option, 22% considered it a "poor" option after the exercise. Of those who rated fusion as a "poor" option, 27% rated fusion a "fair" option and 6% a "good" option after the exercise. Among respondents that rated fusion as a "fair" option, a significant percentage provided a more positive evaluation after the exercise: 26% of them rated fusion as a good option. 12% of respondents that rated fusion as a "good" option later rated it as a "very good" option, and 14% as a "fair" option. Of those who rated fusion as a "very good" option, 25% rated it as a "good" option after the exercise.

		Overall evaluation					
Initial evaluation		Very Poor	Poor	Fair	Good	Very Good	
	Very Poor	68%	22%	7%	2%	1%	100%
	Poor	9	58	27	6	1	100%
	Fair	1	9	63	26	1	100%
	Good	0	1	14	72	12	100%
	Very Good	0	0	3	25	72	100%
	Total	3%	11%	31%	40%	15%	

Table 7. *Changes from initial evaluation to overall evaluation (in %, total sample, n=19970)*

Effect of the type of information

In order to examine the effect of the type of information provided to respondents, we divided the study sample into two groups. We asked respondents in the first group (90% of the sample) to evaluate a number of consequences of developing fusion and then asked them to provide their overall evaluation of fusion. Respondents in the second group were asked to read an information text on the stakeholders' views on fusion.

As shown in the figure below, the overall evaluation of fusion was significantly more positive for respondents in the evaluation of consequences exercise as compared to respondents in the stakeholder text. In the first group, 55% of participants rated fusion as a good or very good option, as compared to 44% in the second group. Respondents providing a more neutral evaluation of fusion energy increased from 30% in the first group to 39% in the second group. Participants providing a negative evaluation of fusion increased very weakly in the second group (from 14% of respondents to 17%).

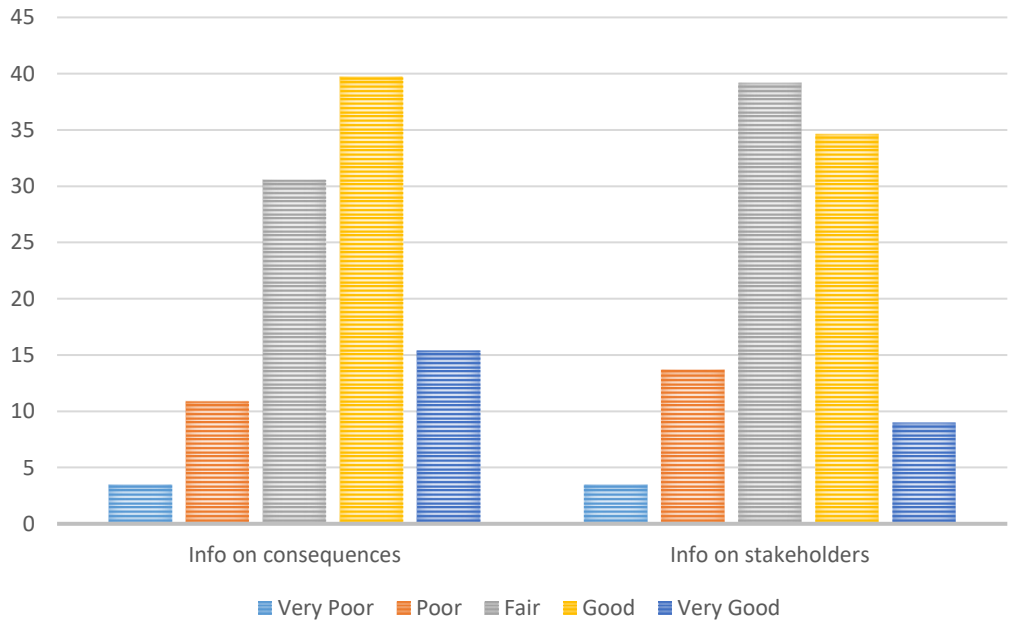


Figure 16. *Evaluation of fusion energy in two information conditions (in %, total sample, n=19970)*

Empirical model of support of fusion energy

With the aim of examining the more proximal direct and indirect **determinants** of **support** of **fusion energy**, a path analysis was estimated for the whole sample. The figure below displays the causal model. Table 8 shows the direct and indirect standardized effects of the independent variables (trust, prior beliefs, affects, perceived benefits/costs and attitude) over the main dependent variable (acceptance of residential fuel cell micro-CHP).

Results showed, first, that, according to the model presented, variables indirectly related to support to fusion such as trust, attitude towards nuclear and attitude towards science had a significant effect on acceptance. Trust had a moderate and significant indirect effect on support to fusion. Trust strongly influenced perceived benefits (.62) and affect (.59). Those who express higher levels of trust in the actors involved in the development of fusion tend to perceive fusion as more beneficial as well as to report more positive emotions regarding fusion energy. Attitude towards nuclear energy was also significantly associated to support to fusion: according to the model, those with a more positive attitude towards nuclear energy tended to trust fusion actors and therefore support fusion. Attitude towards science was also positively associated to support to fusion.

