

Supplementary materials

Supplementary Table 1: Focus group participant demographics

		Gender	Age	Ethnicity	Home Area
Focus group 1 (FG1)	P1	Male	35-44	Asian	Urban
	P2	Female	55-64	White	Rural
	P3	Male	45-54	White	Rural
	P4	Female	35-44	White	Rural
	P5	Female	25-34	White	Rural
	P6	Male	25-34	White	Urban
Focus group 2 (FG2)	P1	Female	35-44	White	Rural
	P2	Male	45-54	White	Suburban
	P3	Male	18-24	Mixed / Multiple ethnic	Urban
	P4	Male	35-44	Mixed / Multiple ethnic	Urban
	P5	Female	25-34	White	Urban
	P6	Female	25-34	White	Rural
	P7	Male	55-64	White	Suburban

Supplementary Table 2: Focus group 1 protocol

Time	Length	Task	Logistics	Purpose
17:40	10	Set-up and mic check	Zoom, chat function and phone if needed	Solving any technical difficulties in time for participants' arrival from 5.50pm
17:50	10	Participant arrival	Check for tech issues	Participants relax into the group, answer questions, explain full briefing will take place at 6pm
18:00	10	Introductions	Zoom [facilitator]	Introduce the project team and aims Check consent to record Housekeeping Participant intros and ice-breaker
18:10	10	Introduce RES and vignettes	PowerPoint Google Slides	Brief PPT introduction to renewable energy Link to vignettes: 2 mins on each tech
18:20	40	Discussion of vignettes	Zoom [participants] (Google Slide available)	Discuss perceptions of geothermal and hydrogen Probe for connections made with other techs
19:00	10	Coffee break		
19:10	5	Fracking vignette	Google Slides	Introduce participants to fracking
19:15	30	Fracking discussion	Zoom [participants]	Probe the connection between fracking and other techs Identify salient discourses
19:45	10	Q&A	Zoom [participants]	Participants ask questions of the project team Use additional prompt questions
19:55	5	Wrap up	Zoom [facilitator]	Thank participants for their time and inform them of next steps

Supplementary Table 3: Focus group 2 protocol

Time	Length	Task	Logistics	Purpose
17:40	10	Set-up and mic check	Zoom, chat function and phone if needed	Solving any technical difficulties in time for participants arrival from 5.50pm
17:50	10	Participant arrival	Check for tech issues	Participants relax into the group, answer questions, explain full briefing will take place at 6pm
18:00	10	Introductions	Zoom [facilitator]	Introduce the project team and aims Check consent to record Housekeeping Participant intros and ice-breaker
18:10	5	Introduce RES and hydrogen vignette	PowerPoint Google Slides	Brief PPT introduction to renewable energy Link to Hydrogen vignette; 3 mins reading time
18:15	25	Hydrogen discussion	Zoom [participants] (Google Slide available)	Discuss perceptions of hydrogen Probe for connections made with other techs
18:40	5	Geothermal vignette	Google Slides	Link to geothermal vignette; 3 mins reading time
18:45	25	Geothermal discussion	Zoom [participants] (Google Slide available)	Discuss perceptions of hydrogen Probe for connections made with other techs Probe questions around depth
19:10	10	Coffee break		
19:20	5	Fracking vignette	Google Slides	Introduce participants to fracking
19:25	20	Fracking discussion	Zoom [participants]	Probe the connection between fracking and other techs Identify salient discourses
19:45	10	Q&A	Zoom [participants]	Participants ask questions of the project team 'Spare' prompt questions used to fill session
19:55	5	Wrap up	Zoom [facilitator]	Thank participants for their time and inform them of next steps

