A CO_2GeoNet Initiative

ENOS D5.5 | v1.0

CO_2 Storage Best Practice Guidelines from the GeoEnergy Test Bed Site Community

Questioning CCS: Developing Best Practice Public Engagement Guidelines

Date	25th February 2020
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Number of pages	45
Number of appendices	3
Project name	ENOS
Project website	http://www.enos-project.eu
Project number	Grant Agreement No 653718

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653718

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1. Executive summary

The ENOS (ENabling Onshore CO_2 Storage) project (www.enos-project.eu), addresses the challenges to apply the CCS technology onshore in Europe, with its unique geological and socio-economic context. The advantages of local onshore storage include empowering communities to steer the process, supporting local jobs and industries and enabling sustainable development. Onshore storage is needed to meet climate targets and offer opportunities for EU Member States that do not have easy access to storage potential in the North Sea (where CO_2 storage has been demonstrated for over two decades). In addition, the costs for transport and storage onshore are much lower than offshore.

The ENOS consortium includes more than 100 professionals (scientists and engineers, experts in geology, monitoring and social sciences and many others) from 29 organisations based in 17 European countries.
The main objective of the project is to enable the development of CO_2 storage onshore in Europe by:

- Developing, testing and demonstrating in the field, under "real-life conditions", key technologies specifically adapted to onshore contexts (for example tools to monitor CO_2 storage sites);
- Involving local communities in CO_2 geological storage development (e.g. establishing dialogue groups with researchers, citizens and civil society representatives);
- Sharing experience and knowledge across Europe to contribute to the creation of a favourable environment for onshore storage.

This is a report on the findings of the UK national team from Work Package (WP) 5 of the European Union (EU) Horizon 2020[1] funded ENOS project – "Enabling Onshore CO_2 Storage in Europe".[2] WP5 focuses on co-ordination with local communities, and this report emerges from a series of eleven meetings held over one and a half years with ten members of the local community living near the GeoEnergy Test Bed – a field laboratory near Sutton Bonington in south-west Nottinghamshire where work will include tests related to the underground injection of Carbon Dioxide (CO_2).

Carbon Dioxide Capture and Storage (CCS)[3] and Carbon Dioxide Capture, Utilisation, and Storage (CCUS) is the process by which CO_2 is captured from a source point, such as a fossil fuel-fired power station, an industrial plant (cement, steel, and chemicals), or directly for the air, and then stored underground. For CCUS, the CO_2 is utilised in processes such as chemical production or enhanced oil recovery (EOR). CCS and CCUS are methods for decarbonising industrial processes to help tackle climate change.

The aim of our work with local citizens was to organise collaborative research with them, in order to support the broader ENOS project in developing best practices for CO_2 storage processes, with particular regard to safety and potential environmental impacts. Working with the same groups of citizens over a sustained period of time allowed citizens to gain increased knowledge of the technical aspects of CCS (and CO_2 storage in particular) as they interacted with experts. The collaborative research format enabled our citizen participants to set the direction of travel in terms of which areas they wanted to focus on and the questions that were asked. The extended format also allowed for the development of trust between researchers and lay participants, and for an unhurried and wide-ranging series of discussions

[1] EC CORDIS, 2019
[2] This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 653718.
[3] In some versions, particularly in United States discourses, the 'S' is taken to stand for 'sequestration'. The process is the same in both cases.

about not only many aspects of CCS itself, but also the broader environmental context in which CCS has a potential role to play.

The meetings were focused on the questions that emerged from group discussions among our citizen participants in response to expert presentations. The questions and concerns raised were tracked over time to see how they may or may not change in the light of increased exposure to information about CCS. The nature of the questions our lay-participant group had did appear to change over time, becoming less general and more specifically focused on potential risks and problems that they had identified as they learned more. However, the broad categories of questions, listed below, remained quite constant throughout. The categories represent a framework of topics which should be discussed with any public group engaging with CCS.

1. **Safety and regulation:** This was a key priority for participants. If there is a proposal to store significant amounts of CO_2 in the vicinity of a community, local citizens will want to know who audits and regulates this activity, how the site will be monitored, and what the response will be if there is a leakage problem. Assurances that leaks are highly unlikely will not nullify this final question, community members will want to know what the response will be to the detection of a leak.