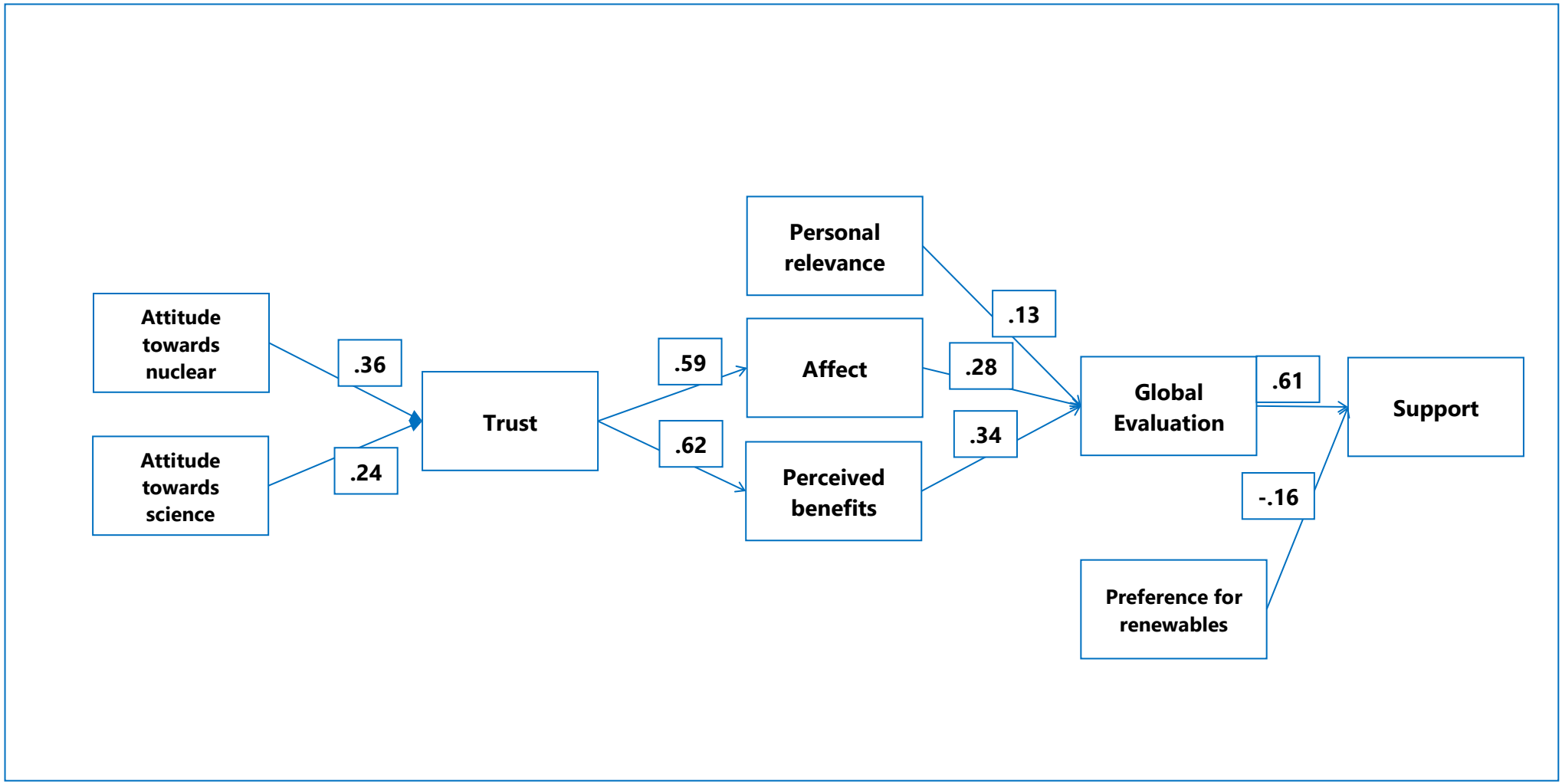
	Direct effect	**Indirect effect (one step)**	**Indirect effect (two steps)**	**Indirect effect (three steps)**
Overall evaluation	.61			
Preference for renewables	-.16			
Personal relevance		.08		
Affect		.17		
Perceived benefits		.21		
Trust			0.23	
Attitude towards nuclear				.08
Attitude towards science				.05

Table 8. *Direct and indirect effects on acceptance of residential hydrogen fuel cells of distinct variables (standardized coefficients β)*

Second, according to the model and the data analysed, personal relevance, affect and perceived benefits had a moderate influence on acceptance through the global evaluation of fusion. Perceived benefits was the variable most strongly associated with support to fusion energy (.21). Those who reported more positive beliefs regarding the potential impacts of fusion energy tended to have a more positive attitude towards it and a higher level of support. Affect had also a significant effect on support (.17). Positive emotions were associated to higher support to fusion through their effect on the global evaluation of fusion (.17). Personal relevance had a significant but very weak positive effect on support (.08).

Finally, preference for investments in renewables had a significant and negative effect on support (-.16). Those who prefered investing in renewables instead of fusion energy tended to report less support to fusion. Overall evaluation of fusion had a positive and strong association (.61) with support.

Figure 14. *Path analysis of determinants of support of public investments in fusion energy*



Ranking of countries

In order to synthesize the various attitudinal dimensions studied to create a measure of overall support for fusion in each country, we constructed an index based upon the sum of five of the principal study variables: (a) perceived personal relevance; (b) subjective evaluation of fusion; (c) acceptance, (d) support for public investments and (e) trust in decision makers. For each of the variables, we identified the percentage of respondents that provided a positive evaluation (generally, values 4 and 5 in a five-point scale). The ranks of all 21 countries studied are shown the table and figures below.

	Index	Personal relevance	Subjective evaluation	Acceptance	Support	Trust
RO	66	51	69	82	68	59
BG	64	46	65	81	65	62
UKR	58	36	62	81	67	44
FI	57	35	62	80	58	49
PL	57	33	66	78	64	40
SI	57	44	57	74	55	53
SE	56	30	63	73	61	52
LT	55	39	66	66	47	58
ES	53	44	48	69	55	47
UK	52	35	55	70	59	39
GR	51	44	58	65	45	43
PT	51	48	48	67	51	43
All countries (average)	51	35	55	68	53	42
CZ	50	25	62	65	54	46
DK	46	29	46	63	52	41
NL	45	33	49	60	47	36
FR	43	28	43	60	52	33
DE	43	36	48	61	47	25
LV	43	20	48	73	38	37
IT	42	32	47	60	44	26
BE	38	27	39	54	42	27
AT	33	28	34	53	32	20

Table 9. Countries ranked according to their level of support towards fusion energy *(in %, total sample, n=19970)*

We found strong differences in public support to fusion energy across Europe. Countries such as Romania and Bulgaria displayed support levels of higher than 60 percentage points according to the standardized index, whereas countries such as Austria or Belgium score less than 40 points.

The countries falling above the average in the support index are (in descending order): Romania, Bulgaria, Ukraine, Finland, Poland, Slovenia, Sweden, Lithuania, Spain, the United Kingdom, Greece and Portugal. Countries below the full sample mean for support are the Czech Republic, Denmark, the Netherlands, France, Germany, Latvia, Italy, Belgium and Austria.

