THE PUBLIC ACCEPTANCE OF FUSION ENERGY RESEARCH IN EUROPE: RESULTS FROM A CROSS-NATIONAL SURVEY STUDY

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“*WITHOUT **PUBLIC ACCEPTANCE**, IT MAY BE IMPOSSIBLE FOR ELECTRIC SECTOR INNOVATIONS TO GAIN REGULATORY APPROVAL, FIND SITES, OR SECURE FUNDING…TOO OFTEN, THOUGH THE PUBLIC FACE OF NEW TECHNOLOGIES IS AN **AFTERTHOUGHT***”

Apt & Fischhoff (2006)

The aim of our research is to make the public face of Fusion a forethought in the RDD&D of the technology.

BACKGROUND AND AIMS

THE NEED FOR FUSION

- Industrialisation and population expansion means global energy demand is increasing (IEA, 2018)
- Sustainably meeting this demand is sparking innovation in supply-side tech
  - e.g. Carbon Capture and Storage; Energy Storage; Nuclear Fusion
- Benefits of Fusion
  - Fuel used to power reaction (deuterium and tritium) are readily available
  - Carbon neutral at point of generation
  - Short-lived, low-level radioactive waste
  - Fusion reaction stops as with any damage to reactor

THE CURRENT STATUS OF FUSION IN EUROPE

- **EUROFUSION** – large research programme financing research on fusion in 26 EU countries
- Joint European Torus (**JET**) experiments ongoing @ Culham Centre for Fusion Energy (UK)
- **ITER** – first plant to produce sustained fusion reaction @ Saint-Paul-lès-Durance (France) – DUE 2025.
  - Joint collaboration between 35 nations (incl. China, US, Russia, EU, Japan, Korea, India)
- **DEMO** – first functioning plant able to supply electricity to the grid @ TBD – DUE c. 2050

ITER FACILITY UNDER CONSTRUCTION IN SOUTH OF FRANCE

PUBLIC PERCEPTIONS OF FUSION

- Few articles devoted to understanding public perceptions of fusion
  - Public awareness is low but majority are favourable to the technology (e.g. Prades et al., 2008)
  - Differences in 'general' vs. 'local' attitudes (e.g. Prades et al., 2008)
  - Nuclear label is stigmatizing as is some affiliated nuclear terminology (e.g. Horlick-Jones et al., 2012; Jones et al., 2019)

AIMS OF CURRENT RESEARCH

- Investigate 'informed' lay-attitudes to fusion energy and research in representative samples of 4 x EU nations: Finland; Spain; UK; Austria* (November 2018)
- To examine key determinants of lay-attitudes to fusion

*Part of wider EU perceptions project comprising 21 nations

METHOD:
ONLINE INFORMATION CHOICE QUESTIONNAIRE

- ICQ combats assessment of 'pseudo-opinions' (e.g. Dowd et al., 2012)
  - Present policy issue and provide structured information relevant to decision context
  - Participants helped to evaluate attitude object in relation to policy issue
- Gender/age representative samples recruited via online panels (**Norstat**)
  - Soft-quota: Education and size of place of residence
  - N per country = 1,200
- Focus on Finland (positive); UK and Spain (mild-positive); Austria (negative)

METHODS AND MATERIALS

PARTICIPANT PROFILE * COUNTRY

Variable	Category	Austria (%)	Finland (%)	Spain (%)	UK (%)	P
	N	921	944	969	943	
Sex*	**Female** **Male**	51.7 48.2	49.3 50.6	47.9 52.0	47.7 52.1	= .634
Age	**18-29** **30-39** **40-49** **50-64** **65+**	17.8 16.0 21.1 27.1 18.0	19.3 16.0 20.7 22.9 20.0	16.4 21.1 20.7 22.9 18.9	17.9 16.3 19.4 24.4 22.0	= .016
Education	**< Ugrad.** **≥ Ugrad.**	75.6 24.4	74.6 25.4	46.7 53.3	65.6 34.4	< .001
Residence	**< 100,000** **≥ 100,000**	60.9 39.1	48.5 51.5	44.4 55.6	61.3 38.7	< .001