2. **The process of separating and storing CO_2:** Clear explanations of the processes involved in CCS are essential, with visual representations and 'hands-on' props especially useful. In particular, outlining which part of the process is the focus of local engagement (e.g. CO_2 storage site and/or CO_2 capture from source point) will support understanding.

3. **Costs and benefits of CCS:** There was significant scepticism in our participant group as to whether CCS would ever be economically viable, or scalable to the point where it could actually make a difference to global climate change. The economic case for Enhanced Oil Recovery was clear, but participants were concerned this would negate reductions in CO_2 emissions. There was also scepticism as to the wisdom of one country (in this case the UK) taking on the costs of CCS in the absence of comprehensive international co-operation.

4. **The wider context:** A consensus emerged within our participant group that CCS provides a net benefit to society by helping to mitigate climate change. The process was not seen as a 'silver bullet', in part because of questions of economic feasibility and scalability, and was placed into a broader picture of societal and economic changes needed alongside CCS to support decarbonisation and sustainable living in order to effectively mitigate climate change.

5. **Local impacts:** Local participants have concerns about local environmental impacts, including visual impacts, noise, increased traffic movements, the impact on local businesses, house prices, and effects on local wildlife. We found significant concern about what a CCS installation would actually look like, and what kind of visual impact it would have on the local landscape.

6. **Further Information:** The last set of topics related to information, and the degree of engagement with the public around CCS. For example, is this taught in schools? Where could citizens find (authoritative) further information? Are there examples of CCS working in other parts of the world that could be used as case studies?

2. Introduction

Climate change has become an ever more prominent social and political issue in the last few years. Mass rallies and protests organised by the international environmental group Extinction Rebellion have drawn significant crowds and public interest,[4] and around the world, governments have been making pledges on greenhouse gas emissions, such as the United Kingdom's (UK) pledge to be a net zero emitter of CO_2 by 2050,[5] and Finland's commitment to carbon neutrality by 2035.[6] Alongside these changes there are now international and national treaties and commitments to mitigate and slow the progression of climate change, such as the 2015 Paris Agreement, which required that all signatory countries make their best efforts to cut their CO_2 emissions in order to limit planetary warming to no more than 2°C.[7]

Reaching this target will require significant decarbonising efforts across economies, from energy production, to transport and industrial production.[8] Some sectors of the economy, such as energy, are relatively easy to decarbonise through the expansion of renewable energy technologies, such as wind, tidal, and solar power.. Areas such as chemical, steel, and cement production, fundamental products to modern life, are much harder to decarbonise. For this to happen, CO_2 needs to be separated from the emissions of industrial processes, or from the air, and stored.

The process of carbon dioxide capture and storage (CCS) is currently the only major technology which can achieve this by removing up to 90% of CO_2 from industrial processes, such as cement and chemical manufacture, and then storing it underground.[9] This process has the potential to reduce CO_2 emissions from many industrial processes and is recognised as a necessity in realising future emissions targets. To date, CCS has captured and stored around 260 million tonnes of CO_2 underground.[10]

The development of CCS is still in its early stages, however, and there would have to be a significant increase in capacity to meet the challenge of significantly mitigating climate change. There are new developments in CCS,[11] but CCS projects are relatively rare compared to, for example, the significant expansion in deployed renewable energy technology over the past decade, which has seen renewable electricity increase its share of electricity production fourfold since 2010.[12] A major expansion in the number of CCS projects is clearly required if this potentially fundamental technology is going to help mitigate climate change in the ways that national and international climate bodies recommend. Developments need to be made technically, economically, and socially to enable the rapid global expansion of CCS.

Enabling Onshore CO_2 Storage in Europe (ENOS) is a pan-European research consortium that seeks to support and enable the development of onshore CO_2 storage in Europe. The research combines technical work, such as advancing equipment and techniques to monitor the wells used in CO_2 storage, to the social through developing effective engagement strategies with the public on CCS. Engagement with the public, particularly those participants living close to potential onshore CO_2 storage, is a primary focus of the ENOS project.

[4] BBC News, 2019
[5] UK Government, 2019a
[6] United Nations Sustainable Development, 2019
[7] United Nations Climate Change, 2019
[8] IPCC, 2014
[9] Grantham Institute, 2018
[10] Global CCS Institute, 2019a
[11] Global CCS Institute, 2019b
[12] Carbon Brief, 2019

Effective public engagement is crucial to the success of developing new or novel technologies. There are numerous examples of new technologies which failed to develop to the envisaged level because of a lack of public involvement leading to negative public perceptions. Public engagement with new technological developments is therefore key, and although CCS is an established technological process, it is relatively new to public consciousness. It is therefore reasonable to consider it a new technology. In the case of CCS, effective public engagement would seem particularly important, given the potential fundamental role the technology could play in global efforts to decarbonise economic activity.

