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Decarbonisation and Resource Management

Open Report OR/22/004

BRITISH GEOLOGICAL SURVEY

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Societal and cultural research opportunities at a deep UK geological carbon dioxide storage research facility: results from a social science 'sandpit' discussion

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Foreword

This report is a component of a scoping study for a UK carbon dioxide (CO_2) storage research facility by the British Geological Survey (BGS) and UKRI. The report describes a 'sandpit' discussion meeting of academic researchers and members of public sector organisations to discuss and develop social and cultural research activities around a UK deep geological CO_2 storage research facility. The report is a deliverable from the scoping study achieved within the scoping study six-month period of extension to end-March 2022 and additional budget. This report presents the research community view, their outputs and recommendations arising from the sandpit discussions, rather than the views of NERC and BGS.

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In addition to the authors, a large number of individuals (see names below) have contributed to this report; freely and openly sharing their thoughts and research ideas during a research sandpit event and during follow up conversations. This contribution was offered despite an absence of funding from the project and in the spirit of collaboration and in recognition of the value of growing new research partnerships. I would particularly like to thank Jen Roberts (University of Strathclyde) and Jennifer Dickie (University of Stirling) for their contribution to the planning and development of the sandpit, Peter Woodward of Quest Associates Ltd for his professional planning and facilitation of the sandpit, Ellie Evans (BGS) for managing the technical demands associated with online group events and Maxine Akhurst (BGS), Eilidh Dunnet (BGS), Ceri Vincent (BGS), Thomas Robinson (NERC), Kola Akinola (NERC) and Tao Chang (AHRC) for facilitating breakout sessions.

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Summary

This report describes the outcomes of a sandpit activity in December 2021, and initial follow up discussions, designed to bring together academics from across and beyond the UK, as well as members of public sector organisations. The intended outcomes were to discuss and develop societal and cultural research opportunities as part of a scoping study for a UK CO_2 storage research facility. These outcomes are a research community view that inform the questions and knowledge gaps that a research facility would address. The sandpit is the first of many activities that will enable us to build an evidence base to demonstrate how a research facility would benefit from societal and cultural research and unlock new research themes. In particular, how the identified research themes support the UK's transition to a sustainable future.

The following themes were identified:

- the role of culture and heritage in shaping community views and energy literacy;
- placed-based and participatory research and the links between people's sense of place and new energy infrastructure activities;
- the value of tacit knowledge and collective memory to support co-design and community agency;
- energy justice in support of a just and inclusive energy transition;
- good governance to support ethical and responsible innovation;
- benefits and risks, inclusive knowledge production and community involvement in decision making;
- social conflict, controversies and trust in 'energy actors';
- existing CO_2 storage narratives and how these might be changed;
- use of creative arts-based approaches to deepen community engagement;
- the CO_2 storage research facility as a 'public lab' to support a range of engagement approaches.

Recommendations are made in this report concerning the development a new programme of integrated, interdisciplinary and inclusive research, based on priority research themes, in a timely fashion to ensure maximum benefit and impact. We also recommend that a cross-research council funding strategy is developed in support of this research.

We suggest that developing such an integrated programme would: enable community agency in the development and co-design of a CO_2 storage research facility; encourage dialogue and investment in wider carbon mitigation strategies and support localised behaviour change; embed an understanding of the role CO_2 storage could play in the energy transition; and enable positive, transparent and inclusive energy and climate policy development both locally and nationally.

1 Introduction

Carbon Capture and Storage (CCS) is critical to the UK achieving net zero by 2050 (CCC, December 2020; HMG, March 2021; IEA May, 2021). In order to support the transition to net zero, and building on existing expertise and research, the British Geological Survey (BGS) put forward a proposal for a carbon dioxide (CO_2) storage research facility, hereafter called a 'research facility', to inform planned offshore UK CCS operations. This proposal enabled the BGS to secure funding to undertake a scoping study; to outline investment options for a storage research facility on behalf of the Natural Environment Research Council (NERC) and UK Research and Innovation (UKRI).

The vision is to create a world-leading research and innovation facility in subsurface CO_2 storage that would cover the breadth of the UKRI remit. Research at a facility would span engineering and technological innovation (EPSRC and Innovate UK), research opportunities for earth and environmental sciences (NERC), social sciences (ESRC), and arts and humanities (AHRC). A research facility would support long-term plans for research campaigns throughout its life.

