British Geological Survey

UNIVERSITY of STIRLING

Natural Environment Research Council

Evaluating the relationship between public perception, engagement and attitudes towards underground energy technologies

UK Geoenergy Observatories Programme

Open Report OR/20/056

BRITISH GEOLOGICAL SURVEY

UK GEOENERGY OBSERVATORIES

Keywords

Report; perceptions, geoenergy.

Bibliographical reference

DICKIE, J; WATSON, E; NAPIER, H 2020.

This report was written by Stirling University under contract for the BGS.

Evaluating the relationship between public perception, engagement and attitudes towards underground energy technologies

Dickie, Jennifer (Stirling University); Watson, Eilidh (Stirling University); Napier, Hazel

Keyworth, Nottingham British Geological Survey 2020

BRITISH GEOLOGICAL SURVEY

The full range of our publications is available from BGS shops at Nottingham, Edinburgh, London and Cardiff (Welsh publications only) see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications, including maps, for consultation.

We publish an annual catalogue of our maps and other publications; this catalogue is available online or from any of the BGS shops.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as basic research projects. It also undertakes programmes of technical aid in geology in developing countries.

The British Geological Survey is a component body of UK Research and Innovation.

British Geological Survey offices

Nicker Hill, Keyworth,
Nottingham NG12 5GG
Tel 0115 936 3100

BGS Central Enquiries Desk
Tel 0115 936 3143
email enquiries@bgs.ac.uk

BGS Sales
Tel 0115 936 3241
email sales@bgs.ac.uk

The Lyell Centre, Research Avenue South,
Edinburgh EH14 4AP
Tel 0131 667 1000
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road,
London SW7 5BD
Tel 020 7589 4090
Tel 020 7942 5344/45
email bgslondon@bgs.ac.uk

Cardiff University, Main Building, Park Place,
Cardiff CF10 3AT
Tel 029 2167 4280

Maclean Building, Crowmarsh Gifford,
Wallingford OX10 8BB
Tel 01491 838800

Geological Survey of Northern Ireland, Department of Enterprise, Trade & Investment, Dundonald House, Upper Newtownards Road, Ballymiscaw,
Belfast, BT4 3SB
Tel 01232 666595
www.bgs.ac.uk/gsni/

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU
Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

UK Research and Innovation, Polaris House,
Swindon SN2 1FL
Tel 01793 444000
www.ukri.org

Website www.bgs.ac.uk
Shop online at www.geologyshop.com

Contents

FIGURES

TABLES

1 Executive Summary

This report summarises key findings from a series of participatory workshops used to evaluate the relationship between public perception, engagement and attitudes towards underground energy technologies.

The main aim of this project is to get a better understanding of attitudes towards publicly-funded energy decarbonisation science from a cross section of society by evaluating public awareness and understanding of underground energy decarbonisation techniques, investigating the role of energy literacy and evaluating levels of engagement and public attitudes towards the £31m investment in UK Geoenergy Observatories and the UK earth science decarbonisation research agenda. Participatory workshops were developed to actively engage members of the public in discourse; these included pre and post workshop questionnaires, creative drawing exercises and participant-led discussions. In order to reach the target audience, the non-engaged public, and to encourage peer-to-peer discussions, an experimental approach was used in the recruitment process – that of inviting a variety of existing community groups to take part. Community groups included church groups, U3A, mother and baby and student groups. In total, 7 workshops were held in 3 different locations: Glasgow, Stirling and Lincolnshire; with 41 participants taking part. The workshops focussed on 4 main topics:

1.1 PUBLIC PERCEPTIONS AND ATTITUDES TOWARDS UNDERGROUND ENERGY TECHNOLOGIES

Energy policy framings and beliefs were investigated to give an indication about how best to frame the development of subsurface energy technologies. High levels of awareness and concern about climate change were demonstrated, suggesting that primarily framing the development of sub-surface energy technologies around the role they will play in the transition to a low carbon future would seem to be a sensible approach. Levels of **energy literacy** were assessed; participants generally had a good grasp of energy generation and associated technologies, but acknowledgement of the distribution and storage components of the energy system were relatively lacking. Given the role the subsurface and associated technologies have in these aspects, the importance of these 'less considered' aspects of the energy system should be a key focus in any engagement strategy. It was also evident that the language used by scientists and policymakers needs to be more accessible to the public. If using the terms 'energy system' or 'energy landscape' they should be described appropriately using language familiar to a lay person, for example, 'the way we generate, use, store and distribute energy'. **Attitudes and perceptions of sub-surface technologies** were explored, demonstrating that awareness of these technologies is generally low and participants found it difficult to express strong opinions. Three key inter-linked themes emerged from the discussions: risk, accountability and trust, and the influence of the media. With much debate around the potential risks involved, many participants felt that they needed more information about the benefits and risks of each of the technologies in order to make more informed decisions.

1.2 IMPROVING LEVELS OF ENGAGEMENT WITH PUBLICLY FUNDED GEOENERGY SCIENCE

Workshop activities enabled the project team to explore 3 main themes – knowledge of the BGS and its activities, sources of participants' energy knowledge and participant trust in different sources of information. One of the key challenges identified is that **the public are largely unaware of the types of research and activities carried out by the BGS**, and knowledge of the UK Geoenergy Observatories is very low. Although over half the participants had heard of the BGS and **levels of trust were high**, participants wanted to know more about the organisation and suggested any information should be easily accessible via the BGS website and engagement materials. **BGS is seen as an organisation associated with 'mapping,**

surveying, research, environment and geology' rather than a source of energy information and pathways to a low carbon future. Participants suggested more accessible communication channels such as documentaries or radio shows would be more effective in engaging the public with these aspects of geoscience.

1.3 DO PUBLIC ATTITUDES AND PERCEPTIONS OF GEOENERGY OPTIONS ALIGN WITH THE RESEARCH AGENDAS OF THE EARTH SCIENCE COMMUNITY?

Broad questions were asked about the perceived benefits and disadvantages of sub-surface energy technologies, the communication of these by experts and whether they considered the research to be a good use of public money, particularly in relation to the UK Geoenergy Observatories and the science being funded. The focus on disadvantages was heavily on risks and uncertainty, followed by cost and lack of research. The benefits, however, included a range of socio-economic and environmental benefits that suggests there is value in BGS pursuing research in this area. Despite a variety of concerns being raised about the use of the subsurface for energy related activities, there was **recognition that a better scientific understanding of the risks and uncertainties associated with each technology is needed**. Overall, participants were **supportive of the UK Geoenergy Observatories** in principle, however, the low level of awareness of the observatories, and the research being carried out, meant that participants were wary of providing their support.

1.4 EVALUATING THE EFFECTIVENESS OF COMMUNITY-FOCUSED, PARTICIPATORY WORKSHOPS AS AN APPROACH TO ENGAGE THE PUBLIC IN ENERGY-RELATED DEBATES AND DECISION-MAKING

By providing participants with information and giving them a platform to discuss the risks and benefits, we show that **levels of support for technologies increases**. Although this was not a specific goal of the workshop, it does provide evidence that a deeper level of engagement with the public could be important in shaping positive public attitudes towards subsurface energy technologies in the move towards a zero-carbon future. The **levels of engagement were high during the workshops**, evidenced through the quantity and quality of the questions that were asked about the different technologies. The use of a variety of participatory activities results in **more sustained levels of interest and enabled participants to contribute in different ways** depending on their confidence levels. This project piloted a novel recruitment approach in an attempt to gain access to segments of society who would not normally volunteer to participate in academic research. Nevertheless, recruitment proved to be very challenging; identifying groups to approach was time consuming and the response rate to our invitations was very low. It was clear that whilst this method of recruitment could be effective for gaining a spread of societal inputs to research, a more personal, face-to-face approach and longer lead in time to build trust with the groups is needed.

2 Project aims: public engagement with the subsurface energy system

The main aim of this project is to gain a better understanding of attitudes towards publicly-funded energy decarbonisation science from a wide cross section of society, exploring the ways in which different 'publics' engage with potential subsurface energy technologies and the research being undertaken to determine the role they could play in a future energy mix.

This project will address this aim by:

(i) evaluating public awareness and understanding of underground energy decarbonisation techniques and related research from the Earth Science community,

(ii) investigating the role that energy literacy has on public understanding of underground energy technologies and the need for research around the technologies,

(iii) evaluating how this may impact on levels of engagement and public attitudes towards the £31m investment in UK Geoenergy Observatories and the UK earth science decarbonisation research agenda.

3 Methodology

3.1 WORKSHOP PROCEDURE AND QUESTIONNAIRES

Participatory workshops were developed to actively engage members of the public in discussions around subsurface energy technologies and the science being undertaken by the UK Geoenergy Observatories. Community groups were invited to take part in a 2 hour session between August-November 2019. The workshops were made up of four key parts:

Drawing the energy system: Individual participants were asked to draw a representation of 'the energy system' to illustrate their awareness and understanding of production, distribution and consumption of energy. If guidance was requested around the meaning of the 'energy system', the researcher explained that they should draw the different aspects of what makes up the 'energy landscape'. An experimental approach was taken to assess whether a prompt would make people think more about the energy technologies above and below ground. The prompt was a simple line on the page that could be interpreted as a hill and ground (see figure 4 e-f), the prompt was used in the Lincolnshire workshops. Finally, participants were asked to create a master drawing as a group bringing together their ideas, and open up discussion in preparation for the next activities. The prompt was provided in all group drawings.

Baseline questionnaire: A short questionnaire was used to assess participant values and beliefs, evaluate their awareness and perceptions of different aspects of the energy system and underground technologies, and identify key sources of information and the levels of trust associated with these. The questionnaire was also used to investigate participant awareness of the British Geological Society and their activities.

Participant-led discussion: A group discussion was facilitated by the researcher but was largely led by the participants themselves. To initiate and encourage discussion, a series of show cards were used that outlined six energy-related, sub-surface technologies/uses. These included compressed air and storage; shale gas extraction; carbon capture and storage; shallow mine geothermal, deep geothermal and nuclear waste disposal. The cards were designed to be accessible to non-experts, and provided some background information, a fun fact and a diagram or image of the technology. The information was mostly derived from existing BGS resources and BGS staff expertise.

Post-workshop questionnaire: Participants filled out a short questionnaire at the end of the workshop to evaluate the effectiveness of the participatory event. Changes in knowledge and understanding, perceptions of technology and levels of interest were measured.

3.2 3.2 RESPONDENTS AND SAMPLE CHARACTERISTICS

The target population for this project were the non-engaged public. We define 'non-engaged' as those who have not actively sought out to take part in the research; rather they participate by

invitation. Although 'invited public dialogue' is a common approach to engaging the public (Chilvers, 2010), such sessions are often highly structured to address specific policy agendas, and bring together individuals who are unknown to each other. In contrast, the aim of these participatory workshops was to creatively engage peer-to-peer discussions to explore everyday understandings of the energy system and current levels of knowledge and attitudes towards subsurface technologies.

To achieve this, we took an experimental approach to our recruitment process by inviting a variety of existing community groups to take part in the participatory workshops. Not all community group members were required to take part, therefore we acknowledge that we may not have captured input from more disengaged members of the community (those who are the least enthusiastic and interested in energy, science and technology). As such, there is a likelihood of bias towards more engaged participants, nevertheless, this creative approach provided insights into the perceptions and understandings from a cross section of society.

Over 50 established community groups across Glasgow, Stirling, Leicester, Lincolnshire were invited via email or social media to take part in the workshops. In total, seven workshops were held, four in the Glasgow area, one in Stirling and two in Lincolnshire; 41 participants took part in the workshops, 63% were female and 37% were male. The majority of our participants (76%) were over 50 years old.

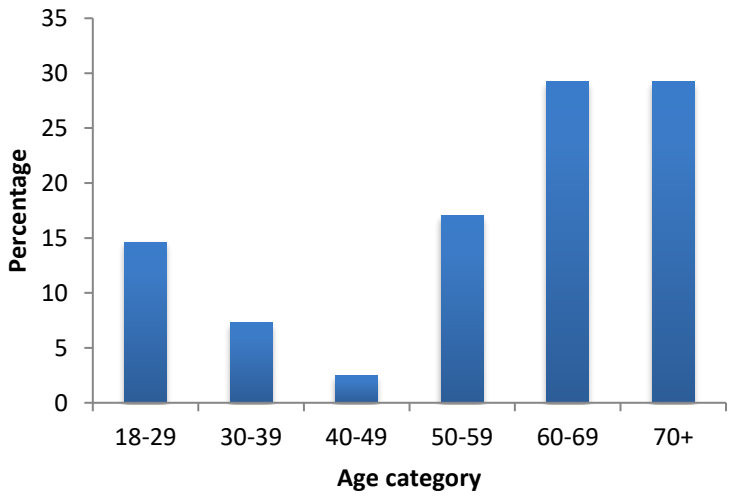


Figure 1 Age profile of participants

The following provides a short description of the participant groups that took part in the workshops. An evaluation of the recruitment approach and the challenges faced are provided in section 7.