Supplementary Table 4: Survey Demographics

Demographic		Frequency	Percent
Gender	Female	471	50.8%
	Male	447	48.2%
	Gender fluid	2	0.2%
	Gender neutral/non-binary	1	0.1%
	Write-in	2	0.2%
	Prefer not to say	4	0.4%
Age	18-24	122	13.2%
	25-34	162	17.5%
	35-44	159	17.2%
	45-54	167	18.0%
	55-64	220	23.7%
	65+	94	10.1%
	Prefer not to say	3	0.3%
Ethnicity	White	772	83.3%
	Asian	74	8.0%
	Black	37	4.0%
	Mixed	23	2.5%
	Other	17	1.8%
	Prefer Not to Say	4	0.4%
Personal Income Per Year (before tax)	Less than £13,000	255	27.5%
	Between £13,000 and £18,000	112	12.1%
	Between £18,001 and £25,000	164	17.7%
	Between £25,001 and £37,000	180	19.4%
	More than £37,000 per year	128	13.8%
	Prefer not to say	88	9.5%
Highest education level	Primary school	1	0.1%
	Secondary school (under 15 yrs old)	32	3.5%
	General NVQ Foundation or intermediate / GCSE / SCE Standard	105	11.3%
	NVQ 1 or NVQ 2	28	3.0%
	A Level / NVQ3 / SCE Higher Grade / Scottish cert. of sixth year studies / GNVQ Advanced	211	22.8%
	Bachelor's Degree / NVQ4 / Higher National Certificate / HND / Diploma in HE	369	39.8%
	Post Graduate (e.g. MSc, PhD) / NVQ5	178	19.2%
	Prefer not to say	3	0.3%
Political party 'most likely to support'	Conservative ¹	188	20.3%
	Labour ²	286	30.9%
	Liberal Democrats (Lib Dems) ²	93	10.0%
	Green Party ²	82	8.8%
	UK Independence Party (UKIP) ¹	3	0.3%
	British National Party (BNP) ¹	1	0.1%
	Scottish National Party (SNP) ²	24	2.6%
	Plaid Cymru ²	9	1.0%
	Democratic Unionist Party ¹	2	0.2%
	Sinn Féin ²	3	0.3%
	Other	15	1.6%
	Undecided	134	14.5%
	Would Not Vote	53	5.7%
	Prefer Not To Say	34	3.7%

¹ Right-of-centre political party ² Left-of-centre political party

Supplementary Note 1: Survey Protocol

The survey made extensive use of branching logic, where a participants' answer to a previous question determined the questions they saw and the wording of the questions. For example, where people said they 'strongly supported' something, the following question would ask 'please explain why you strongly support'... For brevity, the branching text has been included in square brackets.

We also included timing checks after each vignette, which prevented participants from clicking through to the next question until enough time had passed for them to fully read the information. We included an attention check (Q18) which was successfully completed by 100% of participants. 28 responses were removed from all analysis as they did not complete the survey.

Q1 Information about the survey

The survey is investigating opinions towards alternative energy technologies. It should take around 10 minutes to complete. The survey is anonymous and your computer's IP address will not be recorded.

What will I need to do?

You'll be asked to read a short piece of information about an alternative energy technology, before answering some questions about your opinions on this technology. You will then answer some short survey questions, before giving us some information about yourself at the end of the study. There are no right or wrong answers, so please answer as honestly as you can. At the bottom-right of the screen is an arrow button. Click on the arrow each time you are ready to move to the next page.

What's in it for you?

You will automatically receive £1.25 via Prolific on completion of the survey. You will need to submit your answers on the final screen to be redirected back to Prolific and receive payment.

Who is the survey for?

The survey is being carried out by researchers at Cardiff University. Overall results may be used in reports, presentations and academic articles. If you have any questions or concerns about the survey, please contact [insert]. The data controller is Cardiff University and the Data Protection Officer is [name]. The lawful basis for the processing of the data you provide is public interest.

By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age or older, you are aware that you may choose to terminate your participation in the study at any time, for any reason, without penalty.

Q2 Do you give your consent to take part in this study?

Q4 To help prevent climate change and global warming, new forms of 'clean' energy will be required. Often, these are referred to as renewable energy. Wind power and solar power are well-known forms of renewable energy. There are also other renewable technologies that are being developed, one of which you will read about below.