This proposed research facility would be a novel borehole research infrastructure to study secure injection and subsurface storage of CO_2 at depths greater than 800 metres. Its capabilities will enable a step-change in our understanding of permanent CO_2 geological storage, which is integral to the government's strategy for future UK CCS deployment, starting with the industrial clusters by 2030 (HMG, December 2020).

A research facility is planned to be delivered through phased funding, initially via this Phase 1 scoping study (Akhurst et al., 2022) which has submitted a funding proposal for a second Phase 2 scoping study. The Phase 1 study has identified geoscience research and technology development knowledge gaps defined by stakeholders. Phase 1 has involved extensive community consultations with industrial, policy, academic and international stakeholders. They have defined science questions relevant to UKRI that are necessary to: (i) accelerate and de-risk secure CO_2 storage to ensure the UK meets its ambitious net zero targets; (ii) address fundamental research and innovation challenges; (iii) present a longlist of infrastructure options. The proposed Phase 2 scoping study in 2022 to 2024 would shortlist and further scope the infrastructure options, refine the research questions to inform facility design and technical feasibility studies. Selection would include consideration of how all UK industrial clusters could gain benefits from research at a facility.

The UK Government recognises that understanding public attitudes towards technologies such as CCS is crucial to ensure effective implementation according to a recent BEIS-commissioned report (Wicket-Whyte et al., 2021). Previous experience of large energy infrastructure projects, such as unconventional hydrocarbons, shows the impact negative public opinion can have on such developments, particular policy decisions (Ryder et al, 2020 and Devine-Wright et al, 2021). A storage research facility provides a unique opportunity to take a truly interdisciplinary approach to each scoping phase; to take an in-depth look at the range of public attitudes at different scales, consider different approaches to community engagement and the role society can play in building carbon mitigation strategies for a sustainable energy future. UKRI is, therefore, committed to the development of social science, arts and humanities research alongside, and integrated with, the geoscience research and technological innovation.

Feedback from preceding phases of stakeholder engagement with technical stakeholders had also highlighted social science research as a key element of the scoping study. To maximise this opportunity, a social science sandpit was organised as a first step. The aim was to develop a network of diverse social science, arts and humanities researchers who would come together to explore new, exciting and unexpected research opportunities; it would be the start of many future diverse conversations. To widen engagement with the social sciences, representatives from the Arts and Humanities Research Council (AHRC) and the Economic and Social Research Council (ESRC) were approached. They were involved in planning the sandpit to ensure any outcomes aligned with a diverse range of UKRI's research portfolio.

It is important to note here that a separate public engagement programme is being designed alongside, and will be informed by, this social science research programme.

1.1 ORGANISATION

The sandpit was held on 6th December 2021 as an online 'virtual' discussion to ensure maximum possible participation.

1.1.1 Selection of participants

A potential participant list was generated by the scoping study members. This relied on existing networks and was 'by invitation only' to ensure a good range of disciplines and expertise was included, but that numbers remained manageable. Invitees included academics from the social sciences, the project technical team, arts and humanities, as well as those from public sector organisations with expertise in social science research and participatory monitoring. All potential participants were contacted initially to gauge interest in participating in a sandpit event focused on social science research opportunities of a CO_2 storage research facility. This also served to promote early engagement. Those that showed interest were then individually invited to register for the event and were automatically sent a link and calendar invitation.

1.1.2 Planning and facilitation

A professional facilitator was engaged early in the process to advise on design of a programme that would meet the requirements of NERC and UKRI whilst serving to engage a wide range of academic researchers.

The facilitator advised on optimum participant numbers, nature and number of presentations, size and number of breakout sessions and clarity of tasks set for participants. The involvement of an external facilitator also enabled the project team to either participate in discussions or concentrate on background tasks such as note taking and recording of 'chat' discussions.

1.1.3 Participants

Thirty-one participants registered to attend, in addition to the NERC, AHRC, ESRC and BGS project team. Twenty-nine of the 31 registrants participated on the day. Participants included registrants from UK and a Netherlands university: Aberdeen; Bath; Birmingham; Cambridge; Cardiff; Edinburgh; Edinburgh Napier; Erasmus University, The Netherlands; Exeter; Glasgow; Imperial College London; Lancaster; Open University; Oxford; Royal Holloway; Stirling; Strathclyde. In addition, participants attended from Curating Tomorrow, the Environment Agency, Historic England, Plymouth Marine Laboratory, TNO (The Netherlands), and Scottish Carbon Capture and Storage (SCCS).