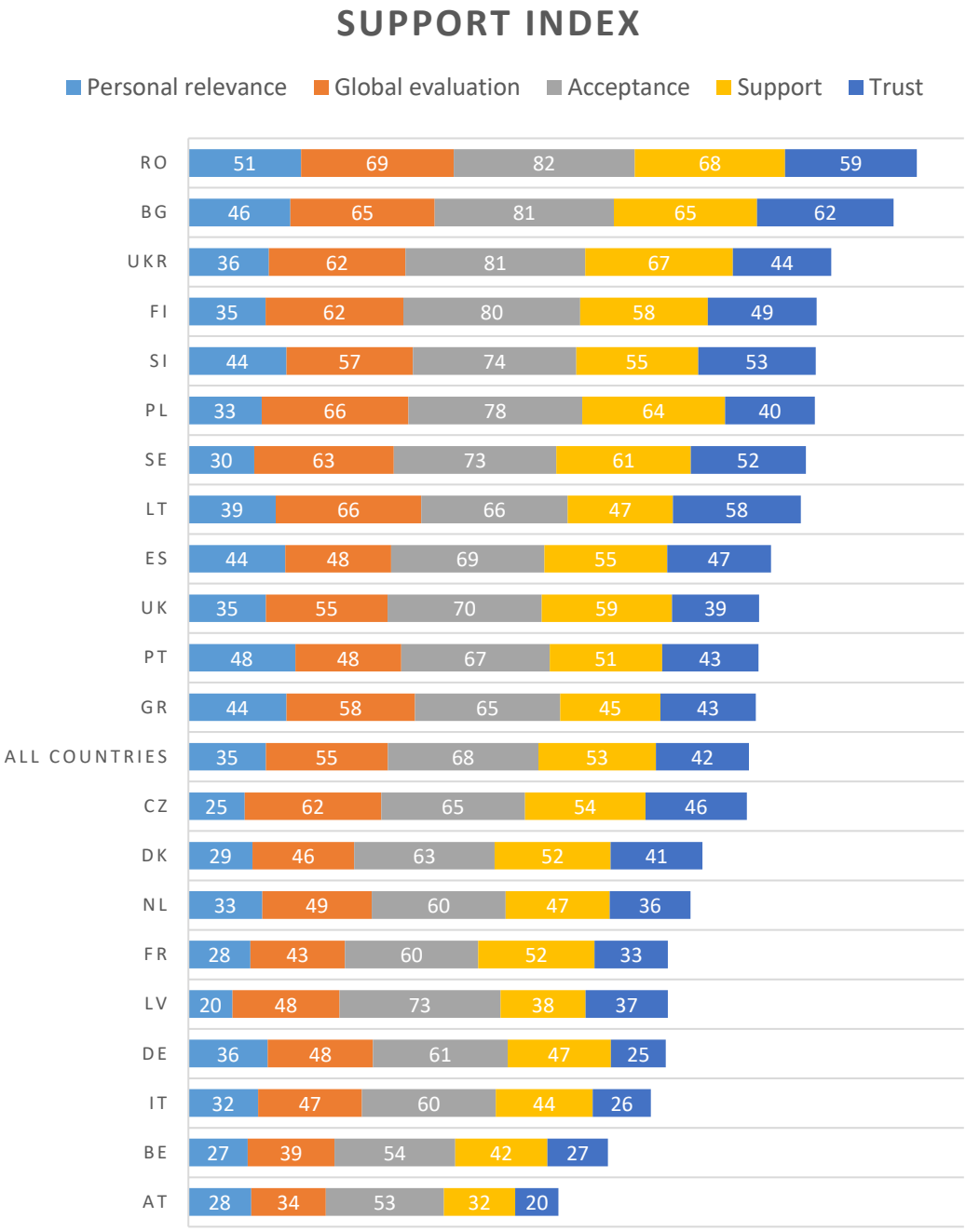


Figure 15. Countries ranked according to their level of support towards fusion energy *(in %, total sample, n=19970)*

Summary of results

This report has examined public awareness, attitudes and acceptance of fusion energy research in 21 European countries. The analysis has been based on survey data collected from a representative sample of residents in the 21 countries and specifically examines the differences in awareness, affects, beliefs, attitude, acceptance and support of fusion energy. The following are some of the key findings of the study:

- Around 50% of respondents reported having heard about fusion energy before the study. Awareness of fusion energy ranged from countries like Czech Republic, France or Germany where around three out of ten respondents reported having heard about fusion to countries like Sweden, Poland, Romania or Ukraine, where more than five out of 10 respondents reported having heard about fusion
- Altogether, 36% of respondents considered fusion energy as "important" or "very important" and 40% as "somewhat important". Personal relevance associated with fusion energy varied from countries like Latvia, where only 20% of respondents consider fusion to be important or very important, to countries like Romania or Portugal, where almost 50% of respondent considered fusion important or very important
- The initial evaluation of fusion energy in the whole sample was generally positive. On average, respondents rated fusion energy as a fair option (the average evaluation for the whole sample is 3.48 in a 1 to 5 scale)
- Affective associations with fusion energy were generally neutral to positive among our studied population. On average, respondents reported neutral feelings of worry-tranquility (3.00), slightly more enthusiasm than aversion (3.38), quite more interest than disinterest (3.71) and slightly more optimism than pessimism (3.49).
- Generally, respondents perceived fusion as having neutral to positive impacts on the energy system, the environment, public health and society.
- All the consequences of developing fusion energy were evaluated as moderate or large advantages. The consequences evaluated as more positive were the "contribution of fusion to climate change" and the "(less) dependence on scarce resources". The consequences that correlated highest with the overall evaluation of fusion were "price of electricity generated" (r = .56) and "generation of radioactive waste" (r = .54) indicating that these consequences had the most influence on the overall evaluation of fusion. The consequence that correlated lowest with the overall evaluation of fusion was the "(long) time horizon to build the technology" (r = .36). This indicates that this consequence had very little influence on the overall evaluation.
- After having read all the information on fusion energy, respondents evaluated fusion above the midpoint of the scale, grading it with a 3.50. This indicates that respondents considered that nuclear fusion is a fair option for energy generation. Altogether, 54% of respondents rated fusion energy as a good or very good option, 31% as a fair option and 15% as a poor or very poor option. When comparing among countries, the evaluation of fusion ranged from 2.97 in Austria to 3.86 in Romania.
- Overall, the majority of respondents considered acceptable the development of fusion power: more than 65% of the studied population considered the development of fusion as "acceptable" or "totally acceptable". 24% of participants were unsure or undecided about it and less than 10% considered the development of fusion as unacceptable. The level of public acceptance of fusion ranged from 54% in Austria and Belgium to 80% in Romania, Ukraine, Bulgaria or Finland.

- Support for public investments in the nuclear fusion research programme was also relatively high, with 52% of respondents supporting public investments on fusion in their own country and 61% supporting public investments at the EU level. Support of investments in the national level ranged from 33% in Austria to 68% in Romania. Support of investments in fusion in the EU level ranged from 38% in Austria to 77% in Bulgaria.
- Respondents would invest, on average, around 34% of resources for energy research and development in wind and solar energy, 20% in fusion, 17% in energy saving and efficiency, 12% in bioenergy, 7% in natural gas, 6% in nuclear fission and 2% in coal.
- Trust in actors involved in the development of fusion energy varied significantly among countries. Altogether, trust was higher for nuclear fusion scientists (3.35 in a 1 to 5 scale) and lower for national decision makers (2.70). Specifically, we find that 45% of respondents expressed a high level of trust in nuclear fusion scientists, 39% in nuclear fusion research managers, 30% in EU decision makers and 22% in national decision makers.
- The type of information provided to respondents influenced respondents' attitudes towards fusion energy. The overall evaluation of fusion was significantly more positive for respondents in the evaluation of consequences exercise as compared to respondents reading the information about the views of the stakeholders. The general evaluation of fusion energy was slightly more neutral and positive when respondents evaluated the consequences of developing fusion.
- Individuals' level of support to fusion energy and research was determined by their overall evaluation of fusion, the preference for alternative technologies, trust, perceived benefits of fusion, the affect associated to fusion, the level of personal relevance attributed to fusion, attitude towards nuclear and attitude towards science.
- There were strong differences in public support to fusion energy across Europe. Countries such as Romania and Bulgaria displayed support levels of higher than 60 percentage points whereas countries such as Austria or Belgium scored less than 40 points of support. The countries above the average in the support index were, in descending order: Romania, Bulgaria, Ukraine, Finland, Poland, Slovenia, Sweden, Lithuania, Spain, the United Kingdom, Greece and Portugal. Countries below the average level of support were the Czech Republic, Denmark, the Netherlands, France, Germany, Latvia, Italy, Belgium and Austria.