Reflective perhaps of the limited development of CCS in the past, there is a small but rapidly growing literature published on public engagement and public preferences in relation to it. The research presented in this report on the WP5 element of ENOS, seeks to further develop scientific knowledge in this area. The work reported on herein seeks to take public attitudes research on CO_2 capture and storage in a new direction by taking a group of lay participants and engaging in dialogue with them about the CCS process over a sustained period of time. We hoped to use this collaborative research approach to get informed citizen views on what issues should be taken into account when planning future CO_2 storage projects.

3. Carbon Dioxide Capture & Storage

CCS and CCUS are processes by which CO_2 is captured from large emission points, such as fossil fuel-fired power stations or cement works, and then pumped underground for storage. In the case of CCUS, part or all of the captured CO_2 is utilised in some form, often in the production of chemicals, enhanced oil recovery (EOR), or for use in large greenhouses. CCS can capture up to 90% of CO_2 emissions from fossil fuel power stations and industrial plants, and is a method for decarbonising these industries. It is expected that CCS will have different applications in different contexts. In countries such as the UK, and in most of western Europe, where electricity generation is decarbonising through increased use of renewables,[13] it is likely that the main application of CCS will be to reduce the carbon footprint of heavy industries such as cement, steel, and chemical manufacture, as these are industries that would find it difficult to decarbonise by other means. In countries such as Poland, India, and possibly China, where coal is likely to remain a significant source of power generation for some time to come, CCS may well also be deployed in the power generation sector.

The process of CCS begins with CO_2 being captured. This can be achieved in a number of ways, but the primary three methods are post-combustion; pre-combustion; and Oxyfuel.[14] In post-combustion, CO_2 is removed from high emission sources such as the chimney of a coal-fired power station. Pre-combustion involves converting the intended fuel into a mixture of hydrogen and CO_2 which is done prior to combustion. Oxyfuel technology burns fossil fuels with almost pure oxygen to produce CO_2 and steam. Both Oxyfuel and post-combustion can be applied to new, or retro-fitted to existing, power stations or other high-emission points such as cement works. Pre-combustion technology is more suited to new build sites due to the complexity of the technology involved in the process. During this process the CO_2 is cleaned to remove impurities which might later react with minerals in the subsurface. Once the CO_2 is cleaned it is transported by pipeline, trucks, or ship to the storage site, or for utilisation. At the storage site, the CO_2 is compressed into a fluid where it takes on the properties of both a liquid and a gas. This enables the captured CO_2 to take up much less space within the pores of the rocks (than it would in gaseous form) and allow a greater quantity to be stored.

CCS is a process in which the three main components must align for the technology to be feasible. The first stage, the capture and separation of CO_2 is well understood with numerous projects operating globally. For example, CO_2 capture using chemicals (amines) has been employed in industrial settings for over 90 years.[15] The second aspect is that of transportation. It is not always practical, or indeed possible, to store CO_2 near the source point. Storage, the third aspect, is highly dependent on geological conditions which may not be present near the source point.

Onshore transportation of CO_2 can be via pipeline, although in some cases it could be moved in specially designed trucks, from source to storage site in much the same way natural gas is moved around the country for heating and cooking in domestic homes. The US is the pioneer of onshore CO_2 transportation, with an estimated 7,000 miles of CO_2 pipelines installed, much of which was developed to support Enhanced Oil Recovery (EOR)[16] which is sometimes considered to be a form of CCUS. The process of EOR involves injecting CO_2 under pressure into an oil or gas reservoir to force out more oil or gas.