Disciplines and specialisms of participants included: energy geography; human geography; psychology; behavioural science; poetry; arts and creative practice; science communication; environmental politics; energy policy; social sustainability; subsurface energy governance; participatory monitoring, geological sciences.

1.1.4 Rationale

It was an exciting opportunity to engage with such a diverse range of participants and explore, as yet, unknown and unexpected research ideas, within the context of NERC's clearly defined objectives specific to a CO_2 storage research facility. These objectives were to explore what social science research questions a research facility would enable and how social science research might support the development of a research facility. The AHRC was clear that its priority would be the exploration of creative methods and how they might be applied to research that would support human behaviour change in the move to net zero emissions.

A balance, therefore, needed to be struck between the specific needs of NERC around a research facility and the exploration of research themes and ideas with academic researchers. How might we promote a creative and dynamic, free-thinking approach to the sandpit whilst ensuring that NERC achieved the outcomes they needed?

With this in mind, two clear tasks were completed during separate breakout sessions:

Task 1. Identify potential social science research areas that will inform a timely and fair energy transition;
Task 2. Identify potential social science research questions directly related to CO_2 storage.

Task 1 would enable participants to consider the wider issues of the energy transition. To encourage free exploration of research opportunities, not constrained by CO_2 storage and a research facility, and enable collective and collaborative discussion with other participants.

Task 2 was more focused on CO_2 storage and the proposed research facility. It would also allow participants to consider if research areas identified during the first discussion might be translatable to a more focused project. Also, whether there were other more specific issues and research questions that would be directly aligned with the research facility.

1.2 FORMAT

1.2.1 Introductory presentations

Two separate presentations were given during the sandpit. One, at the start of the sandpit, outlined the research facility project vision, mission, the development phases of a facility and the sandpit aims, from a NERC perspective. This presentation would lead directly into the first breakout session. A second presentation was given which described carbon capture and storage, what the project hoped to achieve and what a CO_2 storage research facility might look like. This gave participants an insight into current science and technical thinking, providing valuable context for the second breakout session discussion.

1.2.2 Breakout sessions

The two tasks (Section 1.1.4) were assigned to participants to discuss during the two consecutive breakout sessions. The groups comprised up to six people, a note taker had been pre-assigned to each group and each group was asked to identify a group facilitator. Membership of each breakout group was rotated for the two breakout sessions so that participants had a chance to meet and discuss ideas with a range of participants. A mix of Early Career Researchers, senior researchers and public body representatives was chosen, where possible, for each group.

Note takers were given a template to record discussions during the breakouts. They were asked to articulate research areas and research questions in up to 20 words and put them in priority order. The groups were also asked to select one observation to share beyond the group.

1.2.3 Plenary sessions

Each breakout session was followed by a plenary session. On returning to the plenary session, each breakout group was invited, in turn, to contribute one research area (breakout 1) or research question (breakout 2) in priority order. Further input was invited as time permitted. This ensured that all groups were given equal time to share ideas in a consistent manner. All the ideas and discussion points presented at plenary were recorded in a document shared on screen to allow participants to either check and correct the notes, or contribute further comments in the meeting chat function. Participants were also invited to add additional comments and ideas via the chat as they occurred. The meeting chat was saved to ensure these contributions were not lost.

There was a very high level of engagement from all groups. Discussion was active and a wide variety of ideas were contributed and shared.

2 Results

2.1 BREAKOUT SESSION 1, TASK 1 – RESEARCH AREAS THAT INFORM A TIMELY AND FAIR ENERGY TRANSITION

The discussions in all breakout sessions were wide ranging but tended to follow particular themes. What follows is a subset of the most common themes.

2.1.1 Place-based and participatory research

We need an understanding of what the energy transition and CO_2 storage mean to local communities. What measures could be taken to understand and mitigate any tensions? When considering and comparing onshore and offshore settings, each setting will involve different communities.

Should social research start at the local scale and work outwards or consider the national picture and work inwards to the local level? Those closest to a proposed activity may have a different perspective to that held nationally.

We need to think about a community's identity in terms of place, occupation, families etc. Also issues of 'fossil fuel identities' i.e. communities that have a history of energy development but have not necessarily benefitted from this development.