* Where figures do not add up to 100, due to participants responding 'other'

SURVEY FLOW: BASELINE

Baseline 1

- Self-claimed knowledge of energy tech.: (1) Nothing – (7) Quite a lot
- Attitudes to govt. investment in sci. research: (1) Unnecessary – (7) Necessary
- Agreement in need for nuclear energy: (1) S. Disagree – (7) S. Agree
- Ecocentric and technocentric belief statements: (1) S. Disagree – (7) S. Agree
- Agreement in need for new energy tech. options: (1) S. Disagree – (7) S. Agree

Baseline 2

- **INFORMATION 1: Fusion is an experimental technology that could be used for power generation and works by fusing together atoms to release energy.**
- Have you heard of Fusion: Yes, No
- Familiarity with Fusion: (1) Not at all familiar – (4) V. Familiar
- Personal relevance of Fusion: (1) Non-relevant – (5) V. Relevant

SURVEY FLOW: GENERAL INFORMATION & INFORMED ATTITUDES 1

General Information

- **INFORMATION 2: Reaffirming govt. desire for alternative energy sources; potential of fusion to complement other options; sustainability of fusion; significance of engineering challenges; as yet unproven (377 words)**

Informed Attitudes 1

- Attitude to Fusion as potential energy source: (1) V. Poor – (5) V. Good
- 4-items assessing affective responses to Fusion: 5-pt SD scales*
- 7-items assessing costs, risks and benefits of Fusion: 5-pt SD scales**
- Trust in science to judge risk with Fusion: (1) S. Disagree – (5) S. Agree

* EXAMPLE: (1) Optimism – (5) Pessimism

** EXAMPLE: (1) Technologically unviable – (5) Technologically viable

SURVEY FLOW: STRUCTURED EVALUATION OF CONSEQUENCES

Structured Information

- **INFORMATION 3: Outline characteristics of Fusion in randomised order: (1) Timescale to commercial demo; (2) Low dependency on scarce resource; (3) Low contribution to climate change; (4) Price of electricity; (5) Necessity for new infrastructure; (6) Low risk from radioactive waste**

Characteristic Evaluation

- Information checked with Fusion experts
- Each characteristic evaluated: (1) V. Negative – (5) V. Positive
- Restate 'global attitude' to Fusion: (1) V. Poor – (5) V. Good
- Acceptability of development of Fusion: (1) T. Unacceptable – (5) T. Acceptable

SURVEY FLOW: FINAL ATTITUDES TOWARDS INVESTMENT IN FUSION

Investment Attitudes

- Support for investment in Fusion research at (a) Country level and (b) EU level: (1) S. Oppose – (5) S. Support
- Agreement that funding in Fusion should be redirect to (a) renewables (b) efficiency and (c) conventional sources: (1) S. Disagree; (5) S. Agree

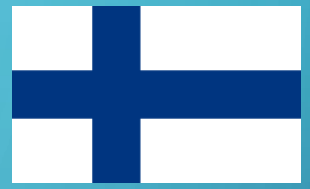
Investment Task & Trust

- Distribution of hypothetical EURO 100 between (1) wind and solar; (2) bio-energy; (3) energy efficiency; (4) nuclear fission; (5) Fusion; (6) natural gas; (7) coal
- Trust in four groups of decision-makers (i.e. fusion scientists; fusion plant managers; national decision makers; EU decision makers): (1) Not at all – (5) V. much

ANALYSIS AND RESULTS

4 X COUNTRY COMPARATIVE ANALYSIS (FINLAND, AUSTRIA, SPAIN, UK)

COMBINED PATH ANALYSIS

Gen.		Attitude*
30%		Pro-nuclear
19%		Split
21%		
0%		Anti-nuclear

*Public attitudes to nuclear power (NEA, 2010)