This report, building on previous studies on the social acceptance of energy technologies, provided an overview of public attitudes towards fusion energy research in 21 European countries. These results contribute to improve our understanding of public acceptance of fusion energy through cross-national research. Acceptance of fusion energy will likely vary across time, countries and regions and segments of the population. Future research will provide the evidence needed to examine the trends of public acceptance of fusion energy and attempt to document and explain some of the observations in this report.

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Annex 1. Details of the sample

For details on specific countries, please visit: link to survey details

Sex					
		Frequency	Percent	Valid Percent	Cumulative Percent
	Female	9814	49,1	49,2	49,2
	Male	10121	50,7	50,8	100
	Total	19935	99,8	100	
Total		19970	100		

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
	18-29	3704	18,5	18,5	18,5
	30-39	3536	17,7	17,7	36,3
	40-49	3735	18,7	18,7	55,0
	50-64	5186	26,0	26,0	80,9
	65 and above	3809	19,1	19,1	100
	Total	19970	100	100	

What is the highest level of education that you have completed?				
	Frequency	Percent	Valid Percent	Cumulative Percent
None completed	172	,9	,9	,9
Degree level or higher	1431	7,2	7,2	8,0
Up to GCSEs/O level or equivalent	3064	15,3	15,3	23,4
Up to A levels or equivalent	4684	23,5	23,5	46,8
Other qualifications/apprenticeships	1846	9,2	9,2	56,1
Undergraduate (not a Bachelor's degree)	1602	8,0	8,0	64,1
Graduate (Bachelor's degree)	4558	22,8	22,8	86,9
Postgraduate (master, doctorate, PHD etc.)	2613	13,1	13,1	100
Total	19970	100	100	

What is the size of your place of residence?(city, town, village)				
	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 1,000 inhabitants (village)	1748	8,8	8,8	8,8
Between 1,000 and 20,000 (town)	4768	23,9	23,9	32,6
Between 20,000 and 100,000 (town, small city)	4780	23,9	23,9	56,6
Between 100,000 and 300,000 (city)	3146	15,8	15,8	72,3
Between 300,000 and 1 million (medium sized city)	2600	13,0	13,0	85,3
More than 1 million inhabitants (big city)	2928	14,7	14,7	100
Total	19970	100	100	

Annex 2. Results by country (main study variables)

FIRST SECTION

Q5. Before participating in this study, had you ever heard of fusion energy? (%)

Q6. How would you rate your familiarity with fusion energy? Are you...? (%)

	No	**Yes**			
Country		Not at all familiar	Slightly familiar	Familiar	Very familiar
AT	58	6	28	7	1
BE	62	5	26	6	1
BG	29	3	54	13	1
CZ	67	3	26	4	0
DK	49	3	37	10	1
FI	46	4	40	10	1
FR	71	3	21	4	1
DE	66	4	23	6	2
GR	54	4	34	6	2
IT	53	7	31	8	1
LV	54	5	36	5	0
LT	68	1	27	4	0
NL	63	3	27	6	1
PL	34	5	51	9	1
PT	58	4	32	6	1
RO	20	8	56	14	2
SI	49	5	39	6	0
ES	56	5	31	7	1
SE	45	7	41	7	1
UKR	27	3	58	11	1
UK	57	5	27	9	2

Q7. How important is the development of fusion energy to you? (%)

Country	Non-relevant	Only slightly important	Somewhat important	Important	Very important
AT	14	16	42	20	8
BE	10	18	46	20	7
BG	3	10	41	35	11
CZ	12	22	41	21	5
DK	10	21	40	24	5
FI	11	12	42	28	7
FR	4	18	50	22	6
DE	11	15	39	28	8
GR	5	6	44	35	9

IT	16	17	36	22	10
LV	14	29	37	16	4
LT	5	13	44	34	5
NL	11	14	41	28	6
PL	9	20	38	26	7
PT	2	8	42	39	9
RO	3	10	37	38	13
SI	4	15	37	32	13
ES	3	12	41	32	11
SE	6	20	45	23	7
UKR	14	18	32	31	5
UK	12	16	37	26	10

SECOND SECTION

Q9. To what extent does fusion energy evoke the following feelings in you, if at all? (▪)

Scale 1 (nothing) to 5 (very much)

Country	Tranquility	Enthusiasm	Interest	Optimism
AT	2.6	2.8	3.5	3
BE	3	3.3	3.5	3.3
BG	3.4	3.6	4	3.7
CZ	3.2	3.4	3.7	3.5
DK	2.9	3.2	3.5	3.3
FI	3.3	3.6	3.8	3.6
FR	3	3.3	3.5	3.3
DE	3	3.1	3.7	3.4
GR	3	3.3	3.8	3.4
IT	2.9	3.2	3.8	3.2
LV	3	3.4	3.7	3.5
LT	3.1	3.4	3.8	3.5
NL	3.1	3.4	3.6	3.4
PL	3.1	3.4	3.8	3.5
PT	2.9	3.3	3.7	3.3
RO	3.4	3.7	4	3.8
SI	3.1	3.4	3.8	3.5
ES	3.2	3.4	3.8	3.5
SE	3.3	3.5	3.7	3.5
UKR	3.2	3.5	3.9	3.7
UK	3.1	3.5	3.8	3.5

Q10. What are your beliefs and expectations regarding fusion technology? (•)

Scale 1 (nothing) to 5 (very much)

Country	Technologically viable	Acceptable costs	Contribute to the energy system	Effect on the environment	Human health	Economically competitive	Social impacts
AT	2.8	2.8	3.2	2.7	2.7	3	3
BE	3.3	3	3.3	3.2	3.1	3.2	3.2
BG	3.7	3.4	3.8	3.6	3.4	3.7	3.7
CZ	3.5	3.1	3.5	3.5	3.3	3.3	3.5
DK	3.2	3	3.4	3.3	3.2	3.1	3.2
FI	3.6	3.4	3.7	3.7	3.5	3.4	3.5
FR	3.4	2.9	3.3	3.2	3	3.2	3.2
DE	2.6	2.9	3.4	3.1	3	3.1	3.2
GR	3.5	3	3.4	3.1	3.1	3.4	3.3
IT	3.3	3	3.3	3.1	3	3.2	3.2
LV	3.6	3	3.4	3.3	3.1	3.3	3.4
LT	3.8	3.4	3.6	3.4	3.3	3.4	3.5
NL	3.4	3.1	3.5	3.4	3.2	3.3	3.3
PL	3.7	3.4	3.6	3.4	3.1	3.5	3.4
PT	3.4	3.1	3.4	3.2	3	3.3	3.3
RO	3.7	3.3	3.8	3.5	3.2	3.6	3.7
SI	3.6	3.2	3.6	3.4	3.4	3.4	3.5
ES	3.6	3.1	3.6	3.5	3.3	3.5	3.5
SE	3.5	3.2	3.7	3.5	3.4	3.4	3.5
UKR	3.7	3.3	3.6	3.3	3.2	3.7	3.5
UK	3.5	3.2	3.7	3.5	3.3	3.3	3.4