If we take an ecosystems services approach, we can connect people to the changes in their environment from which they are often separated. Local place-based ecological knowledge amongst site communities is also valuable.

What could be the role of arts and heritage-based research approaches?

2.1.2 Energy justice and the just transition

What is energy justice and to whom does it relate? What is an energy transition, whose transition is it and who decides it? What can we learn from other large energy infrastructure projects and previous energy transitions e.g. coal to oil, gas to nuclear. We need continuous learning as the conversation changes.

Fairness is a complex issue; who does fairness relate to? Is it just the communities affected by investment or is it a wider issue? Given the timescales involved, what about intergenerational inequalities? Energy justice should be inclusive and not rely on western thinking; it should include global and indigenous perspectives. What happens when fairness falls short or fails?

We are making decisions and creating an industrial legacy for the local and global community that will impact us all for thousands of years, therefore, we need to consider different perspectives, not just those in the UK. Not taking action sufficiently fast enough may mean other global communities may be affected long before us; what are the global justice implications of the UK net-zero approach – including CO_2 storage options alongside cuts in emissions?

Is there a conflict between timeliness and justice in terms of energy transition? Will a timely energy transition be made at the expense of a just one? If it is not timely, will it be even less just? Are the concepts of 'timely' and 'justice' complementary?

We need to consider distributive justice and even restorative justice. How does CO_2 storage interact with climate adaptation needs, policies and measures?

Could we use a rights-based approach to assess the infrastructure programme, CO_2 storage and the energy transition more broadly? How do we assess the rights of future generations and the rights of non-humans e.g. water bodies, glaciers, the underground?

2.1.3 Social conflict and trust

What is the level of trust in large corporations if they are seen to make all the decisions? We also need to understand levels of trust in government and academic institutions; this can often present as big, or even bigger problems than with large corporations. We need to consider who the real stakeholders are, requiring an in depth look at community structures/make-up so that

those most likely to be affected are clearly identified. How do you gain commitment with local communities?

Where are the likely controversies and what impacts will they have? What is the interface between policy and public acceptance – how influential is public opinion on policy decisions? What about the negative spill-over effect from past large energy infrastructure programmes?

2.1.4 Energy futures

How and by whom are energy futures made, understood, imagined and communicated? How do we encourage a more collective deliberation around what the energy transition is, or should be, so that everyone can join in and contribute to it? There is an opportunity for lifelong learning and improving energy literacy.

It is difficult for people, and experts, to imagine a distant future. The CO_2 storage research facility is about decades, but what about centuries and millennia? How do we cope with different futures and uncertainties and increase our 'futures literacy'? How can we use the past, our industrial heritage, to imagine the future? Can we imagine a shared future through economics, arts and heritage?

How can arts and humanities help people sit with and understand unknowns and frame challenges, risks and decisions in an uncertain environment?

2.1.5 Role of culture

What are the cultures of decision making and how does this affect energy justice at all levels? Who is making the decisions and who is influencing them? How can culture influence the energy transition agenda and how can cultural products, such as media and films, encourage sustainable consumption practices? What about greenwashing narratives in the media? Who gets to decide on the stories that are being told? Some view CCUS as extending the life of fossil fuels.

2.1.6 Trade-offs, benefits and risks

How are local communities involved in the decisions of new developments and how do you ensure affected communities benefit to a suitable level? We need robust data collection and analysis to understand co-benefits and trade-offs of the energy transition. Any data collection should include participatory data collection and consideration of who decides what data is needed, who collects it, who will analyse it and how the outcomes will be used and by whom.

What is sustainability? We need to challenge ourselves to go beyond the United Nations Sustainable Development Goals. The transition towards more sustainability is not only positive. It will bring some losses so how will we cope with those losses?

If things go wrong, risks are shared and risks become a 'commons', that is the universal access to cultural and natural resources. If things work well, do the benefits and Intellectual Property go to the companies? What happens if there are leaks, who is liable?

Offsets and permanence: There will be many technical, social, political and economic arguments around the terms by which negative emissions and CO_2 removal will be allowed to meet national targets. These will be closely related to the perceived permanence of CO_2 storage in geological formations versus natural systems such as forests or soil carbon.

The framing of risk and how it is portrayed could be considered as a research facility is developed.

2.1.7 Communication

How are communications developed, using communication theory? Can we take an arts-based approach to communication and community engagement?

People-centred communication is important and an understanding of what is important to people through behavioural science, economics and psychology.