INITIAL AWARENESS AND FAMILIARITY

		Austria (AT)	Finland (FN)	Spain (ES)	UK (UK)
Self-claimed awareness	**Yes**	41.6	54.1	43.6	42.9
	No	58.4	45.9	56.4	57.1
Self-claimed familiarity*		2.07 (0.62)	2.16 (0.55)	2.09 (0.59)	2.19 (0.67)
* 1 = Not at all familiar; 4 = Very familiar					

Self-claimed awareness = highest in FINLAND

Self-claimed familiarity = low-overall; highest in UK and FINLAND

SELECT COMPARISONS

Variable	Austria (AT)	Finland (FN)	Spain (ES)	UK (UK)	Comparisons
N	921	944	969	943	
Attitudes to nuclear energy	1.68 (0.98)	3.30 (1.12)	2.85 (1.13)	3.30 (1.12)	• AT < FN/ES/UK*** • ES < FN/UK***
Attitudes towards science	5.57 (1.40)	5.65 (1.25)	6.12 (1.10)	5.36 (1.31)	• AT/FN/UK < ES*** • UK < AT/FN***
Trust in fusion decision makers	2.64 (0.81)	3.18 (0.79)	3.11 (0.91)	2.99 (0.95)	• AT < FN/ES/UK*** • UK < FN/ES**
Personal relevance of fusion	2.93 (1.10)	3.07 (1.05)	3.37 (0.94)	3.05 (1.13)	• AT < FN/ES/UK* • FN/UK < ES***

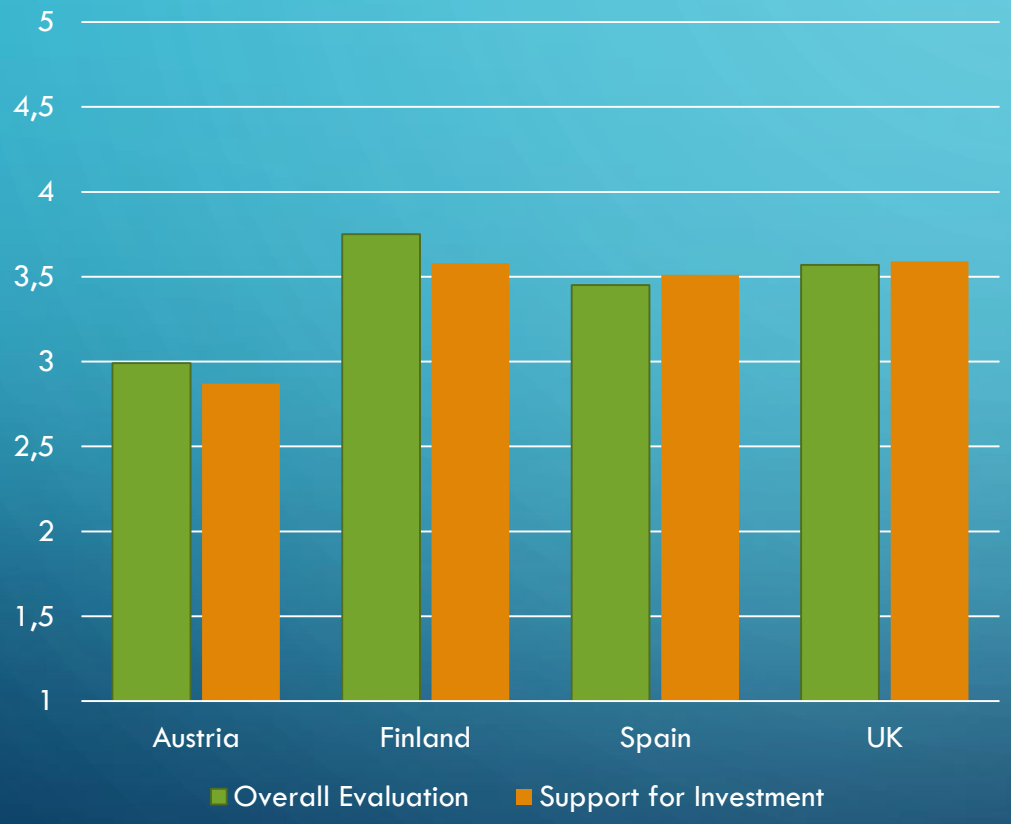
AUSTRIA = Dislike nuclear energy; favourable towards scientific innovation; distrust fusion decision-makers; feel like fusion is not relevant
FINLAND = Like nuclear energy; favourable towards scientific innovation; trust fusion decision-makers; feel fusion is somewhat relevant
SPAIN = Dislike nuclear energy; very favourable towards scientific innovation; trust fusion decision-makers; feel fusion is personally relevant
UK = Like nuclear energy; favourable towards scientific innovation; ambivalent in trust for decision-makers; feel fusion is somewhat relevant.