Q5, Q9 [Show hydrogen / geothermal vignette]

Q6, Q10 After reading this information, do you support or oppose Hydrogen / Deep Geothermal as an energy source to be used in the UK? (7-point Likert, strongly support / support / slightly support / neither support nor oppose / slightly oppose / oppose / strongly oppose)

Q12 – Q17 Please list the reasons why you [support/oppose] Hydrogen / Deep Geothermal being used as an energy source in the UK (open ended)

Q18 Please answer 4 to this question (attention check)

Q19 Have you ever heard of "fracking" as a method of gas production? (Yes / No)

Participants answering 'yes' to this question, go to Q20. Participants answering 'no' to this question go straight to Q23

Q20, Q21 Did your knowledge of fracking influence your opinion of Hydrogen / Deep Geothermal? (7-point Likert, 'Made me much more positive to 'made me much more negative')

Q22 Please tell us how and why fracking influenced your opinion (Open-ended)

Q23 Please read the information below. Following this you will be asked some questions about your opinion of fracking.

Q25 [Show fracking vignette]

Q26 Do you support or oppose Fracking as an energy source to be used in the UK? (7-point Likert, 'strongly support' to 'strongly oppose')

Q28 Next we are interested in whether reading about Fracking has changed your opinion of Hydrogen / Deep Geothermal as an energy source in the UK. Please answer honestly. If your opinion has not changed then select the same answer as you previously gave (you will be reminded of what this was).

Q30 – Q56 You previously answered that you ["strongly support / support / slightly support / neither support nor oppose / slightly oppose / oppose / strongly oppose"] Hydrogen / Deep Geothermal. After reading about fracking, we are interested in whether your opinion on Hydrogen / Deep Geothermal has changed at all, or stayed the same? (7-point Likert, strongly support to strongly oppose)

Q31 – Q57 Please tell us how and why fracking influenced your opinion (open ended)

Q58 Now for some general questions. To what extent do you trust each of the following? [Scientists; Government; Industry / fuel companies] (Distrust a lot / distrust a little / neither trust nor distrust / trust a little / trust a lot)

Q59 Please indicate how much you **agree** or **disagree** with the statements that follow. There are no right or wrong answers, please answer how you feel. (All measured on 5-point Likert, Strongly agree / somewhat agree / neither agree nor disagree / somewhat disagree / strongly disagree)

Q60 When humans interfere with nature, it often produces disastrous consequences

Q61 The balance of nature is strong enough to cope with the impacts of modern industrial nations.

Q62 The balance of nature is very delicate and easily upset.

Q63 Humans are severely abusing the environment.

Q64 The so-called 'ecological crisis' facing humankind has been greatly exaggerated.

Q65 If things continue on their present course, we will soon experience a major ecological catastrophe.

Q66 The final section will ask some questions about yourself (demographics, see Supplementary Table 4 for options)

Q67 What best describes your gender?

Q68 Age

Q69 Where is your permanent residence within the UK? (Country plus county drop-down)

Q70 What is your highest level of education?

Q71 What is your personal income (before tax)?

Q72 Which political party are you most likely to support?

Supplementary Note 2: Focus group slides

Renewable Energy

- Climate change is already affecting many parts of the world, including the UK
- Burning fossil fuels creates greenhouse gases like carbon dioxide. This is a big cause of climate change
- New forms of clean energy will be required. Often these are referred to as "renewable energy"
- Wind and solar power are well-known forms of renewable energy