Q11. To what extent do you agree with the following statement: *"Science knows all of the conditions important for judging the risks of developing nuclear fusion"* (%)

Country	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
AT	16	29	31	21	3
BE	8	18	44	25	5
BG	2	14	38	39	8
CZ	4	21	48	25	2
DK	13	31	39	15	2
FI	5	35	40	18	2
FR	11	26	35	26	3
DE	9	25	37	26	3
GR	4	19	37	35	5
IT	5	16	39	34	6
LV	6	28	46	19	2
LT	3	18	45	30	3

NL	4	15	43	34	5
PL	5	25	37	29	4
PT	6	29	33	28	4
RO	3	12	37	39	10
SI	7	22	43	25	3
ES	4	17	34	37	8
SE	4	17	49	26	3
UKR	4	28	38	27	2
UK	5	19	39	32	5

THIRD SECTION

Q12. Do you consider this consequence as...? (•)

Scale 1 (very negative) to 5 (very positive)

Country	It will take years to build the technology	Less dependence on scarce resources	New installations are needed	Radioactive waste	Contribution to climate change	Price/Cost
AT	2.7	3.6	3.1	2.5	3.8	3.4
BE	2.9	3.6	3.3	2.9	3.7	3.4
BG	3.5	4	3.7	3.5	4	3.8
CZ	3.3	3.8	3.4	3.3	4	3.7
DK	3	4	3.3	3	4.1	3.6
FI	3.1	4.1	3.6	3.6	4.3	3.9
FR	3.1	3.7	3.2	2.9	3.8	3.5
DE	3	3.9	3.2	2.8	4	3.6
GR	3	3.9	3.4	2.9	3.8	3.5
IT	3	3.8	3.4	2.9	3.8	3.5
LV	3.1	3.9	3.5	3.1	3.7	3.6
LT	3.2	3.8	3.6	3.2	3.9	3.7
NL	2.9	3.8	3.4	3	3.9	3.6
PL	3.3	3.8	3.5	3.3	3.7	3.6
PT	3	3.9	3.4	2.8	3.9	3.6
RO	3.6	4	3.8	3.4	3.9	3.9
SI	3.1	3.9	3.5	3.2	4	3.8
ES	3	4	3.5	2.9	3.9	3.5
SE	3	3.9	3.5	3.5	4.1	3.9
UKR	3.4	4	3.8	3.5	3.8	3.8
UK	3	4	3.4	3.2	4	3.6

Q13. How do you feel about fusion energy? I think that fusion is a _____ energy option (%)

Country	Very poor	Poor	Fair	Good	Very good
AT	11	24	32	25	9
BE	6	13	42	26	13
BG	2	7	26	41	24
CZ	1	6	31	44	18
DK	4	15	34	34	12
FI	1	6	31	44	18
FR	6	14	37	34	9
DE	4	18	31	35	12
GR	4	9	29	44	14
IT	7	14	32	34	13
LV	2	11	39	39	9
LT	1	6	27	55	11
NL	4	11	36	37	12
PL	2	7	25	48	18
PT	4	14	35	37	11
RO	1	6	23	42	27
SI	3	10	30	39	17
ES	4	14	35	34	14
SE	2	11	24	44	19
UKR	1	8	29	46	16
UK	3	10	32	39	15

Q14. Overall, do you personally consider the research and development of fusion energy to be…? (%)

Country	Totally unacceptable	Unacceptable	Neither acceptable nor unacceptable/ undecided	Acceptable	Totally acceptable
AT	6	12	28	43	11
BE	2	7	36	39	15
BG	2	4	14	55	26
CZ	2	3	30	61	3
DK	2	6	29	47	16
FI	1	1	19	56	24
FR	3	6	30	48	13
DE	2	10	28	48	13
GR	1	5	28	50	15
IT	4	9	27	46	15
LV	1	4	22	59	14
LT	1	4	29	53	13
NL	2	6	32	45	16
PL	1	3	18	59	19

PT	2	6	25	52	15
RO	1	3	15	51	30
SI	1	3	22	51	23
ES	3	5	23	63	6
SE	1	3	23	48	25
UKR	1	5	12	57	24
UK	2	4	25	49	20

Q15. Which of the following statements best expresses your views on fusion energy? (%)

Country	Interested countries should fund research on fusion	We keep research on fusion energy but prioritize other sources of energy	We should reduce or cancel the nuclear fusion program
AT	24	51	25
BE	35	52	13
BG	56	37	7
CZ	49	43	8
DK	33	54	13
FI	53	44	3
FR	37	48	15
DE	30	55	15
GR	40	49	12
IT	36	47	17
LV	43	48	10
LT	47	47	5
NL	41	48	12
PL	46	49	6
PT	33	55	12
RO	59	35	6
SI	50	43	8
ES	37	52	10
SE	51	43	6
UKR	54	40	6
UK	43	50	7

Q16. How much do you support or oppose public financial investments in the nuclear fusion research program

A. In your country? (%)

Country	Strongly oppose	Somewhat oppose	Neither support nor oppose/undecided	Somewhat support	Strongly support
AT	20	13	35	24	9
BE	9	11	39	31	11
BG	5	9	22	40	24

CZ	3	11	31	42	13
DK	9	11	28	36	16
FI	3	7	33	45	13
FR	10	8	30	40	12
DE	10	7	36	31	16
GR	9	13	32	35	10
IT	11	13	33	33	11
LV	9	17	36	33	6
LT	6	11	36	33	14
NL	7	10	36	33	14
PL	4	9	23	47	17
PT	12	12	25	38	13
RO	3	5	24	40	28
SI	6	9	30	35	20
ES	9	8	28	35	21
SE	4	8	27	42	18
UKR	5	8	20	47	19
UK	6	7	29	40	18

B. At a European Union level? (%)

Country	Strongly oppose	Somewhat oppose	Neither support nor oppose/undecided	Somewhat support	Strongly support
AT	18	11	32	26	12
BE	9	9	33	33	16
BG	3	4	16	38	39
CZ	3	6	28	37	26
DK	8	9	23	35	25
FI	1	5	27	43	24
FR	10	8	28	39	16
DE	9	7	35	31	18
GR	6	9	23	40	22
IT	9	10	30	33	18
LV	3	6	24	44	24
LT	2	5	26	34	33
NL	6	8	33	34	19
PL	2	4	20	44	30
PT	9	8	21	37	25
RO	2	3	22	35	38
SI	4	5	24	32	34
ES	7	6	26	33	28
SE	3	6	27	37	27
UKR	3	3	18	41	35

UK	6	7	31	37	19

Q18. If you had to invest 100 Euros in the research and development of energy sources for the purposes of electricity generation, how would you distribute the money among the following options? (·)