Workshop 1: University friendship group based in Glasgow. Students were aged between 20 and 26 and consisted of four females and two males who study a range of disciplines, including Art, English Literature, Nursing, Media, Social Work and Geography. This was a culturally diverse group, which included participants from a range of countries in the Global North.
Workshop 2: Members of the University of the Third Age (U3A) based in the Northwest of Glasgow. Participants were retired, aged between 60 and 78 and consisted of 2 females and 3 males. All participants had lived in and around Glasgow for the majority of their life.
Workshop 3: Members of the University of the Third Age (U3A) based in the Northwest of Glasgow. Participants were retired, aged between 60 and 78 and consisted of 4 females and 1

male. All participants had lived in and around Glasgow for the majority of their life. Groups 2 and 3 joined together for the participant led discussion.
Workshop 4: Church group in North Lanarkshire, on the outskirts of Glasgow. Participants were aged between 56 and 70 and come from an old mining settlement. The group consisted of three males and 4 females who had professional occupations or were retired. They have been friends for 20+ years, and lived in the area all of their lives.
Workshop 5: Mother and baby church group from Stirling. The group consisted of 4 females on maternity leave from professional occupations and were all in their early 30s. This group did not produce a group drawing due to time constraints.
Workshop 6: Church group from Lincolnshire. The group consisted of 7 males and 1 female, all participants were over the age of 60. Some members of the group had a strong interest in the environment and were developing a low carbon strategy for the church. One response from this group was a joint effort between a couple as one of them was visually impaired.
Workshop 7: Ladies church group from Lincolnshire. This group consisted of 7 females, all of whom were over the age of 40. The group meets for coffee on a regular basis and organise a range of church related activities.

4 Public awareness and understanding of underground energy technologies

4.1 ENERGY POLICY FRAMINGS & BELIEFS

The baseline questionnaire examines participants' beliefs about climate change, energy security and affordability, topics that are commonly used to frame energy policy decisions in the UK. The way issues are framed have been shown to be an important influencing factor that shapes public perceptions and attitudes (e.g. Spence and Pidgeon, 2010; Iskandarova and Genus 2019; Jensen et al 2019).

Participants were asked a series of questions about their beliefs around climate change and ways to tackle it (see figure 2). The key findings are:

- 90% of participants agreed or strongly agreed that they were concerned about climate change. Only 5% were not concerned about climate change. Our findings support those in the recent CAST briefing paper 02 (2019), which reported a sustained and growing public concern for the environment since 2018 and unprecedented levels of concern in mid-2019.
- Over 80% believed that being environmentally friendly was an important part of who they were, with 15% indifferent. Only 2% of the participants did not consider being environmentally friendly as something that was important to them.
- Two thirds of the participants believed that human induced climate change is not being exaggerated and that appropriate evidence supports climate change claims. Nevertheless, with nearly 30% of participants agreeing that there is too much conflicting evidence to know whether climate change is happening, and that human-induced climate change is being exaggerated, it appears that there is still some scepticism around the scientific basis of climate change and uncertainty over the contribution of human activities. Demski et al. saw a similar level of scepticism in a study on public values, attitudes and acceptability of the UK energy system in 2012.

- Nearly 60% of participants agreed that new technologies will play a significant role in stopping climate change, however, there was a relatively high amount of uncertainty amongst the group, with 20% not stating an opinion.

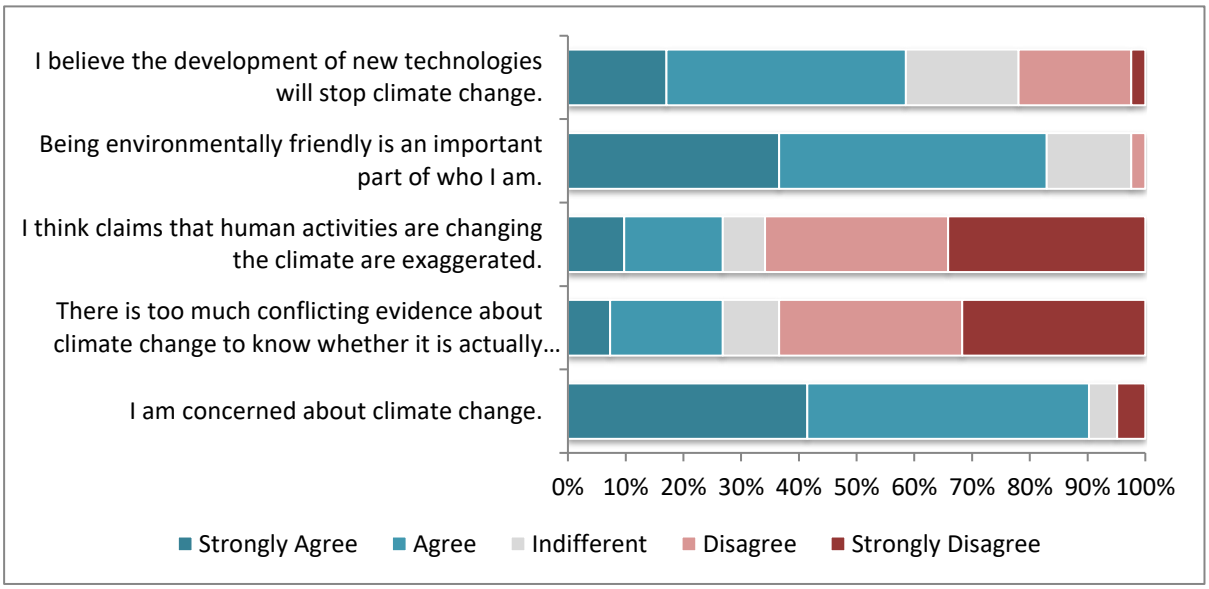


Figure 2 Percentage of participants that agreed or disagreed on different perspectives of climate change and the environment

We asked participants what their key priorities were when thinking about different energy technologies (See figure 3).

- 41% of participants thought that environmental protection was the most important factor to consider when thinking about energy technologies. Energy security, a technology's green credentials and affordable energy bills were each ranked most important by around 20% of participants.
- Half of all participants ranked affordable energy bills as the least important consideration when thinking about energy technologies, followed by the technology's green credentials (24%). Although not directly comparable, Demski et al. (2013) in contrast, found that 40% of their participants ranked affordable energy bills as the most important priority compared to tackling climate change with low carbon energy sources and energy security.

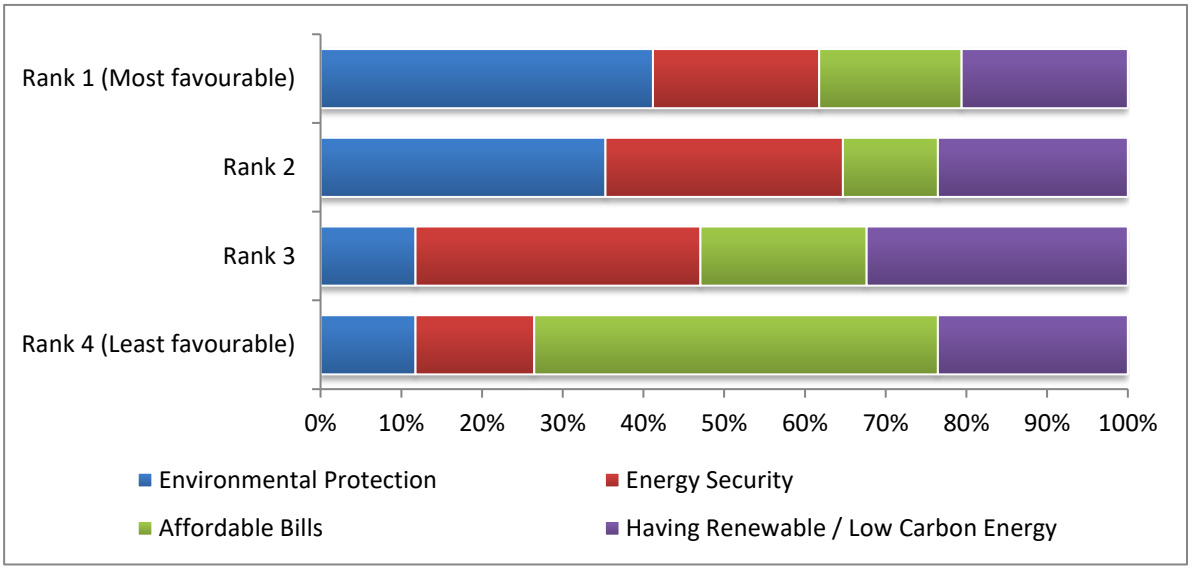


Figure 3 Percentage of participants ranking their most important (Rank 1) to least important (Rank 4) factors when considering energy technologies

The topic of climate change was not prominent in the participant led discussion despite most of the participants (90%) stating a concern about it. There was significantly more debate around the impacts of energy technologies on the environment and the risks and uncertainty associated with them (for more details see section 3.3). This is in line with the findings from the questionnaire, where participants ranked environmental protection as their key concern when thinking about energy technologies. Interestingly, energy security was discussed more than climate change despite more of a spread in the rankings. The narrative around energy security often focused on being self-sufficient and not relying on importing resources from other countries. Some participants, in contrast, expressed their worries around the social impacts of "the lights going out" whilst others had feelings of concern around the foreign ownership of UK energy infrastructure (e.g. new nuclear power stations) particularly around issues of control and trust (see box 1).

Box 1 Examples of participant views on energy security

"Well we also need to think long term as well about security… The politics from energy sources. We can't rely on energy and gas from other countries. We should really be self-sufficient"
Workshop 2&3

"I think the whole area of energy security hasn't really been debated enough. We saw just a few days ago when the lights do go out it is chaos. Grid lock, people stuck on trains, hospitals affected. You could end up with riots and people plundering shops and taking what you want. That is real social unrest if we don't have the lights on. So for me that really is the number one issue. The security of making sure we have enough. Our country was caught out really recently and I hope that's a real wakeup call". *Workshop 2&3*

"I think we're very worried that if we are going to have a new nuclear power station, why does it belong to the Chinese, why isn't our government, why isn't it ours, it worries me that the Chinese are in control of it and can they just switch it of when they like suddenly there'd be no power at all. Why isn't it ours, why do we need to go to the Chinese to build a power station? I don't get that".
Workshop 7

4.1.1 Summary of findings

The results from this part of the study give an indication about how best to frame the development of subsurface energy technologies in the broader context of the environment, energy security and affordability of energy bills. Although the specific technologies were not explicitly discussed here, understanding different publics' values and priorities more widely can help develop a more targeted engagement and communication strategy.

The results from this project demonstrate that there is a high level of awareness and concern about climate change amongst our participants. Concern appears to be increasing, as 90% of participants agreed or strongly agreed that they were concerned about climate change whereas Demski et al. reported in 2013 that only three quarters of their respondents were very or fairly concerned. This increase is in line with findings from a larger scale polling survey from the Centre for Climate Change and Social Transformations in August 2019, which measured national views about climate change. Everyday environmental practices also appear to be becoming the social norm, with over 80% of our participants stating that being environmentally friendly was an important part of who they were.

Despite this, there is still clear scepticism around the scientific evidence and communication of climate change. The percentage of participants who agreed that the seriousness of climate change is exaggerated was only slightly less than the results from the study by Demski et al (2013) conducted 8 years ago. It may be that there is a segment of society that will not change their views on climate change, despite the growing evidence, however, this indicates more needs to be done to foster trust in science and how evidence is presented to the lay person.

Whilst mitigating the impact of climate change is not the primary remit of the BGS, the high levels of concern about climate change amongst the participants suggests that primarily framing the development of sub-surface energy technologies around the role they will play in the transition to a low carbon future would seem to be a sensible approach. Nevertheless, energy security and environmental protection were strong themes that came out of the discussions; therefore these aspects should also be included in the narrative around the investment into, and the development of these technologies as part of the broader energy system. Although the

reduction of energy bills has been shown to be a high priority for some members of the public (Demski et al, 2013), this study suggested the opposite. Given the discussions around distrust in the Government and 'companies' (see section 4), and the lack of control over energy prices, it may be best to avoid the narrative that sub-surface energy technologies would result a potential reduction in energy bills.

4.2 ENERGY LITERACY

The creative drawing exercise and baseline questionnaire were used to determine the levels of knowledge and understanding the participants had on the energy system and sub-surface more widely.