CO_2 storage sites are deep geological formations. These formations are primarily chosen on the basis of two geological characteristics. The first is suitable storage (reservoir) rocks which could be old oil or gas

[13] EnAppSys, 2020
[14] Grantham Institute, 2018
[15] Rochelle, 2009
[16] Edwards & Celia, 2018

reservoirs, or deep saline aquifers.[17] The second is the presence of an impermeable cap rock overlaying the reservoir rock which prevents the CO_2 from moving upwards to the surface.
Once the CO_2 has been converted into fluid form, it is injected via a well directly into the sedimentary formation. Here it moves out into the rock through pore spaces. Well-selected geological storage sites globally will likely retain over 99% of the injected CO_2 over millions of years, with leakage becoming less likely as time goes on because most the CO_2 dissolves into the water in the reservoir rock and sinks to the bottom of the reservoir.[1819] The oil and gas reservoirs which could be used for storage have held oil or gas for millions of years before these commodities were extracted. The longest running CO_2 storage project at Sleipner in the North Sea (Norway) has been storing CO_2 since 1996 and ongoing monitoring of the CO_2 in the formation shows there has been no leakage.[20]

The process of CCS has significant potential to help tackle climate change, and in the UK there is significant opportunity for storage offshore in a manner which mirrors the Sleipner project.[21] The development of CCS itself is expensive as additional equipment needs to be installed at the emission source, and the process of capturing CO_2 is energy intensive, which either increases the industrial plant's energy costs, or reduces the electricity output of a power station. The transportation and storage of CO_2 is a challenge in Europe because there is limited CO_2 infrastructure here. The selection and development of a suitable storage site carries significant costs, and to follow best industry practice, the storage site will have to be monitored in the long-term. In Europe there are few market signals to encourage the wide-scale development of CCS.

Arguably the most well-known CCS project in Europe was developed because of financial pressures, in this case a carbon tax. The Sleipner project in the North Sea off the coast of Norway is an offshore natural gas platform where the gas extracted contains around 9.5% CO_2 which needs to be removed for the gas to be saleable.[22] In the mid-1990s, the company who owned the platform, Statoil, decided that the cost of the carbon tax was similar to the cost of storing the CO_2 1km under the seabed to avoid the carbon tax, and they have been injecting around a million tonnes of CO_2 annually since 1996 with no observed leaks. Such carbon taxes are not universal across Europe, and it has been argued that without the financial incentive to remove CO_2 from industrial processes or energy production, there is little prospect of CCS developing quickly
.
In Europe, CCS (where more than 100,000 tonnes of CO_2 per year is stored) is regulated by the CCS Directive.[23,24] This European policy has been transposed into national laws & regulations by all but one Member State. The CCS Directive establishes a legal framework for the safe geological storage and "aims to ensure that there is no significant risk of leakage of CO_2 or damage to public health or the environment, and to prevent any adverse effects on the security of the transport network or storage sites, thereby addressing public concerns". The Directive sets out requirements for selecting sites, monitoring and confirming the site is behaving as expected, monitoring post injection and handover to the national competent authority for long term stewardship. In the UK the CCS Directive has been transposed into national regulations. [25,26,27.]

[17] BGS, 2019a
[18] IPCC, 2005
[19] BGS, 2019b
[20] Furre et al., 2017
[21] BGS, 2019c
[22] BGS, 2019c
[23] European Parliament and Council, 2009
[24] European Parliament and Council, 2011
[25] UK Government, 2008
[26] UK Government, 2009
[27] Health and Safety Executive, 1974

It should be noted that CCS is viewed by some as a distraction from other low-carbon development by diverting research and development funding from renewables. There are also arguments from some environmental groups that CCS enables fossil fuel producing companies to continue 'business as usual' and continue to extract and develop the fossil fuels which have been a key driver of anthropogenic climate change, rather than begin to shift the economy from a high-carbon to a low-carbon one.[28][29]

3.1 UK CCS Context

The UK has a chequered history with CCS. There is estimated to be significant potential for CO_2 storage under the North Sea as the geology is considered to be ideal,[30] with the possibility for utilising depleted oil and gas fields,[31] and deep saline aquifers. There is also well-developed infrastructure and a skilled workforce from the offshore oil and natural gas industries. In November 2015, however, the UK government withdrew £1bn of proposed competitive funding to develop CCS demonstration in the UK.[32] One of the finalists for the funding was a Scottish and Southern Energy (SSE) and Shell-backed project that intended to capture CO_2 from the Peterhead natural gas power station in Scotland and transport it 100km offshore to the depleted Goldeneye natural gas reservoir for storage.[33]

The potential for CCS development in the UK has increased again in the last couple of years, thanks to the 2018 UK Government's Clean Growth Strategy,[34] and the publication of a report by the UK government's independent climate change advisors The Committee on Climate Change.[35] The Committee on Climate Change document sets out a roadmap and recommendations for the UK government to reach its commitment of net zero CO_2 emissions by 2050. The recommendations highlight CCS as being essential to meeting this target, particularly in decarbonising more challenging sectors of the economy such as chemical manufacture, which can't be replaced in the way a coal-fired power station can largely be replaced with renewables to achieve a broadly similar outcome.