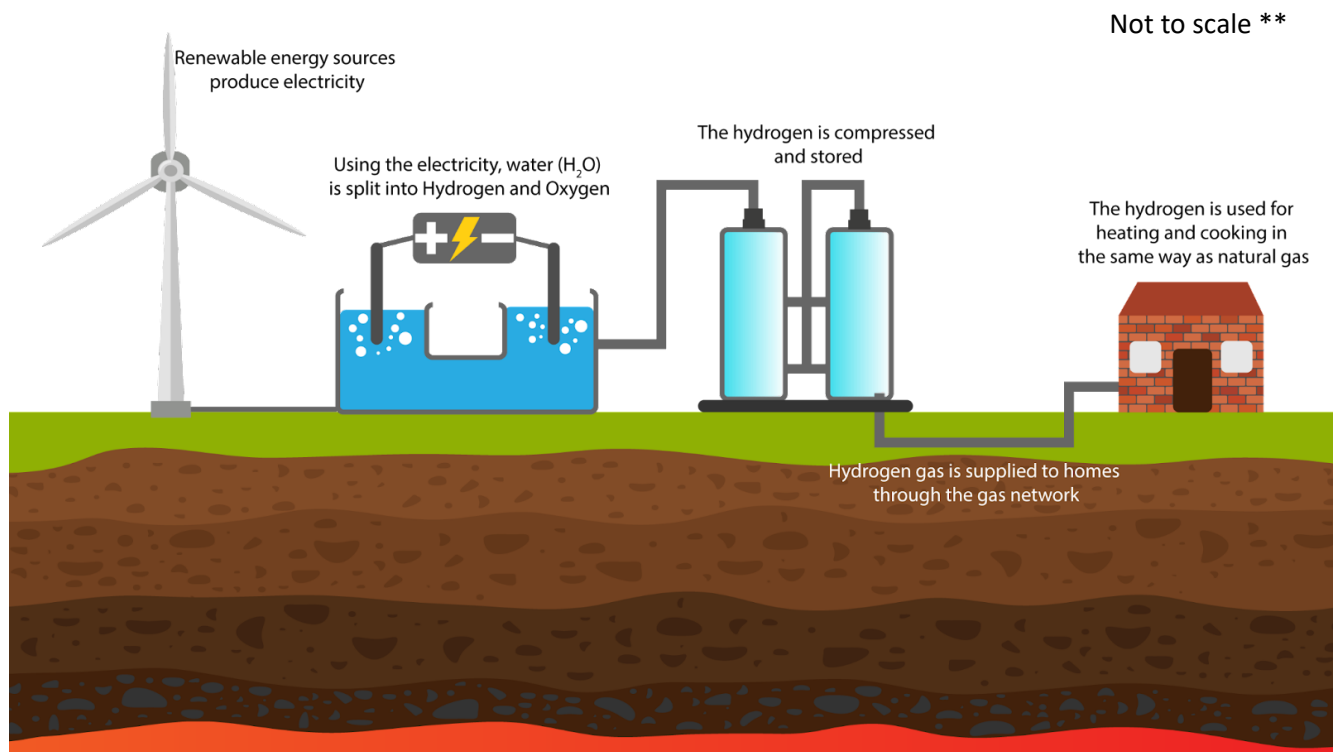
This evening we will be discussing other forms of renewable energy



Images sourced from <http://wallpaperflair.com> (free downloadable wallpaper images)