4.2.1 Individual drawings

The creative drawing exercise demonstrated a range of levels of energy literacy across the individuals. It proved difficult to assign a 'grade' or level of energy literacy to each participant; instead, a point was given if certain aspects of the energy system were included in the drawing. The percentage of participants that mentioned each aspect was calculated to demonstrate the awareness of key features of the energy systems. Examples of the participant drawings can be seen in figure 4 (all drawings can be found in appendix A). The key findings are as follows:

- Most participants did not know what was meant when asked to draw a representation of the 'energy system'. When further guidance was requested, the researcher explained that they should draw the different aspects of what makes up the 'energy landscape'. Peer discussions often followed around the meanings of these terms and the language of 'production and consumption' was more commonly understood.
- Of the individual drawings, 15% of participants drew a pie chart or graph and 32% listed (either in writing or picture format) various energy sources. These interpretations demonstrated some knowledge of the energy mix, but at a relatively basic level. The key issue was that the participants did not specify whether their mix was for the energy landscape or the sources that make up the electricity mix. The absence of 'electricity' in all but one case suggests the latter.
- The focus of most drawings was centred on resources and generation. 37% of drawings included an aspect that represented 'consumption of energy', usually in the form of a house but only 17% of drawings included recognition of the 'transmission' of energy. Transport did not appear in any of the drawings and heat was only mentioned in 7% of them.
- Only 37% of participants acknowledged the 'underground' as part of the energy system and this was largely with respect to fossil fuel extraction.
- The prompt did help participants situate their understanding of the energy system as part of a 'landscape', and whilst many did include the 'underground' (in the form of fossil fuels) just under half of those participants interpreted the prompt in different ways, excluding the sub-surface.
- Participants were assessed on whether they included the three most common renewables (wind, solar, hydro). Half of participants included 2 forms of renewables in their drawing and just over one third included all three. Knowledge of more advanced renewables was evident in approximately half of drawing, including pumped storage, biofuel, geothermal, ground source heat pump.
- Participants were assessed on whether they included the three most common fossil fuels (coal, gas, oil). One third of participants included 2 forms of fossil fuels in their drawing and just over one fifth included all three. Beyond coal, oil and gas, the only other 'fossil fuel technology' included was fracking (5% of drawings).

- Nuclear power was only included in 41% of the drawings.
- At an individual level, there are a range of levels of energy literacy demonstrated in the drawings of the energy system, however, the group drawing exercise and the discussions associated with them demonstrate that the general public know about many surface and subsurface energy technologies and when prompted by other group members, most realised that they know more than they initially thought.
- The knowledge of the perhaps lesser known technologies (e.g. pumped storage, heat exchange) were largely based on personal experience of those technologies, such as visits to the Dinorwig Power Station in Wales or knowing someone with ground source heat pumps.

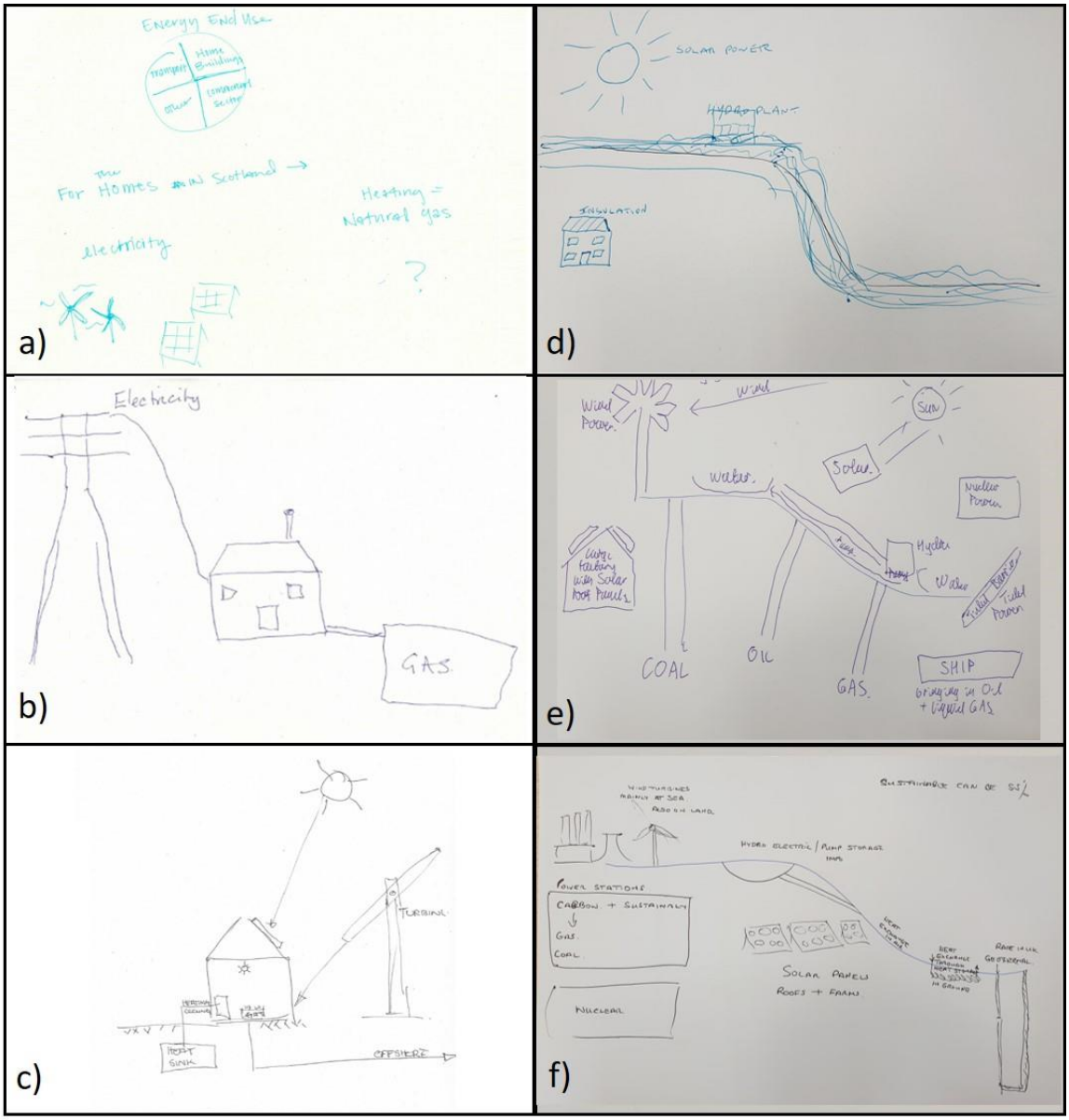


Figure 4 Examples of participant drawings of the energy system (drawings a-c without prompt, d-f with prompt).

Group drawings

The purpose of the group drawing exercise was primarily to initiate a discussion around energy and engage participants in the topic. The drawings from each workshop can be seen in figure 5. Overall, the drawings demonstrate that the participants are knowledgeable about the spectrum

of renewable and non-renewable energy sources across marine and terrestrial landscapes, and the role of both the surface and the sub-surface in energy production. Less common technologies appear more in the group drawings, including for example, pumped storage, ground source heat pumps, biofuels and energy from waste. Although the inclusion of these were driven by specific members of the groups, they facilitated interesting discussions and highlighted that other group members, once prompted, did in fact have wider knowledge of the energy system than was initially perceived.

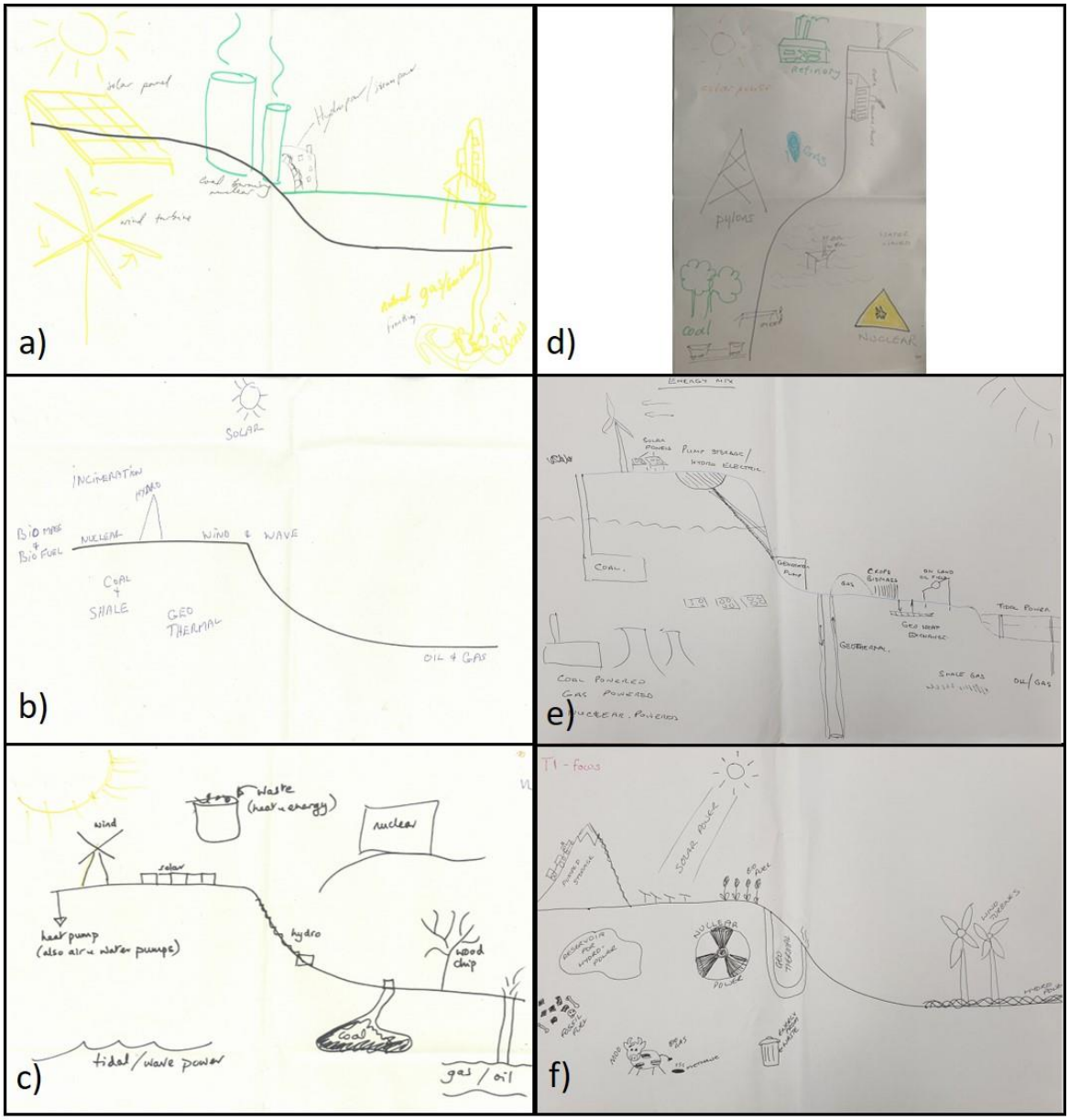


Figure 5 Group drawings of the energy system from each workshop (a = workshop 1, b = workshop 2, c = workshop 3, d = workshop 4, e = workshop 6, f = workshop 7. NB no workshop 5 drawing).

Nevertheless, there was a clear focus on energy sources and generation of heat and electricity (although electricity is often not explicitly mentioned) rather than the consumption of energy, which was largely confined to the domestic sector, and the transmission of energy despite this being an area of significant contention in some places (see for example Cotton and Devine-Wright, 2011; 2013).

4.2.2 Baseline questionnaire

The questionnaire was used to explore the participants' understanding of the energy system in more detail, including uses of the subsurface, the difference between renewables and non-renewable sources and the energy sources that make up the UK's energy mix. Firstly, the participants were asked to provide a short explanation of what they understood the UK's '**energy system**' to be. Most answers generally focused on the types of energy that make up the energy mix, with fossil fuels and the most common renewables (wind, solar, hydro) referenced the most. There was no mention of the terms 'sub-surface' or 'underground' and apart from coal, gas and oil, no other subsurface technologies were referenced, including geothermal energy and shale gas/fracking. Some responses acknowledged the distribution and consumption aspects of the energy system and others referred to different sectors that form the energy system, including industry, transport, buildings etc. These aspects were more prominent in the questionnaire responses than the drawing exercise. Most participants had a reasonably good understanding of the UK's energy mix, providing a range of technologies that demonstrated a medium to high level of awareness of the different renewable and non-renewable sources and most participants provided a reasonable description of renewable and non-renewables. Nevertheless, there was evidence that some members of the public lack this type of basic knowledge. Uses of the underground were also explored in the questionnaire; fossil fuels were referenced the most frequently with gas, oil and coal being the most reported terms, respectively. These were followed by the terms: heat, geothermal, energy, fracking, fuels and extraction.