2.1.8 Governance

There will be a need for good governance to ensure ethical and responsible innovation. Governance of the industry and regulations could be developed as a facility develops.

What about the role of devolved administrations and policy? Scotland and Wales have different policy processes, commitments, ambitions and ways of engaging with communities. How can these differences be factored into the wider narrative around CO_2 storage?

2.1.9 Economics

The policy around energy transitions is currently viewed from an economic viewpoint. Who is going to pay for it, and can we make money from it? How we can move from a process dependent on market, neoliberal economics towards an economy of 'common goods' so that parameters of success are widened to include people and environment?

Are we likely to see similar patterns of benefits and disadvantages for communities that have a history of energy development, and fossil fuel identities.

Economics can be a trade-off. It should not just be about economics but also about health, economics and wellbeing. We need to weigh up social and environmental factors, economic geography and other different dimensions of social science. We need a broader discussion about rights and what a just transition means.

2.2 BREAKOUT SESSION 2, TASK 2 – RESEARCH QUESTIONS DIRECTLY RELATED TO CO_2 STORAGE

Exploration of broad research areas enabled participants to explore a range of issues related to a just energy transition. In the second breakout the focus was specifically aimed at identifying research questions directly linked to issues of CO_2 storage and a proposed CO_2 storage research facility.

The CO_2 storage research questions raised are listed below and have been placed into broad categories. However, it should be noted that there is considerable overlap between categories, therefore, any future work need not be constrained by the categories listed below.

Narratives

What are the existing narratives around CO_2 storage and how might we seek to change them?

How can we construct a larger narrative around CO_2 storage so that it is not just seen as a 'stop-gap' technology between fossil fuel use and a transition to green energy?

Heritage

Can heritage be used as a tool to unlock societal tensions? Industrial legacy still shapes communities through heavy industry such as coal mining, steel etc.

What is the particular nature of communities invested in CO_2 storage?

How might we make use of tacit knowledge, experience and collective memory held in the local population? Could indigenous knowledge be used to co-design the CO_2 storage facility so that it benefits both parties?

Public laboratory

Can a 'public' CO_2 storage research facility (public laboratory) help us understand how people perceive the subsurface in terms of spatial and temporal scales. Can the public laboratory help us to illuminate and increase understanding of these different scales using a whole range of disciplines including arts, humanities, psychology, behavioural science, virtual reality and site visits?

How can a CO_2 storage facility be used as an opportunity to be innovative and creative and support community involvement for a greater level of trust and transparency?

What opportunities does a research facility offer to physically show what CO_2 storage means and looks like?

Can virtual reality (VR) help us to visualise the underground? Could it be used to test creative practices in a VR lab? How can we visualise data alongside social perception? Could VR enhance perception and understanding of depth?

Energy justice

Do people understand the impacts of climate change and excess CO_2 in their life and environment? Local versus global equity.

What does deep participatory engagement look like for geology? How do we empower communities and how do we avoid the 'they can't say no' situation, particularly if incentives are offered?

How can we give communities agency and enable them to be involved in other forms of carbon mitigation? How can we enhance benefits or highlight alternative benefits to the community?

Can a research facility give us an opportunity to move away from mainly economic arguments? Can we reposition CO_2 storage within energy and being part of the carbon cycle and circular economy, rather than being related to making profit? An economy of common goods so that the parameters of success are wider to include people and environment.

Timescales and energy futures

How do different conceptions of timescales work together e.g. economics versus geologic timescales?

How do we make the conversation empowering for the community so that they can make decisions into the far future? We are making decisions for an almost unimaginable future community.

How do you handle governance on permanence; a permanent geological timescale? Permanent storage of CO_2 – an interesting language aspect. How do you govern?

Justice – what is the importance of timescales for governance, regulation, science and social science? How does science make decisions and assess risk over such unimaginable timescales?

In terms of economics, land-use decisions on surface and in subsurface, what is the cycle of distribution of benefits and disadvantages – historically and how they might persist?

How can we imagine a future beyond the next 10 years?

Economics

What are the economic benefits of CO_2 storage? What is inclusive growth?

How will CO_2 storage interfere with other economic factors of, for example, agriculture and tourism?

How do we build momentum behind, and write a business case for, technologies that are only transitional? What can we learn from historical industries?