Supplementary Note 3: Vignettes

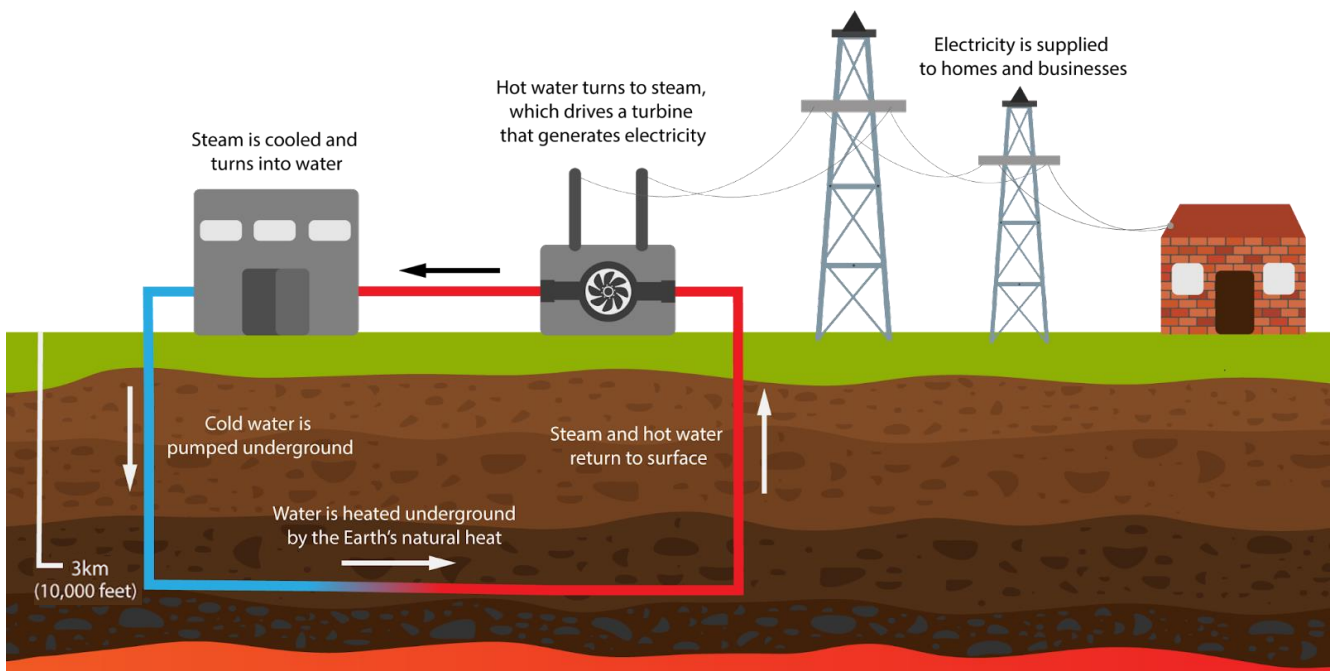
All images created by Conor John.



Hydrogen energy

Hydrogen gas can be used for various purposes including heating homes, powering factories, generating electricity, or as fuel for large vehicles. It can be produced by using electrical energy to split water (H₂O) into Hydrogen and Oxygen, through a process called electrolysis. This creates hydrogen gas, which can be stored or transported by road, rail, or through pipelines. Hydrogen production sites could be located near towns in order to provide gas to the local area.

Producing hydrogen usually requires fossil fuels. However, this alternative form of hydrogen production uses renewable energy, such as wind, solar or tidal power, to make a product called 'green hydrogen'. Hydrogen could be a renewable alternative to natural gas, which is already widely used for energy, and to the hydrogen that is already used in industry which currently comes from fossil fuels. It produces no emissions, and the only by-product is water. However, it is a highly volatile and flammable substance, so it is complex to store and transport. It is also currently expensive to produce, requiring a lot of energy and water.