At the end of the questionnaire, participants were asked to **self-assess their level of knowledge of energy issues and subsurface technologies**.

- 57% of participants rated themselves as having average knowledge of energy issues, 27% rated themselves as having poor knowledge, 16% felt they had good knowledge, and nobody considered themselves as having advanced knowledge of energy issues.
- 73% of participants rated themselves as having poor knowledge of subsurface technologies, 24% rated themselves as having average knowledge, 3% felt they had good knowledge, and nobody considered themselves as having advanced knowledge of subsurface technologies.

4.2.3 Summary of findings

The take home message from the drawing exercises and relevant baseline questions is that the language used by scientists and policymakers to describe the energy system needs to be more accessible to the public. If using the terms 'energy system' or 'energy landscape' they should be described appropriately using language familiar to a lay person, for example, 'the way we generate, use, store and distribute energy' or something similar.

Overall, the participants had a good grasp of the different ways in which electricity and heat are generated, but acknowledgement of the wider ways in which energy is consumed (beyond the home), the distribution and the storage of energy, were relatively lacking. Given the role the subsurface and the underground energy technologies have in the latter two aspects, the importance of these 'less considered' aspects of the energy system, i.e. storage and distribution of energy, should be a key focus in any engagement strategy. The relative absence of two controversial energy sources, nuclear power and hydraulic fracturing of shale gas, in the individual drawings is notable, appearing in only 41% and 5% of the drawings, respectively. The reasons for this are unclear; it could be that some participants do not think these technologies have a role in the current energy system or it could mean that despite relatively high, negative media coverage (past and recent), participants have not retained a strong impression of these technologies. It would be interesting to explore this further.

The inclusion of the sub-surface in the drawings was mostly related to fossil fuel extraction, however, when the prompt was used, participants were more likely to visualise the 'landscape' and include a wider spectrum of energy sources, including other subsurface energy sources, such as geothermal. It also encouraged some of the participants to think about less visible energy technologies whether above ground or below, such as ground source heat pumps, tidal or pumped storage (hydro). Overall, the prompt helped draw out more knowledge from the participants, suggesting that energy literacy levels may have been underestimated in the first five groups where the prompt was not used.

Nevertheless, it is clear from these activities that further work is needed to demonstrate to the public that the subsurface is part of the energy system, beyond the extractive industries. The most prominent aspects of the energy system that featured in the drawings and questionnaires were the most visible such as wind and solar and despite the previous discussions around the group drawings, no participants included subsurface technologies other than coal, gas and oil when asked to describe the energy system. A simple schematic drawing of the energy system, which includes the subsurface technologies, distribution infrastructure and sectors of energy use would be a useful resource for engagement purposes.

4.3 ATTITUDES AND PERCEPTIONS OF SUB-SURFACE TECHNOLOGIES

The following section summarises the participants' attitudes and perceptions of each of the sub-surface technologies.

4.3.1 Shallow mine geothermal

Half of all participants had never heard of shallow mine geothermal. Nobody was unsupportive of the technology, 23% of participants were indifferent.

A number of common threads and interesting debates arose during the participant led discussions on shallow mine geothermal. Firstly, although half of all participants stated they had never heard of the technology, most were interested in learning more about this technology and particularly the district heating scheme in Shettleston. The main argument in support of shallow mine geothermal was that it made use of existing mining infrastructure. After seeking clarification that no new mines would be created, one participant from Lincolnshire stated, *"it's using what's there already…. cause I think it's a great idea… it's there anyway so if you can do something with it…" (Workshop L2)*. Evidence of the implementation of the shallow mine geothermal in Shettleston seemed to give some participants more confidence in the technology although one participant wanted more evidence of it working at a larger scale. Some participants confused shallow mine geothermal district heating with ground source heat pumps, with two participants in Lincolnshire arguing *"I think that's wrong the 17 houses, I think that's more wide spread that technology…"*, *"I think there's firms in Lincolnshire that will do that and install it houses, more common than we think. And environmentally, it's just a house isn't it, it isn't a massive earthworks, its only boreholes in the ground"* (Workshop L1).

For others the discussion raised some concerns, these are outlined below:
(i) Sinkholes and voids: the issue of subsidence was a wider concern about using the sub-surface, however, the risk of sinkholes specifically relating to shallow mine geothermal were raised by a concerned Lincolnshire resident (Workshop L1) who stated *"What worries me as I mentioned earlier on, is the shallow mine geothermal is relatively shallow and you read about sink holes opening up from shallow case mining and going back to my suspicions about them*

taking voids out of strata, underneath the ground… what is the impact of that?". However, further discussion revealed a misunderstanding in how the system worked, with the same participant thinking that the water was extracted, used, and returned, rather than a closed loop system being in place.

(ii) Cost, responsibility and aesthetics: although others in the group were supportive, one participant from Stirling (Workshop 5) was concerned about the cost of the technology and who is responsible if something goes wrong, stating "*You know that sounds expensive though… if you've got your own house and this packs in after a while… who is liable for that… and that's big cause could be a lot of digging… who would pay for the burst pipes?".* Aesthetics are also important, with the same participant concerned about what the system would look like above the ground, asking "What does it look like… is it messy… do you see it above ground?".

4.3.2 Deep geothermal

45% of participants were supportive or very supportive of deep geothermal. 20% were indifferent and nearly one third of participants had never heard of the technology. Less than 3% opposed deep geothermal.

Deep geothermal was the most supported subsurface technology out of the six technologies provided, with a participant from Glasgow commenting *"You could dig up my back garden if there was geothermal energy down there!"* (Workshop 2&3). Another participant from Stirling commented on learning about geothermal at school and drew on her experience of visiting Iceland stating that "*that was something that I hadn't thought of before because it seems like a really good option"* (Workshop 5). Despite the high level of support, however, only one group (Workshop 4) spent a notable amount of time discussing this technology. The key themes that were discussed are as follows:

(i) Risk: Following a discussion on the future of subsurface technology, most participants in workshop 4 agreed that there was a need for such technologies as long as safety was considered. In one participant's opinion, "*the only one underground that's safe nowadays is geothermal that I can think of*" although another participant counter-argued that this type of technology should only be used if surface technology fails, "*I think the underground stuff should be treated as a contingency if the above stuff like wind doesn't work… but only as a contingency*". When probed about the need for drilling in deep geothermal energy extraction, participants did not seem concerned, with one arguing *"Aye but they're nothing wrong with the drilling itself… I think it's only really the fracking one I'm against".*

(ii) **Economics**: The costs associated with the technology were the most prominent discussion point. One participant compared the cost of geothermal in the UK to Iceland, and was concerned that it would be more expensive in the UK. Others discussed a TV programme on geothermal energy that some participants had seen where they expressed surprise at the reported reduction of domestic fuel bills.

4.3.3 Carbon capture and storage

43% of participants were supportive or very supportive of carbon capture and storage. 10% were unsupportive or very unsupportive and 15% indifferent. Nearly one third of participants had not heard of CCS.

The levels of support for carbon capture and storage followed a similar pattern to deep geothermal, although there were some participants that expressed concern over this technology. Again, however, this technology did not receive much attention in the participant led discussions. The key theme that was discussed was:

(i) **Market for technology**: participants discussed whether or not there is a market for CCS, with some arguing that the transition away from fossil fuels should mean that CCS is not needed, whereas others expressed concern about carbon emissions from other countries and the need for such technology in the future.

4.3.4 Shale gas extraction

Shale gas extraction had the least support (15%), 45% of participants were unsupportive or very unsupportive. Less than 18% had never heard of it and nearly 23% were indifferent.

The level of support for shale gas extraction was the lowest of the 6 technologies; although a similar percentage of participants had either never heard of shale gas extraction or were indifferent. In contrast to the previous technologies, shale gas and fracking received notable attention in the participant led discussions. The key themes that was discussed were:

Risk: The risks associated with fracking were the most prominent theme in the participant discussions around shale gas. Some participants did not specify their concerns, but argued "*it doesn't seem safe", "(it's) been proven hasn't it… that it's dangerous"* or *"there is more of a risk and it's bad for the environment"*. Whereas others expressed stronger emotions about fracking such as one Lincolnshire resident who stated, "*I'd want to know an awful lot more information, it's a bit frightening for me*". Others were more specific in their concerns, which covered both environmental and social impacts. Earthquakes and tremors, chemicals in aquifers and the transportation of wastewater were key areas of concern. Participants were particularly concerned about damage to their homes caused by induced earthquakes and the impact this would have on their ability to sell them, with one Lincolnshire participant questioning "*like would it affect people's insurance, everything wouldn't it? Like living near a fracking site, people already own a home there, they might struggle to sell it…*". The lack of available space in the UK was also raised on several occasions, with one participant highlighting *"we're not America are we?".*

Trust: Trust, or lack of it, was also a strong theme in the shale gas discussions. Many participants expressed a strong distrust of the Government and politicians with some claiming that the fracking moratorium was being used as a political tool, "*So how is any of the information provided effective because you can't trust it… you can't… cause there is too much at stake…. And it's the same with this fracking…. Then all of a sudden… 'oh we're stopping fracking' in Blackpool… buts that political… there's an election!"* (Workshop 4). Another participant from Lincolnshire also thought the government has its own agenda, "*we didn't believe the*

government too much when they kept saying, it's all alright cause we don't really trust them, I don't, if they think it suits them I think they will try and convince us" (Workshop 7). Others felt that the public are purposely being left out of the decision-making process and have not been given all the information available about fracking, "*We're just told something will happen, like fracking just suddenly happened and nobody really told us what was going to happen, what could be the problems, what could happen if something, you know.. I don't think we're told that because the Government daren't tell us, cause they don't know themselves"* (Workshop 7*)*.

Knowledge and uncertainty: Participants discussed both personal and societal perceptions of shale gas and some of the factors that influence opinions. Although shale gas had the least support, some participants felt that there was a lack of available information about the benefits of the technology and if this information was available, there would be less resistance to the industry:

"*I'm not saying I don't understand it… I'm saying I don't think there is enough information out there to tell people the benefits".* (Workshop 4)

"But that's the thing I think… if they helped us to know more… and you got a deeper understanding… people would be more tolerant". (Workshop 4)

Further discussion was focused around the need for more scientific knowledge to explore the potential environmental impacts of shale gas extraction, however, it was clear that some participants were unsure how to interpret the scientific evidence:

"*Although the geologists say that over the years fracking does not cause earth tremours! So these are the professionals looking into it. It is really difficult sometimes to know"*. (Workshop 2&3)

"if they did enough research and taught guys on it and monitored and did it really precisely and did it slowly so that you're not going to cause that damage…. That I think is going to happen… but I think they need to do more research on it before they go and approve it". (Workshop 5)

Whilst broader personal understanding of the technology and more scientific evidence to address the uncertainties were discussed, one participant took a different approach, arguing that the most important aspect for them is regulation of the industry:

"if it's out of sight, we think it's safe but it's not information we need, it's reassurance and standards. Because I wouldn't know how to process the information, what I would be able to do is process a hazard warning or a guarantee". (Workshop 7)

Media: Participants discussed the role of the media in shaping opinions; whilst one thought that the media damaged the reputation of the industry by promoting shale gas as a positive solution without highlighting the potential risks, others accused the media of scaremongering, leading to strong negative public perceptions and therefore preventing opportunities to gather scientific evidence.

"There is a lot of scare mongering and stories where people just demonise various things. It used to be nuclear and now its fracking that seems to be demonised… The big problem is that if you start fracking anywhere in the UK all of the environmentalists jump on you. So you don't really get a chance to test it out scientifically and rationally because of public hysteria and the way that the media love that type of story" (Workshop 2&3)

"Cause we've been fed scare stories in the media, you know, it's headline news and they go for what's happening in America, pollution of water, gas coming out of water pipes. We've all seen this but it's got to be put into perspective hasn't it. I mean, how many cases has this happened? The earthquake at Blackpool was quite a moderate, what damage did it cause? You know, we've had a more intense earthquake here at Market Rasen". (Workshop 6)

4.3.5 Deep geological disposal of radioactive waste

The deep disposal of radioactive waste polarised views. Nearly one third of participants supported or highly supported deep disposal of radioactive waste whilst just over one third of participants were unsupportive or very unsupportive. Similar to shale gas, less than 18% had never heard of it and nearly 18% were indifferent.