Risk perception and trust

Risk framing and communication – how can uncertainty and risk be calculated, communicated and visualised? What about unknowable risks?

How does risk perception and trust develop? Explore the relationship between infrastructure projects, commercial partners, businesses, regulators and trust.

What drives perceptions and attitudes on safety CO_2 storage? What drives behaviours and how can we influence them?

3 Outcomes

All participants engaged fully with the discussions both in the breakout sessions and in the plenary sessions. Many contributed additional insightful comments and ideas in the meeting chat facility that had not been captured during the plenary sessions but have been summarised here. All those present showed real enthusiasm for the activities and many provided positive feedback after the event.

Social science, arts and humanities researchers welcomed the opportunity that a CO_2 storage research facility would provide as a platform to conduct their own research. They emphasised it would be vital to engage social sciences, arts and humanities early in the process, to contribute to early thinking on siting of a CO_2 storage research facility and gather qualitative data for social baseline assessments.

The invited participants agreed that this type of research should be properly funded and not be seen as a tool for supporting engagement activities later in the project i.e. down-stream communication activities, however the research would support and inform wider public engagement activities; it would be important to avoid the social sciences becoming a 'bolt-on' activity once all the scientific and technical work had been completed. Early integrated and interdisciplinary research and engagement, alongside geoscience research, was seen as innovative and novel. Many of those present had experience of other large projects that had tried and failed to embrace a truly interdisciplinary approach; this was seen as an exciting step forwards in terms of integration and collaboration across disciplines. Emphasis was also placed on the importance of actively embedding principles of Equality, Diversity and Inclusion across all research themes in terms of research teams, development of research opportunities and approaches to community engagement.

There was particular emphasis on the role of arts and heritage in communication of, and engagement with, a research facility, its purpose and benefits. Existing narratives, place-based research, energy justice and fairness, futures literacy, and governance and policy were also strong themes that emerged. This event was viewed very much as the start of the process to plan social science, and arts and humanities research aligned with a CO_2 storage research facility, but that it would also enable wider conversations around the research facilities potential contribution to a timely and fair energy transition and the wider issues of carbon mitigation and net-zero.

4 Follow on activities

Given the range of research themes and questions identified at the sandpit, it would be important to identify priority research areas. These should align with the research interests of participants and also contribute value during each phase of facility development, particularly the construction phase, and enable delivery of the storage research facility. Whilst the sandpit had been successful in its aims to bring a community of researchers together to discuss opportunities presented by the research facility, it was felt that another large workshop-style event would not elicit any added value.

All results on research areas and research questions from the sandpit were collated into a list and shared with participants. Participants were asked to review the list, check that the sandpit discussion was represented accurately and identify up to three priority research areas that they wished to take forward to a more detailed discussion. Fifteen responses were received and emerging themes identified as priority areas are summarised in table 1.

4.1 EMERGING THEMES

Table 1 lists all those research themes that were identified as priorities by participants, along with an indication of each theme's relevance to the research facility and potential impact. The themes relate to both the research areas identified in breakout 1 and the research questions

identified in breakout 2. What follows, therefore, are themes that reflect all discussions held during the sandpit.