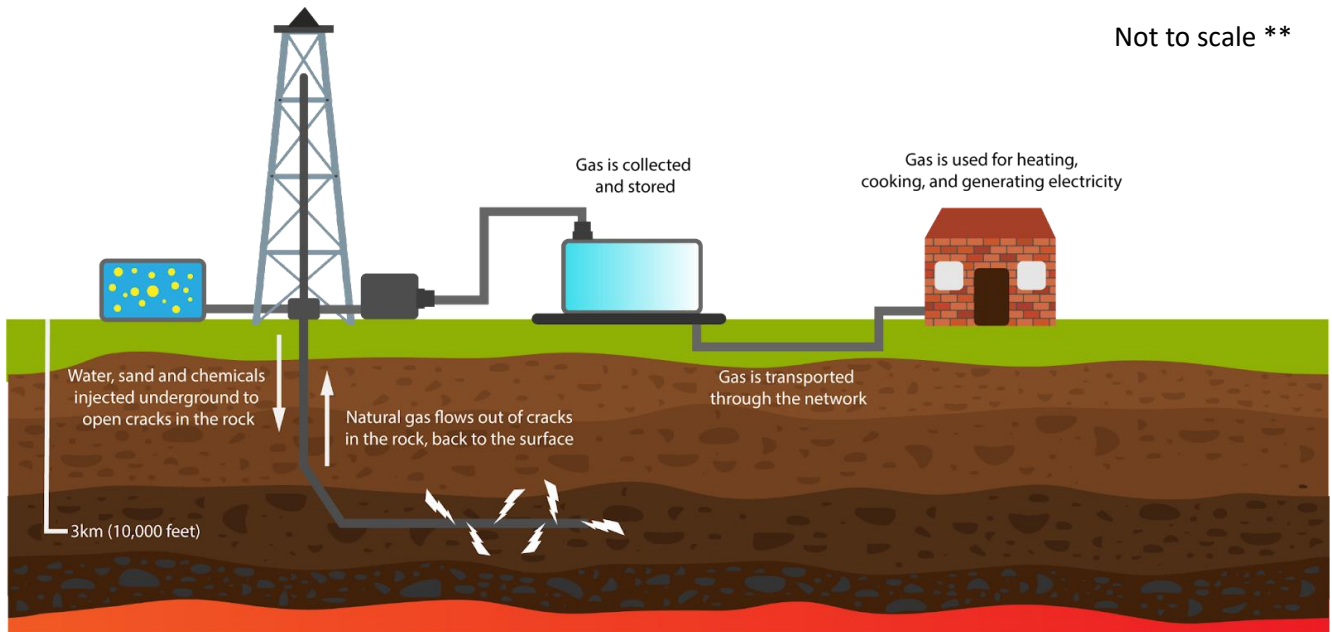


Deep geothermal energy

Geothermal energy is a type of renewable energy that uses the heat from inside the Earth to generate electricity. To extract this heat, water is pumped down a borehole at high pressure to a depth of several kilometres where it creates fractures in the rock. This allows water to travel through the hot rocks deep underground, capturing the heat, until it is pumped up to the surface as hot water. The hot water can be used for heating, or to drive turbines which generate electricity.

Production sites could be located in suitable geological locations near towns in order to provide heating for the local area. Geothermal energy could provide a source of renewable energy which does not depend on the weather. The plants have a low visual impact compared to some renewables such as wind and solar. However, the process used to extract the heat runs the risk of triggering earth tremors. The process uses a lot of water, and can be expensive to set up. There are other forms of Geothermal energy production, such as shallow geothermal (the kind used in Iceland), but this requires specific geology.

Not to scale **



Hydraulic fracturing ('fracking')

Hydraulic fracturing, more commonly known as “fracking”, is a process used to extract natural gas from underground gas reservoirs. Natural gas is a fossil fuel, so is not a renewable energy source. Fracking involves injecting a mix of water, sand and chemicals deep underground at high pressure. This causes fractures in the rock which release gas. The gas then flows up to the surface through pipes.

The gas can be used to heat people's homes using their standard gas boilers, or to create electricity in power stations. Gas can also be used to make materials such as fertilisers. At the moment, the UK imports a significant amount of gas from other countries. If there were a very large number of fracking sites in the UK, the need for these imports could be reduced. However, when gas is burnt as a fossil fuel it creates carbon dioxide, which contributes to climate change. In 2019, the UK government halted all fracking activity because of the risk that drilling activity can cause earth tremors, and because of public opposition.

Supplementary Note 4: Support for hydrogen and geothermal

Both hydrogen and deep geothermal encountered some support, with mean responses of >0 throughout. Independent samples t-tests showed that support for green hydrogen was significantly greater than support for deep geothermal, both at the start of the survey after viewing the vignettes on each technology but before being prompted or primed to consider fracking (Table 5), and after viewing the fracking vignette (Table 6). Paired samples t-tests showed that for green hydrogen, there was no significant change before and after reading about fracking, whereas participants' opinions about deep geothermal became significantly less positive after reading about fracking (Table 7). Note that the hydrogen/geothermal questions after the fracking vignette reminded participants of their initial responses.