It's important to note that UK CCS development will be focused on offshore storage. Offshore development may, however, be no less contentious or less likely to trigger negative public perceptions than onshore, as studies have shown offshore energy developments, such as windfarms, can have negative perceptions for to those living in proximity on the coast.[36]

The UK Government is also beginning to expand CCUS development, with £26 million being awarded to a new project in 2019 aimed at removing 40,000 tonnes of CO_2 per annum from a UK chemical plant.[37] The UK still remains in the early stages of CCS and CCUS development, and correspondingly early engagement with the public about whether CCS is the right path forward, and what their considerations and questions are is crucial if CCS is to be developed at an industrial scale here.

[28] For example Friends of the Earth Europe: 'False Solutions to Climate Change'
[29] It is possible to get a broader view of CCS and the discussion around it in the brochure "What do you think? Pros and cons of CCS" included in the information pack "Participating in CO_2 Geological Storage Research" developed in the ENOS project. See http://www.enos-project.eu/media/1425/18.pdf ; http://www.enos-project.eu/participating-in-co2-geological-storage-research/ENOS Project
[30] UK Government, 2012
[31] CCUS Cost Challenge Taskforce, 2018
[32] BBC News, 2015
[33] Spence et al., 2014
[34] UK Government, 2018
[35] The Committee on Climate Change, 2019
[36] Wiersma & Devine-Wright, 2014
[37] UK Government, 2019b

3.2 Enabling Onshore CO_2 Storage in Europe (ENOS)

> *"ENOS is a European Research project working for the development of a technology that respects scientific requirements, is implemented by specifically trained professionals, is understandable by all, and carried out in collaboration with local communities."*
> The ENOS Vision for Onshore CO_2 storage in Europe[38]

ENOS is a pan-European research consortium comprising of 27 partners, across 15 countries, with five field sites. It addresses the need to refine the technology of CCS for onshore application and to identify best practices that can make onshore CO_2 storage successful in both the technical and social dimensions. The ENOS vision sees CCS playing a key role to meeting the European Union's (EU) target of 80% CO_2 emissions reductions by 2050[39] and expects that onshore storage will be necessary in order to meet this target.

The ENOS project is funded by the EU Horizon 2020 Research and Innovation programme[40] and has eight work packages which collectively aim to develop, test, and demonstrate aspects of onshore CO_2 storage. The work packages are both technical and social, including projects to design and test geological monitoring equipment to improve the safety of CCS, and others to improve and develop relations with scientific media to increase awareness and promote safe implementation of CCS in Europe.

This report relates to the work of Work Package (WP) 5 "Coordination with local communities", which was planned to be conducted over four research sites in Europe, in The Netherlands, Italy, Spain, and the UK, and which is focused on the involvement of local communities in the development of guidelines for the implementation of CO_2 storage projects. WP5 also involved the creation of CCS dissemination materials[41] which presented information on key elements of the CO_2 storage process. These materials were developed in a collaboration between social scientists interested in public engagement, and a range of geological and technical experts on CCS. The dissemination materials formed a starting point in engagement with participants on CO_2 storage.

Specifically, the project aims to develop best practice guidelines for both how to coordinate the technical development of storage projects together with the local communities, and also to develop public engagement materials that future researchers, or CO_2 storage developers may use to more effectively consult with the public on the topic. These guidelines and materials are to be based on collaborative research with citizen participants, emerging from participant questions and concerns about CCS.
Despite its potential role in decarbonising European economies, CCS has had limited development in Europe, currently consisting of a handful of test sites and the Sleipner project. The work presented in this report, therefore, has the potential to shape the way publics are engaged with CCS across Europe over the coming years, and to highlight the need to develop not only the approach to engagement, but also to identify the questions that participants living in different areas and countries ask about CCS. Combined, these activities will create best-practice guidelines to support future research and help commercial projects more effectively engage publics with CCS.