Table 1 Emerging research themes gathered from sandpit and follow up discussions

Theme	Relevance	Potential impact
Role of culture and heritage fossil fuel identities	Exploring how prior experience of subsurface extraction shape community views of future energy projects either positively or negatively. How does this experience affect energy literacy? Link heritage to different possible energy futures.	Understanding community values and different community characteristics may enable community 'investment' in carbon mitigation and behaviour change.
Place-based and participatory research	Linking people's sense of place to new energy activities. Links to role of culture and heritage. Enabling national versus local comparisons. Giving communities agency and enable involvement in other forms of carbon mitigation.	Encourage community 'investment' in a low-carbon future – not only supporting and embracing the CO_2 facility but opening dialogue around net zero and climate change.
Value of tacit and indigenous knowledge, experience and collective memory	Could indigenous knowledge be used to co-design the CO_2 storage research facility so that it benefits all stakeholders, including the public, industry, government, institutions?	Co-design based on local knowledge of community make-up may increase community investment and positivity.
Energy justice and the just transition	What are the cultures of decision making? To what extent are certain groups represented? Consider whether the concepts of a 'timely' and 'just' transition are complementary or in conflict. Justice should be inclusive and consider global and indigenous perspectives.	If we ensure all groups are represented and involved in decision making and are given agency, we are more likely to enable co-design with all stakeholders, including the public.
Energy futures, timescales and futures literacy	How does science make decisions and assess risk over such unimaginable timescales? How do we cope with different futures and uncertainties – over decades, centuries and, millennia. Can arts-based approaches help communities understand future uncertainties, and frame challenges, risks and decisions?	In a space where a common language is absent, can we look to other methods of communication to aid understanding and framing of an uncertain future? Enabling people to imagine different possible futures may enable us to transition.
Governance	Good governance is needed to ensure ethical and responsible innovation. Governance of the industry and regulations could be developed as facility development progresses. What are the right timescales for governance?	Issues of ethical and responsible governance link through to transparency and trust – essential if communities are to understand benefits and risks.
Trade-offs, benefits and risks	Extent to which negative emissions and CO_2 removal will be used to meet national targets. Risk perception and benefit perception. How can benefits be enhanced, and how can communities be involved in decision making? Enhance knowledge production 'upstream' early in the process – how are the risks and probabilities calculated? How will CO_2 storage interfere with other economic factors?	Do 'fossil fuel' communities always benefit from new energy developments? More inclusive knowledge production of how risks are calculated ahead of communication, and a more transparent discussion of trade-offs, may enable a more positive dialogue with communities.
Social conflict and trust	What is the level of trust in large corporations if they are seen to make all the decisions? Need to consider trust in government and institutions, not just in the private industry. Who are the real stakeholders and how to gain commitment with local communities? Where are the likely controversies and what impacts will they have?	Consider the interface between policy and public acceptance – how influential is public opinion likely to be on policy decisions? Can social conflict impact on policy decisions?

CO_2 storage narratives	Who gets to tell existing narratives and how might we change them? Can we construct a larger narrative so that CO_2 storage is not just seen as a 'stop-gap' technology in the transition to green energy. What drives perceptions and attitudes on safety of CO_2 storage? How do we link impacts of climate change with excess CO_2 in the environment?	More honest and open narratives around the role of CO_2 storage in the complex energy transition landscape will be essential to increase understanding and trust in decision makers.
Creative/arts-based approach to engagement and communication	Use of arts approaches when dialogue doesn't work; when we speak different languages How creative and arts approaches can help communities understand new large-scale energy projects like CO_2 storage.	Supports and enhances more traditional engagement activities by opening engagement to different audiences. Different approaches may widen and deepen community understanding.
CO_2 storage research facility as a 'public laboratory'	A research facility offers the opportunity to physically show what CO_2 storage means and looks like. Virtual reality and augmented reality can help us to visualise the underground. Could we test creative practices in a VR lab? How can we visualise data alongside social perception? Could a public laboratory help us to illuminate and increase understanding of different spatial- and timescales using a range of disciplines, such as arts, humanities, psychology etc.	A public laboratory could offer opportunities for more meaningful targeted educational and experiential opportunities could reverse typical trend of less local acceptance. Could help us understand how people perceive different spatial and temporal scales. A laboratory could support community involvement for a greater level of trust and transparency.

5 Recommendations

These initial activities have been successful in enabling us to develop some new and exciting research themes. This has been a positive networking opportunity between like-minded researchers, with great enthusiasm shown by all participants. It clearly demonstrates that a research facility presents a range of research opportunities in the social sciences and arts and humanities and that a number of research themes would support the development of the research facility through promotion of community agency in carbon mitigation strategies, including CO_2 storage, use of novel communication and engagement approaches, and consideration of a research facility as some form of 'public lab'. It is now important to find a way of capitalising on this new partnership and enthusiasm by identifying ways to resource any future activities. Traditionally, individual research councils have supported research that sits firmly within their remit e.g. NERC focuses primarily on earth and environmental sciences. However, research councils are now taking proactive action to develop calls that require a more interdisciplinary approach; these include a requirement for collaboration across at least two disciplines.

The following recommendations represent a collection of views expressed during the sandpit and which participants felt would support development of timely research aligned with a CO_2 storage research facility:

1. *A new programme of interdisciplinary research should be developed which encompasses a number of priority research themes as listed in section 4.1. This would involve regular engagement with representatives from NERC, AHRC and ESRC and creation of smaller research groups tasked with developing concept notes for priority research themes which could be developed into research projects.*
2. *Development of a research programme should be enabled in a timely fashion to ensure maximum benefit and impact for the project, and should be timed before siting of the research facility is confirmed. Activities may support, enhance or contribute to any 'social characterisation' activities planned. The research programme should indicate short-, medium- and long-terms goals*
3. *A funding strategy should be put in place that enables a truly interdisciplinary and integrated approach to any future research in support of a CO_2 storage research facility.*

This would require cross-council funding strategy and close involvement of representatives from NERC, AHRC and ESRC.