Country	Wind and solar energy	Bio energy (biomass and biofuels)	Energy efficiency and saving	Nuclear (fission) energy	Fusion energy	Natural gas	Coal
AT	38.9	16	22.8	1.3	15.3	4	1.7
BE	35.5	13	15.1	6.8	16.2	9.8	3.5
BG	26	13.7	14	9.1	27.1	7.9	2.2
CZ	22.2	13.5	17.6	10.5	25.8	6.7	3.7
DK	44.2	12.9	15.9	3.3	18.1	4.7	1
FI	29.7	14.4	19.7	6.9	23.3	4.7	1.2
FR	32.1	13.2	17.8	7.7	19.3	7.6	2.3
DE	34.4	13.2	20.5	3	20.5	6.3	2.2
GR	35.5	12.2	16.1	3.9	17.3	12.3	2.7
IT	36.1	11.6	19.8	4.4	17.1	8.8	2.1
LV	29.6	14.1	21.1	6.4	19	7	2.8
LT	36.5	12	17.3	5.6	21.5	5.6	1.4
NL	34.6	12.6	14.3	7.1	20	8.5	2.9
PL	30.5	11.4	15.2	6.9	25.3	6.7	4.1
PT	42.6	9.8	19.7	3.4	15.7	6.5	2.2
RO	32.5	13.2	13.8	8.5	20.8	7.3	3.8
SI	36.4	10.9	18.2	5.6	21.6	5.4	1.9
ES	40	12.3	16.3	6.3	17	5.8	2.3
SE	36	11	15.2	8.1	24.2	4.5	0.9
UKR	30.3	11.4	17.8	5.8	25.4	5.9	3.3
UK	28	11.4	18.2	10.6	18.7	9.5	3.5

Q20. Before participating in this study, had you ever heard about ITER? (%)

Q21. What is your opinion about investing in ITER: Do you favor it, oppose it, or neither? (%)

Country	Yes	No	Strongly oppose	Somewhat oppose	Neutral	Somewhat favor	Strongly favor
AT	13	87	14	13	41	23	9
BE	13	87	6	7	55	23	8
BG	21	79	2	6	26	50	16
CZ	12	88	2	4	49	36	9
DK	7	93	6	9	44	29	13
FI	14	86	1	5	39	39	17
FR	23	77	6	9	46	33	6
DE	10	90	8	10	38	29	14
GR	18	82	3	7	44	36	9
IT	13	87	6	9	48	29	9
LV	18	82	2	6	46	36	9
LT	13	87	2	4	44	37	13
NL	14	86	4	7	48	28	12
PL	15	85	2	5	35	46	13
PT	12	88	5	7	43	33	12
RO	24	76	1	4	32	41	21
SI	14	86	3	6	48	28	15
ES	16	84	5	6	43	31	15
SE	10	90	3	6	43	32	17
UKR	21	79	1	3	34	48	13
UK	12	88	4	6	45	34	11

OTHER VARIABLES

Q22. How much do you trust… (•)

Scale 1 (not at all) to 5 (to a large extent)

Country	Nuclear fusion scientists to make good decisions about fusion energy	Nuclear fusion plant managers to make good decisions about fusion energy	Decision makers in your country to make good decisions about fusion energy	Decision makers in the European Union to make good decisions about fusion energy
AT	2.9	2.7	2.5	2.5
BE	3	2.9	2.6	2.7
BG	3.8	3.6	2.7	3.4
CZ	3.6	3.4	2.8	2.8
DK	3.3	3.2	2.9	2.9
FI	3.6	3.3	2.8	3
FR	3.1	3	2.7	2.7
DE	3.1	2.9	2.7	2.7
GR	3.4	3.2	2.6	3

IT	3	2.7	2.4	2.6
LV	3.3	3.1	2.4	3
LT	3.7	3.5	2.9	3.5
NL	3.1	3	2.8	2.8
PL	3.4	3.1	2.6	3
PT	3.4	3.2	2.8	3
RO	3.8	3.6	3.1	3.6
SI	3.5	3.4	2.6	2.9
ES	3.4	3.3	2.7	3
SE	3.6	3.5	3	3
UKR	3.4	3.2	2.5	3.3
UK	3.2	3.1	2.8	2.8

Annex 3. Questionnaire

Presentation of the study

Dear participant,

Through this survey, we want to **know your first impressions of an experimental energy source** that could bring important changes to the energy sector in the future.

During your progression through this survey—which should last no longer than 15 minutes—you will receive information that will introduce you to technology, after which you will be asked to provide answers to some simple questions about your opinions.

We just want to know your personal view, **based upon what you currently know or understand**.

It is important that you provide your best answers to each question in this survey. Your participation is much appreciated as it may help improve the future decisions relating to the development of this technology.

Thanks!

Add name of researchers
Add logos

Demographic questions

Are you?	1. Female 2. Male 3. Other
Please indicate your age range	18-29 30-39 40-49 50-64 65 and above
What is the highest level of education that you have completed?	Did not graduate from high school\ High school graduate, 2-year college degree or Technical education\ 4-year college degree or Postgraduate degree
In which of the following regions do you live?	North East North West Yorkshire and The Humber East Midlands West Midlands East of England London South East South West Wales Scotland Northern Ireland
Size of place of residence (city, town, village)	<2.000 inhabitants 2.000-20.000 20.001-199.000 200.000-1.000.000 > 1.000.000
How would you describe your household's current income?	1. Finding it very difficult to live on current income 2. Finding it difficult to live on current income 3. Coping on current income 4. Living comfortably on current income 5. Living very comfortably on current income Add: Prefer Not to Answer
How would you describe your political orientation?	(1 = extremely left, 7 = extremely right) Add: Prefer Not to Answer

Prior questions

Before introducing the technology, we would like to ask you some questions about your general views on energy and technology issues.

Construct	*Item*	*Scale*
Prior knowledge/ issue involvement	Q1. How would you describe your level of knowledge about energy technologies (technologies to generate, store and manage energy such as wind, nuclear, biofuels, hydrogen, etc.) in general? I know_____about energy technologies	Scale 1-7 Nothing--Quite a lot

Attitude towards science	Q2. What do you think about the following statement? Even if it brings no immediate benefits, scientific research that advances the frontiers of human knowledge is…	Scale 1-7 Unnecessary and should not be supported by the government-- Necessary and should be supported by the Government
Attitude towards nuclear energy	Q3. "We need nuclear power stations because renewable energy sources alone do not produce sufficient electricity".	▪ Strongly disagree (1) ▪ Disagree (2) ▪ Neither agree nor disagree (3) ▪ Agree (4) ▪ Strongly agree (5)

	Q4. How much you disagree or agree with the following statements:	
Ecocentrism	"Humans have the right to modify the natural environment to suit their needs"	▪ Strongly disagree (1) ▪ Disagree (2) ▪ Neither agree nor disagree (3) ▪ Agree (4) ▪ Strongly agree (5)
Technocentrism	"Technological solutions are the best option to cope with environmental problems"	

Attitudes towards new Energy Technologies	Finally, please tell us how much you disagree or agree with the following statements: "We can adequately meet current and future energy demand by using the technologies that are currently available, there is no need to develop new options".	▪ Strongly disagree (1) ▪ Disagree (2) ▪ Neither agree nor disagree (3) ▪ Agree (4) ▪ Strongly agree (5)

First section

Have you ever heard of Fusion Energy?