Radioactive waste disposal split participant opinion. There was a slight bias towards being unsupportive, however nearly one third of participants had either never heard of geological radioactive waste disposal or were indifferent. This technology raised the most debate amongst the groups but it often moved between discussions about the use of nuclear power more generally and disposing of the waste. The key themes discussed were:

Risk and uncertainty: The participants raised some concerns about what would happen if something were to go wrong once the radioactive waste had been disposed of. The main potential risks and uncertainties that were discussed included: the impact of tectonic movement, failure of infrastructure and its impact on the environment, and the risk of terrorist attacks. Others questioned what would happen if technological advancement provided a means to treat the hazardous waste in a safer way, and whether it made better sense to ensure access to the waste in the future. Two participants in Glasgow (Workshop 2&3) stated:

"my only concern is if we put something down there… can we get it back out? If we find something in the future which is more efficient instead of just burying it… could we undo what we had done?

"maybe there is an argument for keeping it there where it can be seen if it has a lifetime and that will allow technology to catch up and potentially provide an alternative involving retreatment instead of disposal…So in some sense it makes sense to keep it above ground if it is contained in a safe containment".

In general though, participants were concerned that we didn't have enough evidence to make an informed decision. Two participants in Lincolnshire (Workshop 7) stated:

"I don't really, I just think 'not on my doorstep'. I know you said about Sweden, and they wanted it cause it generated jobs and that, but I guess they, maybe they're more eh, have more information, cause the thing is I don't think… we don't get told things in this country. I think that's part of the problem".

"We can't though can we, cause we're talking about hundreds of thousands of years whatever aren't we. How can we know, there's no evidence. We've only got theoretical evidence haven't we?"

Responsibility: Regardless of the support for deep geological disposal of radioactive waste, some participants thought it was important that the UK (or Scotland) took responsibility for dealing with its own waste. Some interesting discussions were raised around what would happen in the case of Scottish Independence if the UK repository were in England, with one participant (Workshop 2&3) arguing that the Scottish Government is ignoring the issue:

"The Scottish government just runs away from the issue. Despite the fact we actually have nuclear power stations in Scotland, its refusing to do anything about the waste. It's just head in the sand business. The just think "oh nuclear, can't touch that, UK issue" so in this country we can't actually have a debate about it".

Others believed that by burying the waste underground, the Government was not taking responsibility for processing the waste properly, "*Once it is under the ground then that's it. It's sweeping it under the carpet and you don't know what's happening down there"* (Workshop 2&3), another argued "*I mean you're not really disposing it though really are you? You're just hiding it… hiding it underground"* (Workshop 4). Despite the negative comments, there were some participants that acknowledged the benefits of nuclear power, with a Stirling participant arguing "*like you said it can be sustainable in terms of energy output"* but with the caveat that a responsible approach to the management of the waste was needed "*I think a lot of it needs to be at a sort of government type level with really strict regulations so that it is a safer source".*

Media: The media was discussed in two capacities; firstly, participants drew on television programmes to inform them about nuclear power and waste. Both 'Chernobyl' and 'The Simpsons' were mentioned. Whilst 'The Simpsons' was discussed with humour, 'Chernobyl' seemed to negatively influence perceptions of nuclear power, *"I actually watched the Chernobyl series recently and that has made me look into it a lot more. It made me realise just how dangerous it can be and how horrific it can be if something is not well regulated*" (Workshop 5). Secondly, participants commented that they hear more about nuclear power than other technologies, and particularly the negative aspects such as the accident in Chernobyl. However, one participant in Glasgow was keen to highlight that the media sensationalises such topics:

"you just hear about Chernobyl more so you think if you hear about it a lot that these things happen more than they actually happen. But its only happened with devastating effects in two places…
there's a lot of bias about radioactive stuff that it is quite an emotional topic… cause you think about bombs, then you think about disasters then you think about cancer so there is a lot of buzz words that come to mind with nuclear… if it is emotional it sells newspapers" (Workshop 1).

Nevertheless, participants seemed to be aware of the influencing power of the media, drawing on other evidence to inform their decisions, "*the statistics show that it is pretty safe and we do need solutions now to sustain the current way of life that we have. So it does seem like a more viable solution*" *(Workshop 1).*

4.3.6 Compressed air and storage

20% of participants supported compressed air storage, nearly 13% were indifferent but this was the least known technology with nearly 63% of the participants stating they had never heard of it.

Compressed air storage was the least known subsurface technology. Of those who had heard of it, more participants were supportive than unsupportive, however, the participant led discussions showed fairly mixed feelings. Some were concerned about who would be managing the technology, *"there is risk then that companies could stretch the geological boundaries to make more profit"* (Workshop 1), and the consequences of this "*you know if it isn't managed properly… you'd have a big bomb sitting there…*" (Workshop 1). Others thought that there has not been enough research into the impacts of the technology, although one participant from Stirling argued "this would potentially be a good option for windfarms that are out at sea… you know cause then if something was to go wrong… it wouldn't affect people or cause significant damage". Discussions around this technology were fairly limited, reflecting the low level of awareness.

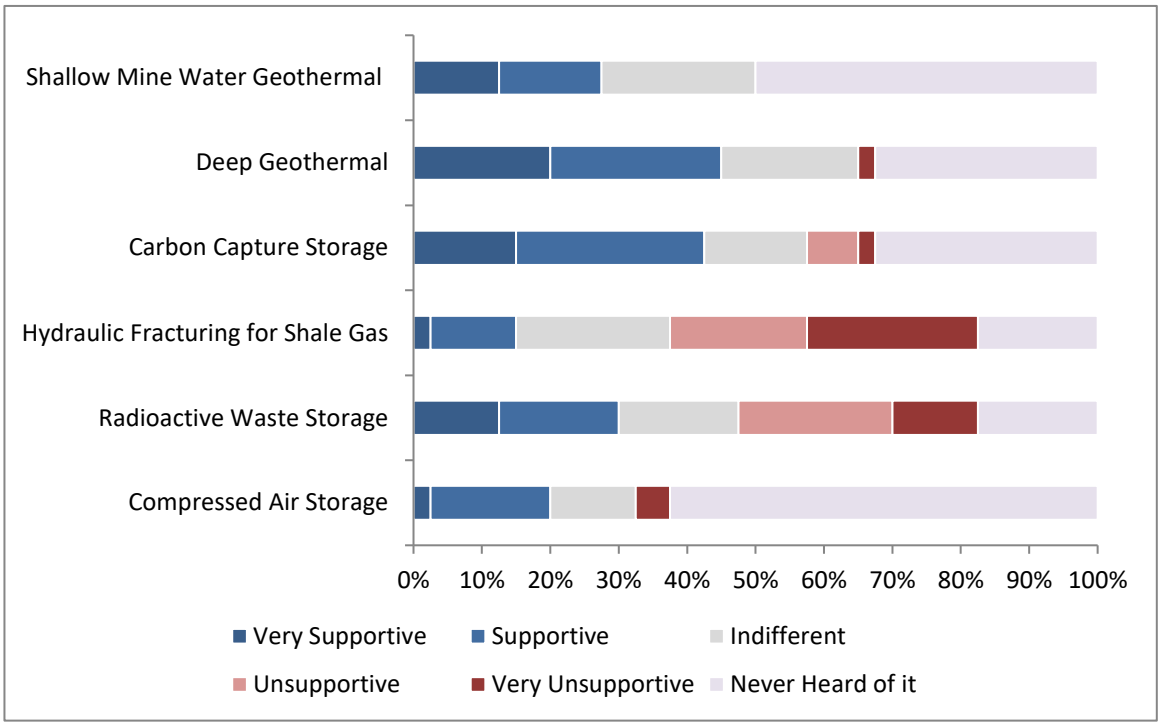


Figure 6 Percentage of participant support for sub-surface energy-related technologies

4.3.7 Summary of findings

The findings from this part of the study highlight that the awareness of sub-surface energy-related technologies is generally low and participants found it difficult to express strong opinions as they felt they knew too little about the technologies to make an informed decision. Three key inter-linked themes emerged from the discussions around the six technologies and the perceptions of the subsurface more widely: risk, accountability and trust, and the influence of the media.

In general, the participants were open and enthusiastic to learn more about the technologies but there were many questions and debate around the potential risks involved. Many participants felt that they needed more information about the benefits and risks of each of the technologies in order to make more informed decisions. One participant from workshop 1 stated, *"I don't know enough about the methods so I want to know more about how many homes could be powered by them etc. so I could see if it would be worth it. I could make decisions better saying this is practical this is worth the risk and this is beneficial. But when you talk about digging*

metres in to the ground it is hard to imagine". Some participants described the subsurface as "*scary*" or "*very foreign*" but thought that by communicating its role differently, the public may be more supportive of its use; a participant in workshop 1 stated, "*I think it has viable solutions yeah but maybe find a term that is less scary".* Again, this highlights the importance of the language used in framings, engagement strategies and science communications.

Linked to concerns about the potential risks, participants wanted to know who would be held accountable if something were to go wrong and whether they would be compensated. Regarding the subsurface more generally, one participant from workshop 2&3 argued, "*I think there would need to be an insurance policy or some sort of insurance backed by the government. So should something awful happen to your house as a result of this then you would be compensated because I think that would reassure a lot of people. If the government put their money where their mouth is".* Others were unsure who was responsible for overseeing the development of the technologies, with one participant in Lincolnshire asking if anyone had "*an overall sense of what is going on because we could each discuss these innovations and say this is a good idea, but there's a common problem I think here in getting social acceptance, political acceptance, political will, to put in the serious money before any of these is a goer. Is there a body which is even starting to look at this is an unified fashion?".* Although the regulation of the subsurface technologies and the wider energy industries are not the responsibility of the BGS, being able to provide the public with this type of information would increase trust and transparency.

Finally, the role the media play in influencing public attitudes was raised on a number of occasions. The way the media can "scaremonger" and shape public views in a negative way featured particularly in discussions around shale gas and radioactive waste disposal, however, the participants felt that using the media to communicate more information about the subsurface would be a useful approach, particularly if an "engaging" presenter hosted the show (see section 5).

5 Improving levels of engagement with publicly funded Geoenergy science

To identify and inform ways in which public engagement with BGS Geoenergy science could be improved we explored three main themes: knowledge of the BGS and their activities, sources of the participants' energy knowledge and the trust participants put in different sources of energy information. The headline findings can be found in Box 2.

Although over half of the participants claimed to have heard of the BGS, nearly one third of these participants were not able to describe what the BGS does. The top answers from those who said they did know were: 'mapping, surveying, research, environment and geology', demonstrating that the participants have relatively limited knowledge of BGS activities. It is therefore unsurprising that only 2% of the participants had heard of the UK Geoenergy Observatories. Knowledge of the Glasgow-based observatory was probed further in the four Glasgow-based workshops, and whilst it was clear that very few people were aware of them, some participants expressed an interest in visiting the sites and learning more about the activities being undertaken.

Box 2: Summary findings for participant knowledge and perceptions of the British Geological Survey

- 56% of participants had heard of the British Geological Survey
- 2% of participants had heard of the UK Geoenergy Observatories
- 2% of participants often use the British Geological Survey as a source of energy related information
- 45% of participants thought the British Geological Survey were very trustworthy

To understand how the participants engage with energy-related information, and to identify the best routes of communication, we asked the participants to tell us what sources they use to get energy related information and how trustworthy they felt the sources are (figure 7). The results show that television, broadsheet newspapers and radio are the most often used sources, respectively. Conversations with family and friends were also popular, although social media less so. University scientists and industry followed a similar pattern, with over half the participants claiming to consult these sources sometimes or often. Nearly 70% of participants used environmental organisations or action groups as sources of information sometimes or often. Interestingly, only 7% of participants used BGS sources sometimes or often, compared to 42% using UK Government and regulator sources making the BGS the least used source for energy-related information.