SELECT COMPARISONS

Variable	Austria (AT)	Finland (FN)	Spain (ES)	UK (UK)	Comparisons
N	921	944	969	943	
Affect related to fusion	3.00 (0.98)	3.59 (0.79)	3.48 (0.94)	3.48 (0.88)	• AT < FN/ES/UK*** • ES/UK < FN**
Perceived consequences of investment in fusion	2.86 (0.68)	3.55 (0.68)	3.43 (0.84)	3.41 (0.81)	• AT < FN/ES/UK*** • ES/UK < FN***
Preference for renewables	3.87 (1.05)	3.37 (0.89)	3.82 (0.95)	3.47 (1.00)	• FN/UK < AT/ES*** • FN < UK*

AUSTRIA = Ambivalent affect; negative evaluation of consequence; strong preference for renewables
FINLAND = Positive affect; positive evaluation of consequence; preference for renewables
SPAIN = Positive affect; positive evaluation of consequences; strong preference for renewables;
UK = Positive affect; positive evaluation of consequences; preference for renewables

OVERALL ATTITUDE AND SUPPORT FOR INVESTMENT



Overall attitude

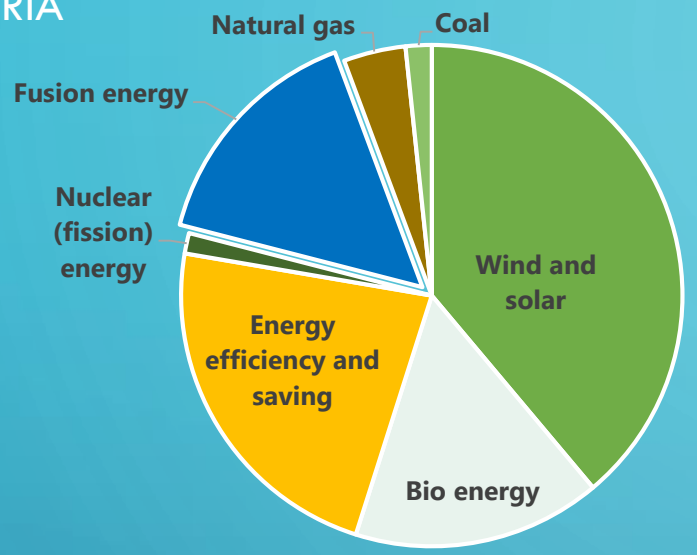
- Finland > UK > Spain > Austria
  - Austrians ambivalent on average