Supplementary Table 5: Independent Samples T-test (two-tailed) comparing support for Hydrogen vs. Deep Geothermal at the beginning of the survey, before fracking was mentioned. N=927

Condition/Tech	Support/Opposition for Technology				t	Sig.
	M*	SD	df	M Difference		
Green Hydrogen	+0.81	1.53	464	0.39	3.632	.000
Deep Geothermal	+0.42	1.73	463			

* Mean on a 7-point Likert scale, where -3 = I strongly oppose, 0 = neither support nor oppose, +3 = I strongly support)

Supplementary Table 6: Independent Samples T-test (two-tailed) comparing support for Hydrogen vs. Deep Geothermal, after reading the fracking Vignette. N=927

Condition/Tech	Support/Opposition for Technology				t	Sig.
	M*	SD	df	M Difference		
Green Hydrogen	+0.74	1.56	906	0.55	4.96	0.000
Deep Geothermal	+0.19	1.80				

* Mean on a 7-point Likert scale, where -3 = I strongly oppose, 0 = neither support nor oppose, +3 = I strongly support)

Supplementary Table 7: Two separate Paired Samples T-tests (two-tailed) comparing support for Hydrogen before and after receiving information on fracking, and comparing support for Deep Geothermal before and after receiving information on fracking. Green hydrogen condition n=464. Deep geothermal condition n=463.

Condition	Before /After Fracking Info	Support/Opposition for Technology				t	Sig.
		M*	SD	df	M Difference		
Green Hydrogen	Before	+0.81	1.53	463	0.07	1.400	0.162
	After	+0.74	1.56				
Deep Geothermal	Before	+0.42	1.73	462	0.23	5.157	0.000
	After	+0.19	1.80				

* Mean on a 7-point Likert scale, where -3 = I strongly oppose, 0 = neither support nor oppose, +3 = I strongly support)

Supplementary Note 5: Word Frequency Counts

Supplementary Table 8: Word frequencies (no. of participants) response to open-ended question, “Please list the reasons why you support / oppose hydrogen / geothermal”, ordered from most to least frequently occurring.

	Hydrogen condition (n=464)				Geothermal condition (n=463)			
	Support	Neither	Oppose	Total	Support	Neither	Oppose	Total
Energy*	123	12	17	152	115	9	9	133
Renewable	98	6	5	109	82	6	2	90
Tremors	0	0	0	0	23	15	80	118
Water	33	4	13	50	13	3	32	48
Risk	4	3	3	10	18	7	47	72
Fossil Fuel	68	2	7	77	0	0	0	0
Danger(ous)	7	7	33	47	2	2	14	18
Expensive	9	7	25	41	2	0	8	10
Safe(r)	15	6	3	24	9	1	4	14
Fracking	2	0	0	2	5	1	21	27
Flammable	4	3	22	29	0	0	0	0
(Earth)quakes	0	0	0	0	6	1	18	25
Safety	6	3	5	14	2	0	0	2
Drill(ing)	0	0	0	0	2	1	3	6
Risky	0	0	0	0	1	0	4	5
Oil	3	0	0	3	1	0	0	1
Fracturing	0	0	0	0	1	0	3	4
Fracture	0	0	0	0	1	0	3	4
Underground	0	0	0	0	1	0	1	2
Shale (gas)	0	0	0	0	0	0	0	0
Tight Gas	0	0	0	0	0	0	0	0

* All include common errors and spelling mistakes

Supplementary Table 9: Word frequencies (number of participants) for responses to the open-ended question “How and why did fracking influence your opinion of [Hydrogen or Deep Geothermal]?”

	Hydrogen condition (n=401)*		Geothermal condition (n=402)*	
	More positive	More negative	More positive	More negative
Fracking	44	17	22	103
Environment	24	14	10	22
Earth	5	1	2	46
Tremors	3	1	2	46
Similar	0	0	3	31
Water	5	3	1	19
(Earth)quakes	4	2	1	17
Danger(ous)	7	7	2	7
Risk	7	1	2	13
Energy	6	0	5	12
Safe(r)	5	5	2	5
Drill(ing)	3	0	2	6
Damaging	5	2	0	3
Oil	2	0	2	4
Renewable	2	1	1	2
Underground	2	0	1	2
Fracturing	1	1	1	0
Shale (gas)	0	0	0	2
Safety	0	1	0	1
Tight Gas	0	0	0	0

* Only the participants who had previously heard of fracking received this question in the survey