The search for alternative methods of energy supply and use has led governments and companies to develop a portfolio of **energy technologies** such as solar, wind, and geothermal energy.

Among these potential solutions to future energy challenges, here we are focusing on **fusion energy**, an experimental technology that could be used for power generation and that works by fusing together atoms in order to release energy.

We will provide you more information regarding **fusion energy** in the next section.

(Experimental condition. N= 100)

Have you ever heard of Nuclear Fusion?

The search for alternative methods of energy supply and use has led governments and companies to develop a portfolio of **energy technologies** such as solar, wind, and geothermal energy.

Among these potential solutions to future energy challenges, here we are focusing on **nuclear fusion**, an experimental nuclear technology that could be used for power generation and that works by fusing together atoms in order to release energy.

We will provide you more information regarding **nuclear fusion** in the next section.

Construct	Item	Scale
Awareness	Q5. Before participating in this study, had you ever heard of fusion energy?	▪ Yes (1) ▪ No (2) If No (2), filter to Q7
Familiarity	Q6. How would you rate your familiarity with fusion energy? Are you…?	▪ Not at all familiar – You know nothing about fusion power (1) ▪ Slightly familiar – You've heard about fusion power, read an article or watched a television feature about the technology, or participated in a casual conversation about the technology (2) ▪ Familiar – You've some experience with fusion power, researched the subject for school, work, or personal interest, or learned about the

		technology in a class or workshop (3) ▪ Very familiar – You consider yourself an expert in fusion power (4)

Personal relevance	Q7. How personally relevant is the development of fusion energy to you?	Five-point scale: 1- Non-relevant 2- Only slightly relevant 3- Somewhat relevant 4- Relevant 5- Very relevant

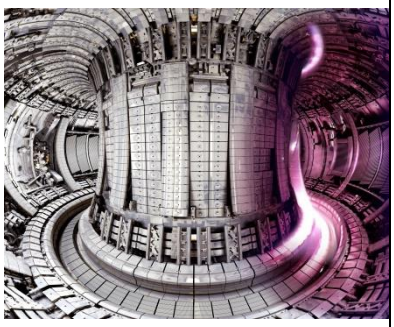
Second section

In this section we will provide you more information about fusion energy and why it might be relevant for energy and science policy, and ask you about what features you like and dislike in this technology.

[TEXT 1]

Please read the information carefully before proceeding Energy consumption is expected to grow dramatically over the next fifty years as the world's population expands and developing countries become more industrialised. **Governments and companies are looking for alternative ways of producing energy**. Coal and natural gas contribute to air pollution and climate change; Governments are divided over whether to include nuclear energy in the energy mix; and renewable sources might not be enough by themselves to reliably meet the demand.

In this sense, **nuclear fusion energy could be an important long-term energy source to complement other options**. Fusion energy is created by fusing two atomic nuclei. The heat produced by the reaction turns water into steam, which drives turbines to generate electricity. The basis of fusion energy is similar to fission energy, the one produced in current nuclear power plants. Both fission and fusion are nuclear processes by which atoms are altered to create energy. However, while nuclear fission is the division of one heavy atom into two, nuclear fusion is the combination of two lighter atoms into a larger one.



The JET fusion reactor with plasma

Fusion energy promises to be an almost inexhaustible and clean source of energy. Fuel for fusion energy (deuterium and tritium) is readily available and abundant in seawater. The nuclear fusion reaction produces helium, which is an inert gas – no greenhouse gases or acid rain-causing particles are emitted. The radioactive products, once the plant is decommissioned, are short lived (50-100 years) compared to the waste from a conventional nuclear power plant (which lasts for thousands of years). Fusion reactions are intrinsically safe as only a few grammes of fuel are ever in the reactor. The reaction stops in the event of the failure of any sub-system. There is no chance of a chain reaction.

However, fusion power also presents scientific and engineering challenges very difficult to overcome. Fusing two nuclei together requires heating the fuel to very high temperatures into a *plasma*, and so far, scientists have not been able to figure out a way to get more energy out of a reaction than they put in. Physicists and engineers have been at work on this question for decades. Many breakthroughs have been made, fusion energy has been produced in laboratories, and there are a number of major projects under development that may bring fusion closer to commercialization. However, fusion energy is yet unproven as a reliable energy source.

Attitude t1	Q8. Overall, how do you feel now about fusion as a potential energy source? I think it is a____option	▪ Very Poor (1) ▪ Poor (2) ▪ Fair (3) ▪ Good (4) ▪ Very Good (5)

Affect	Q9. To what extent does fusion energy evoke the following feelings in you, if at all? ▪ Worry---Tranquility ▪ Aversion---Enthusiasm ▪ Disinterest---Interest ▪ Pessimism---Optimism	Scale 1 to 5 for each affect

Perceived costs, risks and benefits (perceived effects)	Q10. What are your expectations with respect to this technology? I expect that it would be… • Technologically unviable--viable • Cost too much to develop –have acceptable costs (in terms of the investments in research, development and demonstration) • Contribute very negatively – very positively to the energy system (in terms of energy security, diversification of the supply, etc.) • Have a very negative--very positive effect on the environment (thinking about potential impacts on lands, the atmosphere, water, etc.) • Be very dangerous--very safe for human health • Be economically not competitive—competitive (in terms of the price of the electricity produced) • Have other very negative—very positive social impacts (other potential social and economic impacts that you might think)	Scale 1 to 5 + don't know option

Epistemic trust (for fusion specific)	Q11. To what extent do you agree with the following statement: ▪ ''Science knows all of the conditions important for judging the risks of developing nuclear fusion"	Scale 1-5 (totally disagree-totally agree) ▪ Strongly disagree (1) ▪ Disagree (2) ▪ Neither agree nor disagree (3) ▪ Agree (4) ▪ Strongly agree (5)

Third section

[EXPERIMENTAL MANIPULATION] (Random subsample. n=100) (filter to Q13b)

Although nuclear fusion has been largely left out of the popular conversation, it has generated some **debate within energy policy circles**: research on fusion has received substantial public funding and support, but fusion energy is yet unproven as a reliable energy source. Representatives of the fusion research program as Bernard Bigot, Director-General of the ITER Organization, consider that "The world needs to know if this technology is available or not. Fusion could help deliver the energy supplies of the world for a very long time, maybe forever." For the majority of the **European leaders**, it is worth investing in such a technology of the future. As one member of Parliament recently stated: "To meet our long-term energy needs, we must continue to invest into fusion

research. [...] It would be a serious mistake, to deprive ourselves from fusion as a means of safe, economic, environmental and climate-friendly and above all, inexhaustible energy." Not all politicians in all countries agree with this, and some are concerned that support to fusion would come at the expense of other priorities.

Scientists working on fusion consider that although fusion might not emerge as an energy source by 2050, it is worth investing in as many options as possible in case some do not succeed because there are not that many essentially inexhaustible energy options. In addition, and according to some scientists, fusion could be the propulsion that's going to get us to the stars.