Support for investment in fusion

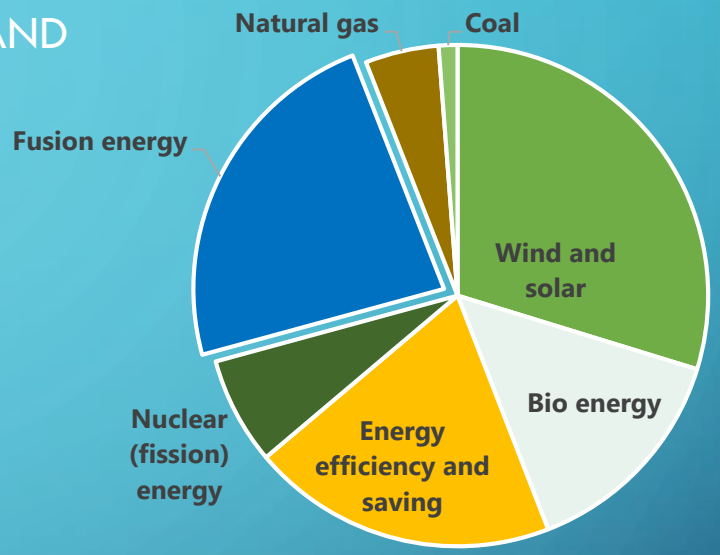
- Finland/UK/Spain > Austria
  - Austrians ambivalent on average