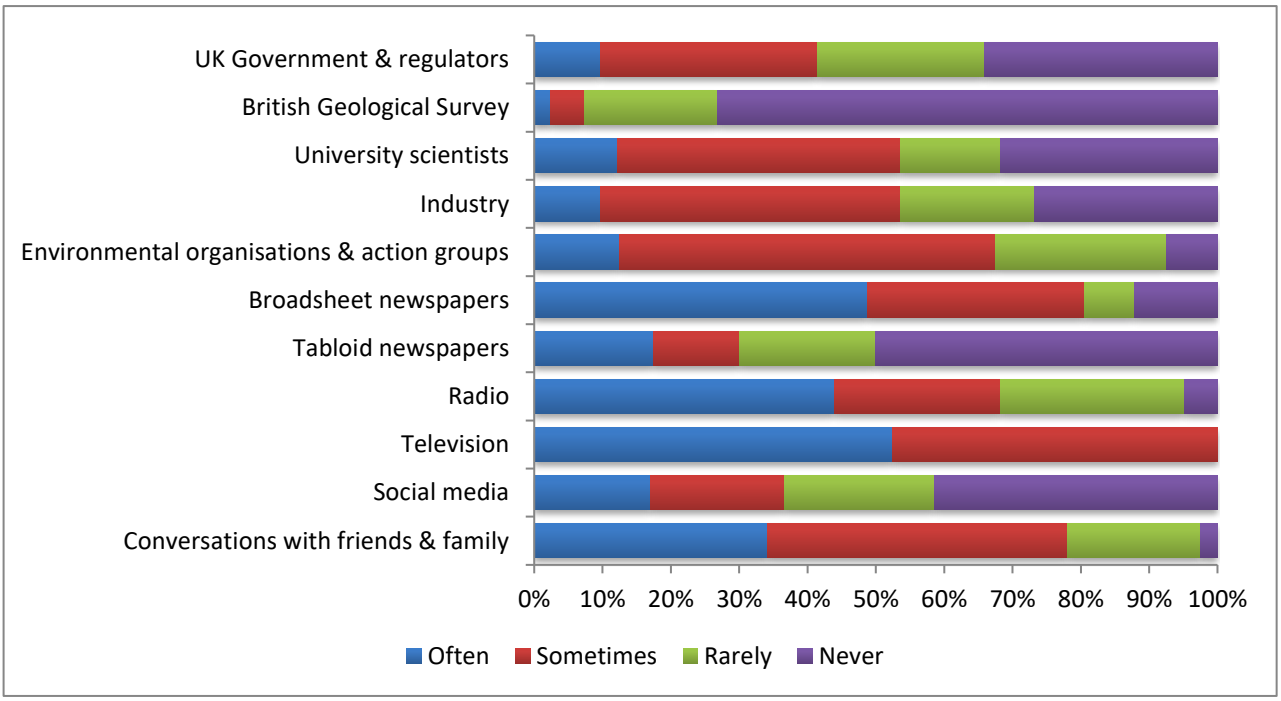


Figure 7 Sources participants use to get energy related information

Despite being the least used source of energy information, 45% of the participants felt the BGS are a very trustworthy source of information, with only University scientists rated higher (55%) (Figure 8). Although there was more uncertainty about the trustworthiness of the BGS

compared to University scientists this may be linked to the lack of awareness of the BGS amongst the participants. Most of the sources were categorised as being 'somewhat trustworthy' overall, however, social media and tabloid newspapers were notably considered as untrustworthy. Interestingly, 20% of participants felt that broadsheet newspapers are untrustworthy, despite nearly 50% of participants often using broadsheet newspapers as sources for their energy related information. Some participants also felt that the Government, regulators and industry are untrustworthy, this came across strongly in some of the participant led discussions where the issue of trust seemed to be primarily associated concerns that funders were driving research to suit their own agendas. A participant in workshop 7 felt particularly strongly about this:

"what we don't want is the government give to independent bodies that loads of these MPs being on them bodies and pushing through their own interest cause they've got shares in the company. That's the bit I don't trust".

"I don't trust the government and I don't trust these people that will be at these University that will also be on these companies…"

Nevertheless, when asked if they trusted the government and regulatory bodies to ensure that the extraction or underground storage of energy-related materials is carried out safely, over 40% of participants agreed they could be trusted.

When asked specifically about their trust in the BGS, the same participant from Lincolnshire questioned "*Who's their pay master?"* whereas another said they would trust the BGS "*more than I would the government but I would also like to know that the directors of the company weren't taking vast amounts of money from other areas".*

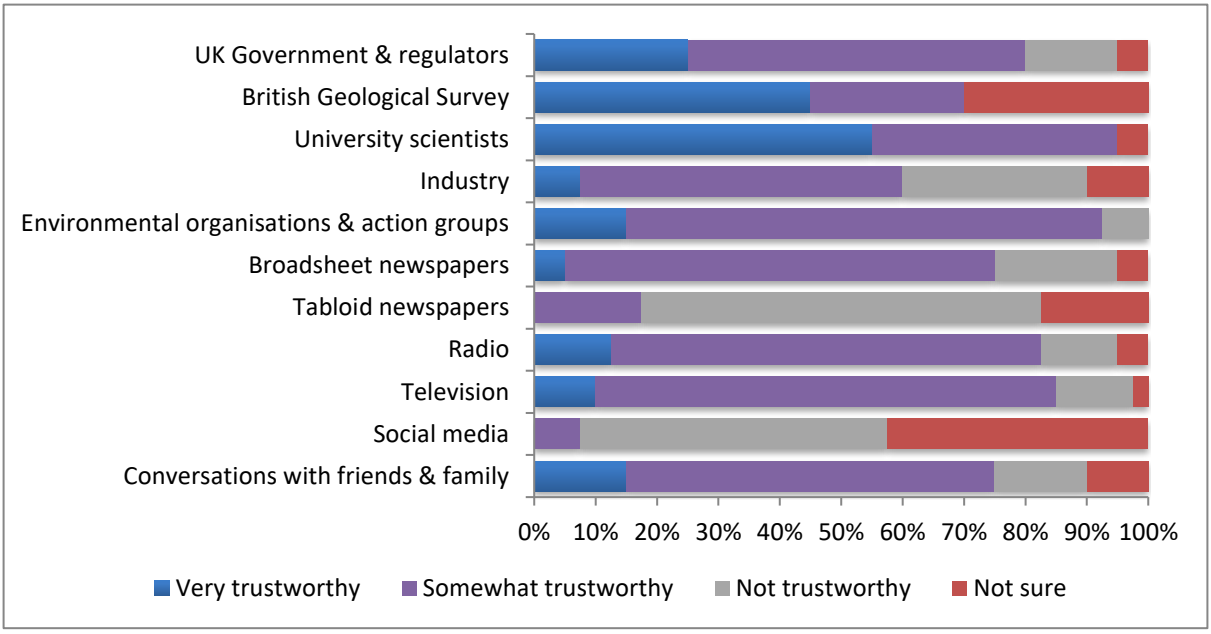


Figure 8 Percentage of participants' perceptions of trustworthiness of energy-related information sources

Finally, the participants were asked how they could improve their knowledge and understanding of energy issues and subsurface technologies. Although they wanted their information from "*an accountable body", "someone trustworthy", "someone without an agenda", "someone without a personal or commercial agenda",* and thought that University research was the most trustworthy, a number of participants discussed the challenges of communicating science: "*It's how you convert a published paper in a Journal like Nature or Science into the everyday*

language, I don't read those, but I do read for example the BBC website and I'm interested. Journalists by in large don't have the capability to interpret a scientific paper" (Workshop 6). Some believed it was their own responsibility to research the topics from a variety of sources, but others discussed the merits of television and radio, particularly if engaging presenters are used in documentaries.

5.1 SUMMARY OF FINDINGS

The results from this study suggest that one of the key challenges facing the BGS in terms of public engagement is that the public are mostly unaware of the type of research and activities it undertakes. Nevertheless, over half the participants had heard of the BGS and levels of trust in the organisation were high, second only to University researchers. The participant led discussions suggest that there are some key ways that BGS could raise its profile and build trust with the public. Firstly, although aware of the BGS, the participants wanted to know more about the organisation, and foremost, who funds their activities. This information should be easily available and visible on the BGS website and in materials developed for engagement events.

Secondly, the results show that the BGS is not being used as a source of energy-related information by the participants. This may be because those who have heard of the organisation associate it with 'mapping, surveying, research, environment and geology' rather than energy or pathways to a low carbon future. Given the high levels of concern about climate change, the role the BGS play in supporting the low carbon transition could be made more prominent. Some participants felt it was their own responsibility to find out more about the energy technologies and expressed an interest in doing so; therefore clear signposting to the layperson-friendly resources would help support better public engagement with the existing materials.

Finally, the participants expressed difficulties in interpreting academic research, and were concerned that journalists were not well equipped to communicate findings adequately, instead they suggested that more accessible communication routes, such as documentaries or radio shows would be more effective to engage the public in these aspects of geoscience.

6 Do public attitudes and perceptions of Geoenergy options align with the research agendas of the Earth Science community?

To explore the alignment of participant understandings of and attitudes towards Geoenergy, with the research agendas of the BGS, the participants were asked some broad questions about the perceived benefits and disadvantages of sub-surface energy technologies, the communication of these by experts and whether they considered the research to be a good use of public money. At the end of the workshops, participants were given the opportunity to suggest areas of research they would like to see the BGS focus on and what further information they would like to have access to. Finally, the participants were asked specifically about their feelings towards the UK Geoenergy Observatories and the science being funded.

A summary of the benefits and challenges of subsurface energy technologies the participants identified after the workshop are outlined in table 1. Although both lists were reasonably extensive, the benefits identified were more diverse than the disadvantages identified, which could be categorised into six main topics. The focus of the disadvantages was heavily on risks

and uncertainty, followed by cost and lack of research. The benefits, however, included a range of socio-economic and environmental benefits such as job opportunities, aesthetics, reduction in carbon emissions and improved energy security. Interestingly, some broad topics appeared in both the benefits and disadvantages, such as pollution and economics.

Table 1 Participant perceptions of benefits and disadvantages of subsurface energy technologies

Benefits of subsurface energy technologies	Disadvantages of subsurface energy technologies
More economic opportunities	Cost
More space above ground	Risk (pollution, security, accidents)
Increased energy capacity	Uncertainty – risks and reliability
More sustainable	Lack of suitable areas
Less polluting/ damaging to environment	Public perception
Out of sight	Lack of relevant research
Improved energy security	
More storage	
Safe	
Using natural resources	

Over half the participants felt that the risks and benefits of using the subsurface for energy-related activities are not particularly well communicated by experts, however, less than one quarter did not have an opinion. Despite this, over 60% of participants thought that public-funded research on the geological subsurface is good value for money. When asked if there were any particular areas of interest that they would like the British Geological Survey to focus on or investigate, there was no one dominant response although geothermal was mentioned the most.

At the start of the workshop, the participants were asked they knew where to find out information about how the 'sub-surface' is used for energy-related activities. Less than a third of participants said they knew where to find information, however, 43% did not. 39% also stated that it is fairly or very difficult to find the information they wanted about energy issues. When prompted further about the information they would like to know about the geological subsurface, the key areas included: a desire for more general information about the subsurface in an easily accessible form, more specific information about their localities, timescales for the research being undertaken by the UK Geoenergy Observatories, the budgets and data being collected and examples in the form of case studies.

When asked specifically about how supportive the participants were of the UK Geoenergy Observatories nobody opposed to them outright, however, a range of views were expressed from being very supportive to questioning their purpose and funding involved. One participant in workshop 6 highlighted the importance of monitoring underground activities:

"I'm afraid I had a very puerile reaction when you said underground observatory. It's dark down there, you can't see a thing, which is a stupid reaction but yes, to know what's going on down

there is essential because I do not know, I know the ground varies, it hasn't mattered in my lifetime and I suspect in most people's lifetimes, now it matters to us all, what's down there, what happens to it naturally, what happens when we start drilling into it and digging about. The only people that have worried about that in the past are essentially coal miners, cause they did not want a cave in".

Other participants in workshop 6 raised several points in which they felt they needed more clarification on before forming a firm opinion:

"We don't know what it costs, we don't know what benefits it brings, sorry… I don't know how we answer that one…"

"I hadn't heard of these things so it's not really on to ask us whether we're supportive of things that we're not being given information on, you know, I would want to read information on these, exactly what they are doing, erm, how much they are costing, erm so you know, to pass comment on, you know, on principle I support them, because we do need more information on these technologies, but I didn't even realise that any of these three observatories, I mean how long have they been.. (operating)"

"It depends what their brief is and it depends how long they are funded for, cause they could be short term observatories, or they might be long term or a change of government may close them down or beef them up, who knows?"

Other participants were more concerned about who is driving the research agenda, questioning who the researchers "report to" and how they may be influenced:

"who is the pay master? You've only got to have, say, a fracking developer start getting tentacles into the funding streams, they'll contribute some towards this because we understand that shale gas is one of those things that's going to be looked at in these observatories and you get vested interest immediately, starting to potentially have an influence. So it all comes back to... we need to be confident that the sponsoring organisation is neutral and has the expertise to interpret the information, risks and benefits and so on…" (Workshop 6).

6.1 SUMMARY OF FINDINGS

Despite a variety of concerns being raised about the use of the subsurface for energy related activities, there was recognition that a better scientific understanding of the risks and uncertainties associated with each technology is needed, aligning well with the geoscience community's research agenda. The participants were able to identify a diverse list of benefits associated with subsurface technologies, which suggests that they think there is value in pursuing research in this area. This is supported by the high percentage of participants (60%) that thought that public-funded research on the geological subsurface is good value for money.

Overall, the participants were supportive of the UK Geoenergy Observatories in principle, however, the low level of awareness of both the Observatories, and the research being carried out, meant that many participants were wary of providing their support. Generally, there was a high level of interest in finding out more information about the UK Geoenergy Observatories and the subsurface technologies discussed in the workshops. Key areas of information that the participants wanted to know about the Observatories included: who is funding the research; how long are the Observatories funded for; how much do they cost; what is research is being conducted and what are the risks and benefits of conducting the research.