4. *The network of researchers should review existing and future funding opportunities that align well with the research themes identified.*
5. *Principles of Equality, Diversity and Inclusion should be embedded across all research themes; in terms of research teams, development of research opportunities and approaches to community engagement at all scales.*

6 Conclusions

By bringing a wide range of researchers together we have clearly shown that there is interest and scope for development of a number of social science, arts and humanities research themes that are either inspired by a proposed CO_2 storage research facility, or may support and enable its development and eventual construction. Taking a tiered approach to the sandpit research discussions enabled a broader dialogue around a fair energy transition but also a more focused discussion on a specific research facility activity proposed in the project science plan.

A CO_2 storage research facility provides a unique opportunity to take a much more integrated approach to research that transcends the traditional boundaries set between different research councils. We know that public opinion can matter, particularly when it comes to development of energy policies both locally and nationally. Therefore, it is crucial that we approach this project holistically through different, yet complementary work streams. Societal and cultural opportunities should be considered when building and using a storage research facility, as well as the challenges that will come in to play at key points in its development. They should progress alongside activities that address the scientific opportunities and technical challenges. Taking this integrated approach will create a greater chance of achieving positive impact in the following ways:

Enabling community agency in the development and co-design of a CO_2 storage research facility

Encouraging dialogue and investment in carbon mitigation strategies and localised behaviour change in support of the transition to net zero

Embedding an understanding of the role CO_2 storage could play in the energy transition alongside other complementary carbon reducing strategies

Enabling positive, transparent and inclusive energy policy development both locally and nationally

Glossary

Carbon capture and storage	The process of capturing and storing carbon dioxide (CO_2) rather than release to the atmosphere
CO_2 geological storage	Removing CO_2 from the atmosphere by injecting it into deeply buried porous rock formations and contained by overlying impermeable rock formations.
Community	People who share or have certain characteristics, attitudes and interests in common.
Sandpit	An interactive meeting which involves a small group of researchers, including lead academics, who define a topic and facilitate discussion.
Subsurface	The geological strata beneath the earth's surface.

References

AKHURST, M., WHITE, J., VINCENT, C., PEARCE, J., BADCOCK, N., ROBINSON, T., NAPIER, H., LAL, D., DEARDEN, R. 2022. A scoping study for a UK deep geological carbon dioxide storage research facility. *British Geological Survey Open Report*, OR/22/006. 37pp.

CCC, December 2020. *The Sixth Carbon Budget – The UK's path to Net Zero*, 448 pages. Sixth Carbon Budget - Climate Change Committee (theccc.org.uk)

DEVINE-WRIGHT, P., RYDER, S., DICKIE, J., EVENSEN, D., VARLEY, A., WHITMARSH, L. AND BARTIE, P. 2021. Induced seismicity or political ploy?: Using a novel mix of methods to identify multiple publics and track responses over time to shale gas policy change. Energy Research & Social Science, Volume 81, 102247

HMG, December 2020. *Energy white paper: powering our net zero future*. CP337, 170 pages. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf

HMG, March 2021. *Industrial Decarbonisation Strategy*. CP399. 170 pages. Industrial decarbonisation strategy - GOV.UK (www.gov.uk)

IEA, May 2021. *Net Zero by 2050. A Roadmap for the Global Energy Sector*. 224 pages. https://www.iea.org/reports/net-zero-by-2050

RYDER, S., DEVINE-WRIGHT, P. AND EVENSEN, D. 2020. Briefing: Public Perceptions of Shale Gas Exploration in the UK: A Summary of Research (2012-2020). http://www.ukuh.org/media/sites/researchwebsites/2ukuh/89490%20Public%20Perceptions.pdf

WICKETT-WHYTE, J., BOELMAN, O., BOLLEN, A., AND BECKETT, A., 2021. *Carbon Capture Usage and Storage: Public Dialogue*. Report for BEIS, 132 pages. Carbon capture, usage and storage (CCUS): public dialogue - GOV.UK (www.gov.uk)