AVERAGE INVESTMENT IN ENERGY OPTIONS

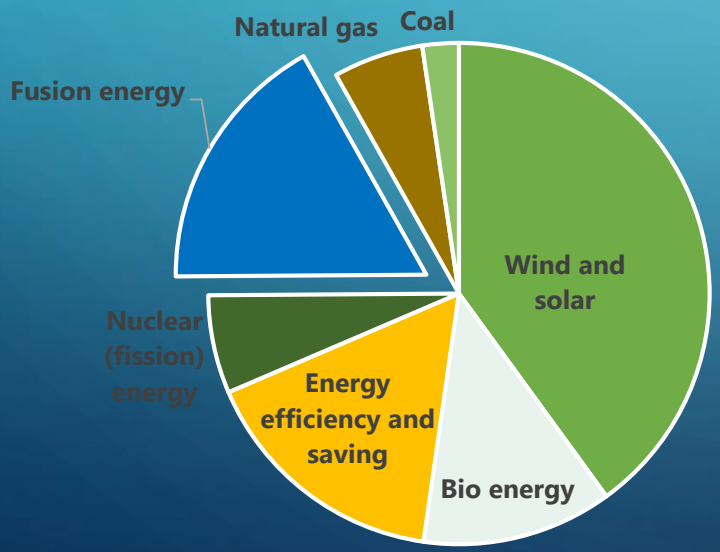
AUSTRIA



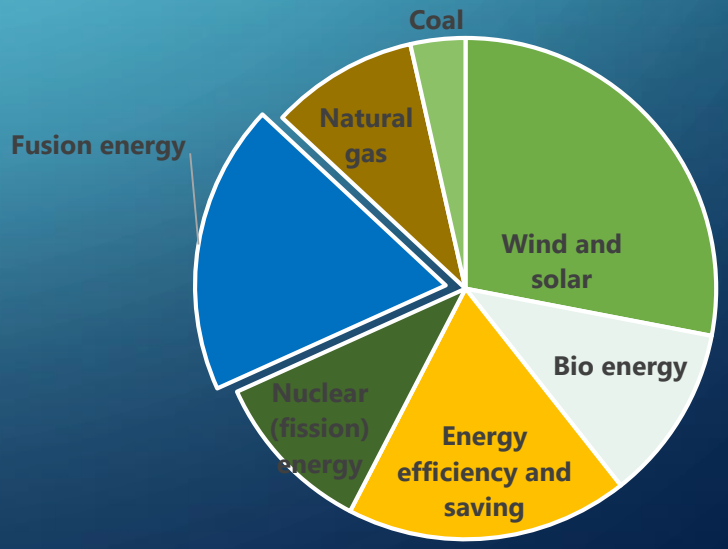
FINLAND



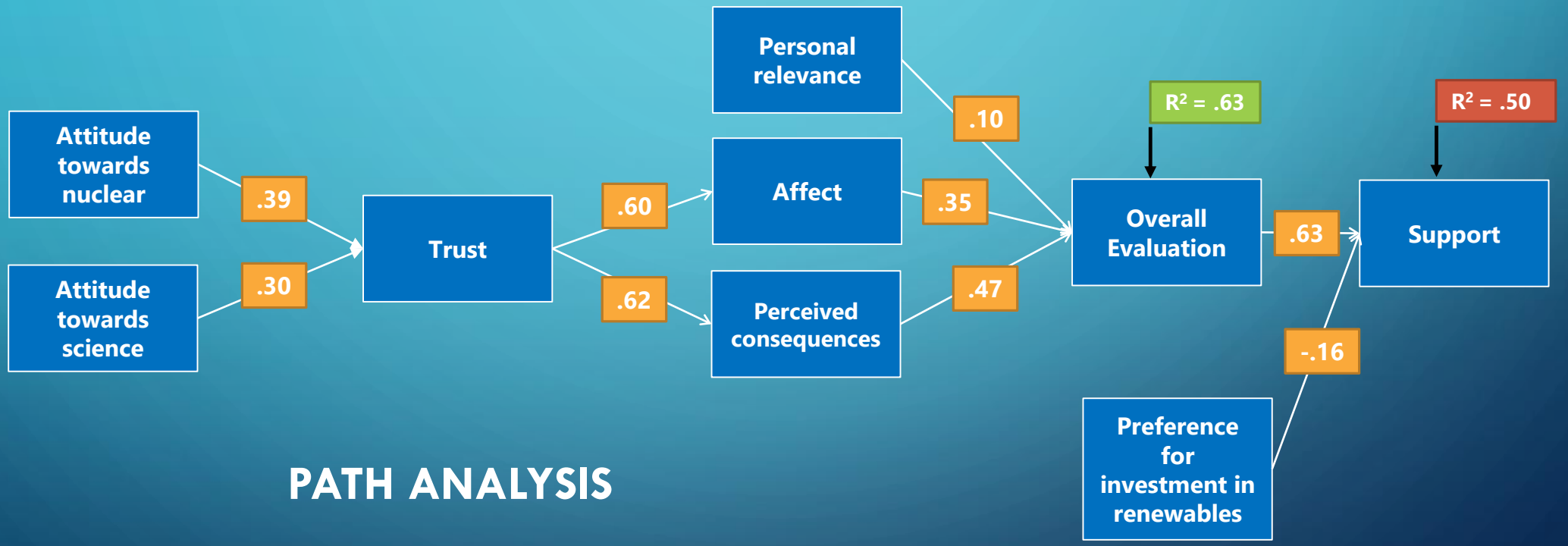
SPAIN



UNITED KINGDOM



DETERMINANTS OF SUPPORT FOR PUBLIC INVESTMENT IN FUSION ENERGY RESEARCH



PATH ANALYSIS

DIRECT AND INDIRECT EFFECTS ON SUPPORT FOR PUBLIC INVESTMENT ON FUSION ENERGY RESEARCH

(STANDARDIZED COEFFICIENTS B)

	Direct effect	Indirect effect	Total effect
Overall evaluation	.63	--	.63
Preference for investments in renewables	- .16	--	- .16
Personal relevance	--	.06	.06
Affect	--	.22	.22
Perceived consequences	--	.30	.30
Trust	--	.32	.32
Attitude towards nuclear	--	.12	.12
Attitude towards science	--	.09	.09

DISCUSSION

- All nations show a moderate level of familiarity with fusion
- The majority of respondents (54-80%) in the four nations accepts the development of fusion. Support for public investments in fusion is lower (35-58%)
- Moderate and statistically significant variation between the four study populations in attitudes towards fusion and acceptance/support
- Perceived consequences and trust, together with a preference for investments in renewables are the strongest predictors of support for fusion energy research
- Relevant influence of evaluation of fission on support for fusion (positive medium correlation with affect, perceived consequences, trust, evaluation and support)

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