7 Evaluating the effectiveness of community-focused, participatory workshops as an approach to engage the public in energy-related debates and decision-making

We wanted to evaluate the effectiveness of the community-focused, participatory approach used in this pilot study both in terms of their impact on engaging the participants in energy-related debates, but also as a method of recruiting members of the 'non-engaged' public whose voices are often absent from public attitude studies.

The post-workshop questionnaire was used to assess two key areas, firstly, whether the participants felt their knowledge of broader energy issues and energy-related subsurface technologies had increased, and secondly, whether their levels of support for the six subsurface technologies had changed.

After completing the workshop, 59% of the participants felt their knowledge on energy-related subsurface technologies had increased a lot, 41% thought it had increased a little, and none thought they had not learned anything. With respect to broader energy issues, 44% felt their knowledge had increased a lot, 54% thought it had increased a little, and 3% thought they had not learned anything.

Without prompting, participants from a number of workshops also commented on how the workshop activities had improved their knowledge:

"I think this is good (the workshop) because it has brought it to our attention so maybe that's the way forward is go into areas with these seminars…." (Workshop 7)

"Well I was just going to say that in the very short time we had I think it has improved my knowledge quite considerably" (Workshop 2&3)

After the workshop, the participants were asked to rank how supportive they were of the six technologies presented in the discussion (See figure 9). The most supported technology was shallow mine geothermal with 37% ranking the technology in first place. Deep geothermal (26%), compressed air storage (23%) and carbon capture and storage (11%) were also ranked by the participants as the most supported technology. A similar pattern is seen for the technologies ranked in second place, with the addition, however, of radioactive waste disposal, which was ranked second most supported technology by 9% of participants.

Hydraulic fracturing for shale gas (fracking) was by far the least supported technology with 46% and 43% of the participants ranking it last or second to last, respectively. Radioactive waste disposal was the second least supported technology with 34% ranking it both last and second to last. 15% of the participants were least supportive of carbon capture and storage and compressed air storage.

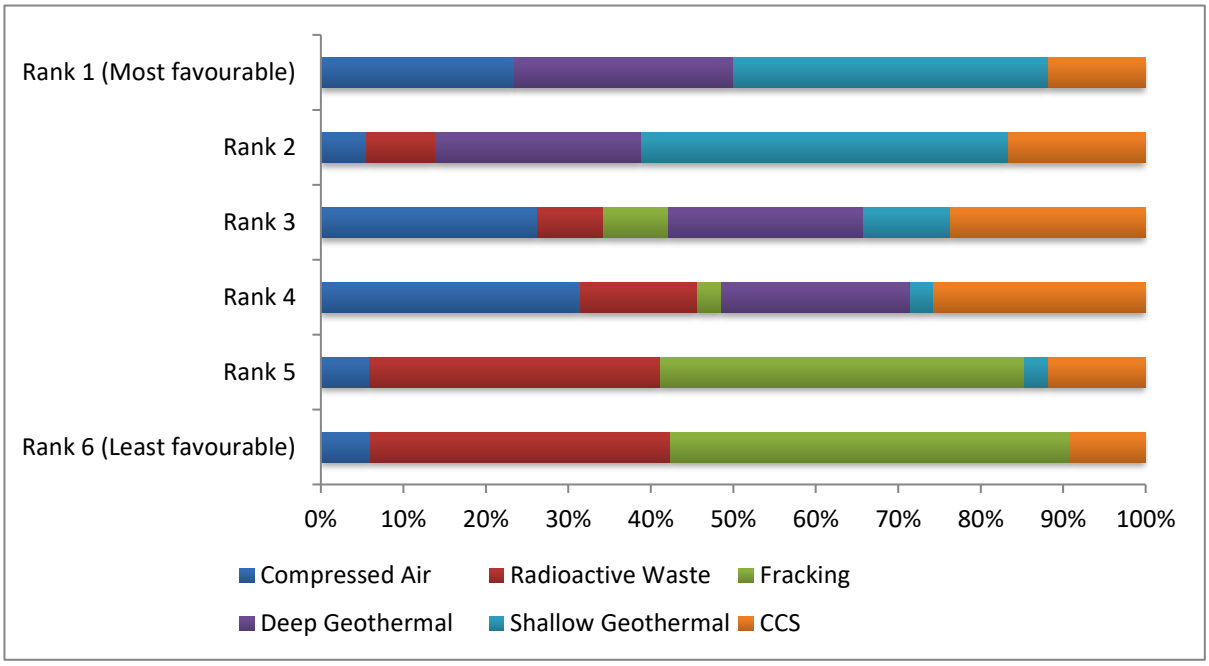


Figure 9 Percentage of participants ranking their most supported (Rank 1) to least supported (Rank 6) subsurface energy technologies

To assess whether the workshop changed the participants' attitudes to the subsurface energy technologies, the participants' level of support for the individual technologies was measured at the end of the workshop (see figure 10). The results show that shallow mine geothermal and deep geothermal were the most supported technologies with 90% and 75% of participants being either supportive/very supportive of the two technologies, respectively. Compressed air storage and carbon capture and storage were reasonably well supported with 63% and 52% of participants being supportive/very supportive. Hydraulic fracturing for shale gas and radioactive waste disposal were the two least supported technologies with only 25% and 35% of the participants expressing support, respectively.

To identify the changes in views more clearly, the difference in the percentage of support for subsurface energy technologies before (see figure 6) and after the workshop (see figure 10) were calculated (see table 2). The results show that taking part in the workshop does seem to change the views of the participants by increasing *and* decreasing support to varying degrees across the technologies. The findings show that the participants' perceptions of shallow mine geothermal changed the most, with support increasing and indifference decreasing. Support for compressed air storage and deep geothermal also saw a reasonably large increase. The workshop seemed to strengthen the more negative perceptions of hydraulic fracturing for shale gas and radioactive waste disposal by increasing the percentage of participants who were very unsupportive of the technologies (by 12.5% and 7.5% respectively), however, no technology saw a change of support in only one direction. Although the percentage of participants who were very supportive of carbon capture and storage increased by 10%, the percentage of those expressing indifference to the technology increased by 20%.

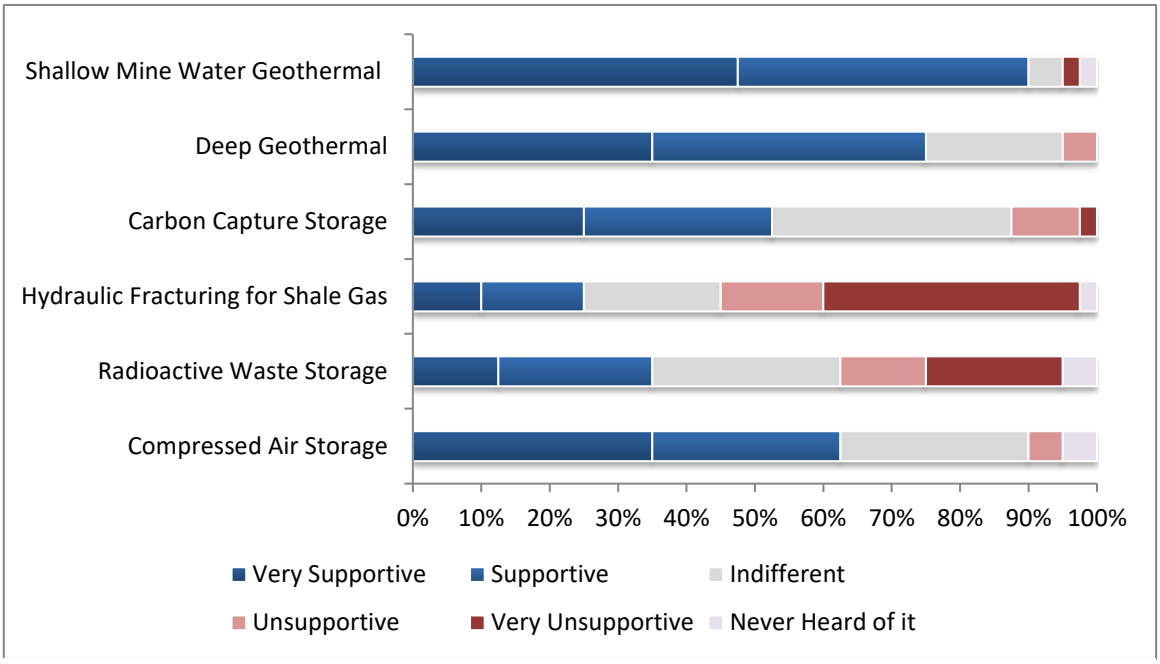


Figure 10 Percentage of participant support for sub-surface energy-related technologies after the workshop

Table 2 : Difference in the percentage of support for subsurface energy technologies before and after the workshop

	Very Supportive	Supportive	Indifferent	Unsupportive	Very Unsupportive
Shallow Mine Geothermal	**+35**	**+27.5**	**-17.5**	**0**	**+2.5**
Deep Geothermal	**+15**	**+15**	**0**	**+5**	**-2.5**
Carbon Capture	**+10**	**0**	**+20**	**+2.5**	**0**
Hydraulic Fracturing	**+7.5**	**+2.5**	**-2.5**	**-5**	**+12.5**
Radioactive Waste	**0**	**+5**	**+10**	**-10**	**+7.5**
Compressed air storage	**+32.5**	**+10**	**+15**	**+5**	**-5**

NB: cold colours represent an increase in support or reduction in indifference, grey indicates no change, and warm colours represent a decrease in support or increase in indifference.

Summary of findings:

Engaging the public in energy-related debates

The results presented above demonstrate that the participatory workshop format was useful in facilitating debate around subsurface energy related technologies. The results show that by providing the participants with information about the technologies, and a platform to discuss the risks and benefits with their peers, the levels of support for all the technologies increased. Although this was not a specific goal of the workshop, it does provide evidence that a deeper level of engagement with the public could be important in shaping positive public attitudes towards subsurface energy technologies. The participants seemed to enjoy the workshop experience with almost 60% stating that their knowledge on energy-related subsurface technologies had increased a lot, and many expressed an interest in learning more about them. The levels of engagement were high during the workshops, evidenced through the quantity and quality of the questions that were asked about the different technologies. The use of a variety of participatory activities results in more sustained levels of interest and enabled participants to contribute in different ways depending on their confidence levels.

The questioning resulted in interesting debates amongst the groups and allowed the identification of any common misconceptions associated with the technologies and the BGS, such as the confusing ground source heat pumps with shallow mine geothermal, and assuming the BGS is a regulator.

Engaging the non-engaged

This project piloted a novel recruitment approach in an attempt to gain access to segments of society who would not normally volunteer to participate in academic research, therefore falling into the ‘non-engaged’ sector of society. The aim was to recruit existing community groups across a range of geographical and socio-economic backgrounds so that a variety of perspectives could be gathered. By approaching established community groups, it was hoped that members of the public would feel more comfortable around their peers and therefore be more likely to participate.

Recruiting community groups proved to be very challenging; identifying groups to approach was time consuming and the response rate to our invitations was very low. It was clear that whilst this method of recruitment could be effective for gaining a spread of societal inputs to research, a more personal, face-to-face approach and longer lead in time to build trust with the groups is needed.

Although the ‘non-engaged’ were the target population, on reflection, the participants who agreed to take part may not strictly fall into this category. The majority of community groups that agreed to take part did so because they thought the topic sounded interesting, therefore demonstrating some level of engagement. The church groups were perhaps the most representative of the ‘non-engaged’ public (although workshop 6 participants were actively interested in climate change), these groups generally agreed to take part because they happened to be meeting anyway. Interestingly, church groups were most receptive to taking part, although again, this means that certain parts of society are over-represented in the project.