Some **environmental groups** are opposed to investments in fusion energy. Greenpeace nuclear and energy campaigner, Sebastien Blavier, for instance, thinks that the cost and uncertainty of fusion means investing in thermonuclear reactors at the expense of other available clean energy options. In his opinion, this is risky and ignorant.

[END EXPERIMENTAL MANIPULATION]

Fusion energy on a large scale will probably not be possible to implement before 2050. The necessary technical advances are expected to have been realized by then, but this is not a complete certainty.

Please read and evaluate the following potential consequences of developing fusion energy

Evaluation of consequences	see text in Annex Q12. Do you consider this consequence as…? [show one consequence per screen]	For each consequence: Scale from 1 to 5 Very negative (1), Negative (2)—Not important (3)—Positive (4), Very positive (5)

Construct	Item	Scale
Global attitude t2	Q13a. Taking into account your previous evaluation of the consequences of fusion energy, how would you rate fusion as a potential energy source? I think it is a____option	▪ Very Poor (1) ▪ Poor (2) ▪ Fair (3) ▪ Good (4) ▪ Very Good (5)
Global attitude t2 (for manipulation)	Q13b. Taking into account the views of the various groups, how would you rate fusion as a potential energy source? I think it is a____option	*idem*

Acceptance	Q14. Overall, do you consider the development of fusion energy to be…?	Scale 1 to 5. 1 – Totally unacceptable 2 – Unacceptable 3 – Neither acceptable nor unacceptable/undecided 4 – Acceptable 5 – Totally acceptable
	Q14b. [filter If answered totally unacceptable or unacceptable] Why is this?	(open answer)

In this last section, we would like to know your personal view on the following policy problem: Should we keep investing efforts to make fusion energy happen or should we rely on other solutions to meet our future energy needs?

Global attitude (categorical)	Q15. Which of the following statements best expresses your views on fusion energy? *select one* a. Fusion power might be an important source of electricity in the future, and interested countries should fund research on fusion b. Fusion might or might not be a viable source of electricity. We should keep research on fusion energy but prioritize other sources of energy. c. Fusion power is unnecessary and dangerous. We should reduce or cancel the nuclear fusion program and invest on other energy sources or alternative programs

Support	Q16. How much do you support or oppose public financial investments in the **nuclear fusion research program** • Q18a. In your country? • Q18b. At a European Union level?	1. Strongly Oppose (1) 2. Somewhat Oppose (2) 3. Neither support nor oppose/undecided (3) 4. Somewhat Support (4) 5. Strongly Support (5)

Preference over other technologies	Q17. To what extent do you agree with the following statement: Q17_1. Instead of investing in fusion energy, we should focus on alternative solutions, like renewable energies (solar, wind, biomass, etc.)	Scale 1-5 (totally disagree-totally agree) ▪ Strongly disagree (1) ▪ Disagree (2) ▪ Neither agree nor disagree (3)

	Q17_2. Instead of investing in fusion energy, we should focus on alternative solutions, like energy efficiency and saving Q17_3. Instead of investing in fusion energy, we should focus on alternative solutions, like conventional energies (nuclear, natural gas, coal)	▪ Agree (4) ▪ Strongly agree (5)

Preference over other technologies	Q18. If you had to invest 100 euros in the development and improvement of the various energy sources, how would you distribute this among the following options? ▪ Wind and solar energy ▪ Bio energy (biomass and biofuels) ▪ Energy efficiency and saving ▪ Nuclear (fission) energy ▪ Fusion energy ▪ Natural gas ▪ Coal *Please attribute money to at least one of the options* [slider or some similar method could be used that does the maths for the person?]	0-100 Sum 100

(OPTIONAL, if we are not running out of time)

ITER, short for International Thermonuclear Experimental Reactor, is being built in the south of France to test that nuclear fusion can be controlled to generate power. ITER is a multinational effort, in which the European Union has a 45 percent stake and the United States, Russia, China and three other partners 9 percent each. It is a crucial step toward fusion power.

If it works — if it produces more energy than it consumes, which smaller fusion experiments so far have not been able to do — it could lead to plants that generate electricity from nuclear fusion. The cost of design and construction is estimated at 20 thousand million euros (around 20 euros per EU citizen).

Awareness of ITER	Q20. Before participating in this study, had you ever heard about ITER?	Yes/No
Acceptance of ITER	Q21. What is your opinion about ITER: Do you favor it, oppose it, or neither?	• Strongly Oppose (1) • Somewhat Oppose (2) • Neutral (3)

		• Somewhat Favor (4) • Strongly Favor (5)

Other variables

Finally, we would like to ask you one last question related to fusion energy

Construct	Item	Scale
General trust	Q22. How much do you trust ▪ Q22_1. Nuclear fusion scientists to make good decisions about fusion energy? ▪ Q22_2. Nuclear fusion plant managers to make good decisions about fusion energy? ▪ Q22_3. Decision makers in your country to make good decisions about fusion energy? ▪ Q22_4. Decision makers in the European Union to make good decisions about fusion energy?	Scale 1 to 5 1-not at all 2-to a small extent 3-to some extent 4-to a moderate extent 5-very much

[End text]

Many thanks for your time!

This questionnaire is part of the project Socio-Economic Research on Fusion (SES), funded by EUROfusion. For more information on the project, you can visit:

https://www.euro-fusion.org/collaborators/socio-economics/

Annex: Text for evaluation of consequences

Fusion energy

It will take years to build the technology

Fusion power presents significant scientific and engineering challenges. So far, the main problem with fusion power generation is that it doesn't produce more energy than the electrical energy required to keep the reaction going. The first commercial fusion power plant, if ITER -the larger fusion experiment going on now- succeeds, is not expected to enter the energy mix before 2050.

Less dependence on scarce resources

In a commercial fusion power station the fuel will consist of a mixture of deuterium and tritium. Deuterium is a stable hydrogen isotope. It is very abundant and may be cheaply extracted from seawater. Tritium can be produced from lithium, which is widely distributed in the Earth's crust. If used to fuel a fusion power station, the lithium in one laptop battery would produce the same amount of electricity as burning 40 tons of coal.

New installations needed

In order to implement this technology, demonstration plants would have to be built in the coming years. The next step for fusion research is the construction of the ITER, a large international fusion experiment in the south of France. The results will help guide the choice of materials for the design of DEMO, the prototype power plant that will follow the ITER experiment.

Radioactive waste

The fusion reaction releases neutrons. The neutrons would be quite dangerous to humans, but when the plant is turned off the production of neutrons ceases within milliseconds. The radioactivity in a fusion power plant will be confined to the power plant itself, there will not be any waste. Once the plant is decommissioned, the radioactive products are short lived (50-100 years) compared to the waste from a fission power plant (which lasts for thousands of years).

Contribution to climate change

The only byproduct that is created during the nuclear fusion process is helium, which is not a greenhouse gas. So the contribution to climate change by generation of electricity would be greatly reduced through the use of this technology

Price/Cost

Although it is difficult to estimate the future cost of the electricity generated by means of fusion power, recent calculations suggest that a fusion power plant could generate electricity at a similar price to a conventional nuclear power station.