8 Lessons learned and recommendations

The overall design of the workshops worked well to engage the public in energy-related debates, and as a small pilot study, the depth of data gathered has provided useful insights into different publics’ values, knowledge and perceptions of the environment, the geological subsurface and underground energy-related technologies. The following outline some of the

lessons learned from the project and some recommendations for future research or engagement:

- Participatory workshops can effectively engage the public in debates around topics that they may not have much knowledge of, although it is important to use well-designed engagement tools to keep interest levels high and give all participants an opportunity to contribute to discussions.
- The scope of the workshop was broad and the sample size was small, therefore the results of the project should not be extrapolated to represent the views of the general public, instead, they should be used to inform the development of future engagement strategies or research projects.
- The workshop format could be modified easily to be more targeted on specific issues or technologies but the possibility of establishing a more formal citizen panel to inform the geoscience research agenda could be explored.
- The participants asked questions about the technologies that the non-expert facilitators were unable to answer. Whilst having an expert attend the workshops may be useful, on reflection, it may have an adverse impact on the dynamics and openness of the group and their discussions. In future studies, it could be useful to have an 'ask the expert' session at the end of the workshop.
- There is significant potential in using existing community groups to inform BGS and wider geoscience research agendas; however, the time and cost of developing meaningful engagements are high. These aspects were underestimated in the pilot project and therefore the sample was not as representative as was initially intended. In future studies, a mixed method approach is recommended – using a national scale questionnaire to solicit values, attitudes and perceptions in conjunction with a small number of participatory workshops across the country to explore the finding in more depth. Appropriate time and funds should be costed into any future projects to allow trust building between the researcher and the groups during the recruitment process.
- It is recommended that a monetary incentive for community groups is included in costings of future projects as feedback from some groups whose members could be considered to be more 'disengaged' (rather than 'non-engaged') felt that participants would be more likely to take part if they were compensated for their time. Nevertheless, it is recommended that a donation be made to the community group rather than individuals.
- The workshop findings indicate that there is an appetite for information and scientific evidence about the geological subsurface and the technologies presented to the participants, although the majority were unaware that the BGS are involved in energy-related research. A reasonable proportion of the participants were aware of the BGS, but they were less confident about their activities and research focus and were interested to know more about who sets (and funds) their research agenda. The findings suggest that perhaps more could be done to communicate these aspects to the public. For example, a review of the BGS website could be considered - the challenge of the current website is that it is aimed at a broad audience, which includes the public and the research community. Whilst the website is effective if you know what you are looking for i.e. data, services etc. it is difficult to find a simple explanation of what the BGS does. Visitors to the site must go to the 'Contacts' tab, then the 'About Us' tab to find out this information. The link to 'How the BGS is funded' is broken', although the link to 'How BGS is involved with industry' provides this information. One way to approach this may be to have a tab that directs visitors to a more public facing site and researchers to the academic material.

- Overall, the findings from this pilot study demonstrate that there is wide interest in the uses of the geological subsurface, particularly in its role in the transition to a low carbon future. Taking part in the workshop changed many of the participants' views on the subsurface energy technologies, which suggests that public engagement activities should be undertaken now to support the public in making informed decisions and before engrained negative perceptions are developed through other media and societal influences.

Appendix 1 Questionnaires

QUESTIONNAIRE 1

Participation Number:

---

1. Please select your age category:

18-29 30-39 40-49 50-59 60-69 70+

2. Please select your gender:

Female Male Other Prefer not to say

3. Please indicate to what extent you agree with the following statements (please tick);

Strongly agree (1) Agree (2) Indifferent (3) Disagree (4) Strongly disagree (5)

		1	2	3	4	5
a.	I am concerned about climate change.					
b.	There is too much conflicting evidence about climate change to know whether it is actually happening.					
c.	I think claims that human activities are changing the climate are exaggerated.					
d.	Being environmentally friendly is an important part of who I am.					
e.	I believe the development of new technologies will stop climate change.					

4. In your own words, please provide a short explanation of what you understand the UK's 'energy system' to be.

---

5. The underground (the geological sub-surface) has a number of different uses, can you list any energy-related uses you can think of?

6. Have you heard of the British Geological Survey (BGS)? Please circle: Yes No
   If yes, please provide details of what you know about BGS and their role.

7. Have you heard of the UK Geoenergy Observatories? Please circle: Yes No
   If yes, what do you know about it?

8. Please list all of the types of energy that you know make up the UK's energy mix

9. Please explain the difference between a renewable and non-renewable energy source?
   If unsure, please leave blank.

10. What comes to mind when you read the words "fossil fuels"?

11. Please rank on order of importance to you in relation to energy technologies:
    (1= Most favourable – 4 = Least favourable)

- ◯ Environmental protection/impact
- ◯ Energy security (having a secure source of energy)
- ◯ Affordable energy bills
- ◯ Having renewable / Low carbon energy

12. What sources of information do you get your energy related information from? (please tick)

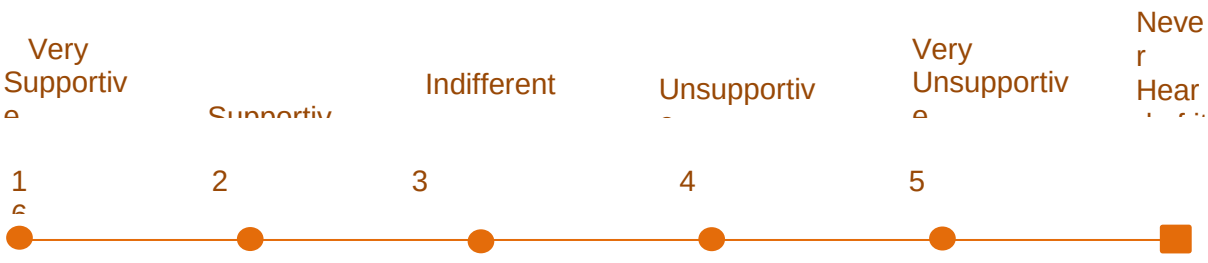
Source	Often	Sometimes	Rarely	Never
UK Government & regulators (e.g. BEIS, DEFRA, Environment Agency)	◯	◯	◯	◯
British Geological Survey	◯	◯	◯	◯
University scientists	◯	◯	◯	◯
Industry (e.g. SSE, BP, INEOS, E.ON)	◯	◯	◯	◯
Environmental organisations & action groups (e.g. Friends of the Earth, Greenpeace, National Trust)	◯	◯	◯	◯
Broadsheet newspapers (e.g. Telegraph, Times, Guardian)	◯	◯	◯	◯
Tabloid newspapers (e.g. Daily Mail, Daily Express, Daily Mirror, The Sun)	◯	◯	◯	◯
Radio	◯	◯	◯	◯
Television	◯	◯	◯	◯
Social media (e.g. Twitter, Facebook)	◯	◯	◯	◯
Conversations with friends & family	◯	◯	◯	◯
Other, please state_____	◯	◯	◯	◯

13. How trustworthy do you deem these organisations to be regarding information on the UK's energy issues? Please tick.

Source	Very trustworthy	Somewhat trustworthy	Not trustworthy	Not sure

UK Government & regulators (e.g. BEIS, DEFRA, Environment Agency)	◯	◯	◯	◯
British Geological Survey	◯	◯	◯	◯
University scientists	◯	◯	◯	◯
Industry (e.g. SSE, BP, INEOS, E.ON)	◯	◯	◯	◯
Environmental organisations & action groups (e.g. Friends of the Earth, Greenpeace, National Trust)	◯	◯	◯	◯
Broadsheet newspapers (e.g. Telegraph, Times, Guardian)	◯	◯	◯	◯
Tabloid newspapers (e.g. Daily Mail, Daily Express, Daily Mirror, The Sun)	◯	◯	◯	◯
Radio	◯	◯	◯	◯
Television	◯	◯	◯	◯
Social media (e.g. Twitter, Facebook)	◯	◯	◯	◯
Conversations with friends & family	◯	◯	◯	◯
Other, please state_____	◯	◯	◯	◯

14. Please indicate your level of support (if you have heard of them) for the following underground (sub-surface) energy-related technologies:



	1	2	3	4	5	6	
(a) Compressed Air Storage	○	○	○	○	○		□
(b) Radioactive Waste Storage	○	○	○	○	○		□
(c) Hydraulic Fracturing for Shale Gas	○	○	○	○	○		□
(d) Carbon Capture Storage	○	○	○	○	○		□
(e) Deep Geothermal	○	○	○	○	○		□
(f) Shallow Mine Water Geothermal	○	○	○	○	○		□

15. Please indicate to what extent you agree with the following statements (please tick);

Strongly Agree 1 — Agree 2 — Indifferent 3 — Disagree 4 — Strongly Disagree 5

	1	2	3	4	5
a. I trust the government and regulatory bodies to ensure that the extraction or underground storage of energy-related materials is carried out safely.	○	○	○	○	○
b. I know where to find out information about how the 'sub-surface' is used for energy-related activities.	○	○	○	○	○
c. The risks and benefits of using the subsurface for energy-related activities are communicated well by experts.	○	○	○	○	○
d. Public-funded research on the geological subsurface is good value for money.	○	○	○	○	○

16. I feel that my level of knowledge on energy issues is:

○ Poor ○ Average ○ Good ○ Advanced

I feel that my level of knowledge on subsurface technologies is:

○ Poor ○ Average ○ Good ○ Advanced

17. I feel that my level of knowledge on energy issues and subsurface technologies could be improved by:

_____

_____

QUESTIONNAIRE 2

Participation Number:

_____

1. After completing the workshop and activity do you feel that your knowledge on energy-related subsurface technologies has increased….
   Please tick

   ◯ A lot ◯ A little ◯ Not at all

2. After completing the workshop and activity do you feel that your knowledge on broader energy issues has increased….
   Please tick

   ◯ A lot ◯ A little ◯ Not at all

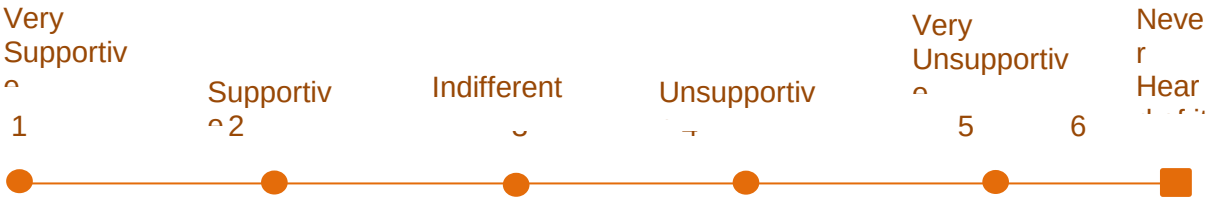
3. Please rank the following subsurface energy technologies in order of supportiveness
   (1 = most supportive, 6 = least supportive)

◯ Compressed Air	◯ Deep Geothermal
◯ Radioactive Waste	◯ Shallow Mine Water Geothermal
◯ Hydraulic Fracturing for Shale Gas	◯ Carbon Capture Storage

4. In your own words, please provide a short explanation of what you understand the UK's 'energy system' to be.

5. In your own words, please provide an explanation of what you understand about the "geological subsurface".

6. Please indicate your level of support for the following energy technologies:



	1	2	3	4	5	6	
(g) Compressed Air Storage	○	○	○	○	○	□	□
(h) Radioactive Waste Storage	○	○	○	○	○		□
(i) Hydraulic Fracturing for Shale Gas	○	○	○	○	○		□
(j) Carbon Capture Storage	○	○	○	○	○		□
(k) Deep Geothermal	○	○	○	○	○		□
(l) Shallow Mine Water Geothermal	○	○	○	○	○		□

7. After this workshop, what do you think the

(a) Benefits of having energy technologies underground might be?

(b) Disadvantages of having energy technologies underground might be?

8. How easy or difficult do you find it to get the information you wanted about energy issues (before this workshop)? Please circle

1. Very Easy 2. Fairly Easy 3. Fairly Difficult 4. Very Difficult

5. Did not want or need to find information 6. Don't know

9. Is there any other information about the geological subsurface that you would still like to know?

10. Are there any areas of interest that you would like the British Geological Survey to focus on or investigate?

References

Chilvers, J., 2010 Sustainable Participation? Mapping Out and Reflecting on the Field of Public Dialogue in Science and Technology Sciencewise Expert Resource Centre, Harwell, Oxon

Cotton, M., & Devine-Wright, P. (2011). Discourses of Energy Infrastructure Development: A Q-Method Study of Electricity Transmission Line Siting in the UK. Environment and Planning A: Economy and Space, 43(4), 942–960.

Cotton, M., & Devine-Wright, P. (2013) Putting pylons into place: a UK case study of public perspectives on the impacts of high voltage overhead transmission lines, Journal of Environmental Planning and Management, 56:8, 1225-1245.

Demski, C., Spence, A. and Pidgeon, N. (2013) Transforming the UK Energy System: Public Values, Attitudes and Acceptability – Summary findings of a survey conducted August 2012. (UKERC: London).

Iskandarova M., Genus A. (2019) UK Responses to the Energy Challenge: Dominant Framings and New Imaginaries. In: Fahy F., Goggins G., Jensen C. (eds) Energy Demand Challenges in Europe. Palgrave Pivot, Cham.

Jensen, C.L., Goggins, G., Røpke, I., Fahy, F. (2019) Achieving sustainability transitions in residential energy use across Europe: The importance of problem framings. Energy Policy, Volume 133

Spence, A., & Pidgeon, N. (2010). Framing and communicating climate change: the effects of distance and outcome frame manipulations. Global Environmental Change, 20(4).

The Centre For Climate Change And Social Transformations, (2019). Briefing Paper 2: Public opinion in a time of climate emergency.