It is important to note that whilst the ENOS project focuses on onshore CO_2 storage, the potential for onshore storage across Europe is not universal. Norway, like the UK, has significant potential offshore,

[38] ENOS Project, 2019
[39] European Parliament, 2019
[40] EC CORDIS, 2019
[41] ENOS Project, 2019

and the UK does not have the right geology to allow for large scale onshore storage. There are, however, experimental CCS sites onshore in the UK, including one (the GeoEnergy Test Bed)[42] at Sutton Bonington in south-west Nottinghamshire. This site was chosen for the ENOS UK citizen engagement fieldwork as the local community would have a 'real' onshore CCS test site in their vicinity, even if, as was made clear to our focus group participants, that site was only to be used for experimental purposes, with only small quantities of CO_2 being injected, and the site would not be employed for actual CO_2 storage.

[42] The Geo Energy Test Bed, 2019

4. Research Questions: Collaborative Research and CCS Public Engagement

As noted, CCS has significant potential to help mitigate climate change, but the technology has undergone only limited development or deployment globally to date, and public knowledge of CCS is at very low levels.[43] The potential of CCS means there is a strong need to engage members of the public effectively. Whilst there is a rich body of literature considering public engagement with energy developments, there is comparatively little (although growing) research on the topic of public engagement with CCS, which is perhaps reflective of its limited deployment to date. The research of ENOS WP5 seeks to develop best practice guidelines and supporting materials for both the technical development of CO_2 storage sites, and for engaging members of the public with CCS. The research presented in this report is built upon the existing literature and poses two research questions in relation to it. This section briefly outlines the existing literature on public engagement with CCS and then presents the questions which guided this research.

CO_2 storage shares similarities with many other developments in large-scale technology. Although the injection phase may bring only a temporary change to the local landscape, and a storage site is visually unobtrusive, the presence of a storage site could change the ways in which people relate to their local environment. It will likely garner both positive and negative responses to its development, as it affects people's 'sense of place'.[44] Perhaps most importantly, effective engagement with local communities has the potential to increase support for development, although consistent scepticism about the feasibility and effectiveness of public consultation about new technologies is a frequent theme in focus group discussions.[45]

There is a general consensus within the literature on the need to move away from experts being the drivers of public engagement through an assumed need for them to persuade and educate communities about new developments.[46] The assumed role of the expert educating the public has created an impasse to effective engagement as experts try to fill a perceived knowledge gap, whilst considering that members of the public's questions or concerns are tainted by emotion and ignorance.[47] Such concerns can be exacerbated by what Wolsink[48] described as the 'Decide, Announce, Defend' model which sees decisions taken in a top-down manner, with the public and/or local community only engaged after the fact. This approach alienates the public from the decision-making process, and as Devine-Wright[49] argues, such exclusion can increase public opposition towards a particular development.

The literature concerning public engagement with CCS notes these more general considerations and highlights a number of CCS-specific ones as well. For example, NEARCO$_2$[50] noted the need for trustworthy independent experts to explain and engage local communities on the topic, and for people's concerns to be listened to and taken seriously. The best practice guidelines developed through this research concur with these recommendations. The guidelines focus on an approach which takes seriously the oft discussed problems of top-down engagement, but also the potential problem of the

[43] de Best-Waldholder et al., 2009; Fleishman et al., 2010 & Karimi & Toikka, 2018
[44] Devine-Wright, 2015
[45] See for example Flynn et al, 2011:255
[46] Owens, 2000
[47] Reno, 2010
[48] Wolsink, 2007
[49] Devine-Wright 2010
[50] Desbararts et al., 2010

public having little or no baseline knowledge of CCS.[51] This research therefore places the focus on the views of an informed public rather than the experts or uninformed public views.

4.1 Research Questions

Linked to these ambitions, this report considers two research questions, the analysis and discussion of which will form corresponding best practice guidelines on the salient topics and themes of CCS, as recognised by the public, and on how best to approach engaging the public about CO_2 storage.

1. What themes, topics, and concerns do members of the public have about CO_2 storage when they are taken through the technical details of it? How do their questions and concerns about CO_2 storage at the start of the process compare and contrast to those at the end?
2. Having enabled members of the public to lead an exploration of CO_2 storage, what lessons can be learnt about the appropriate methods, processes, and approaches to public engagement?

[51] Ashworth et al., 2015

5. Methodology

The aim of this research was to be guided by lay members of the public, and to understand what their questions, concerns, or positive views were about CO_2 storage. This would facilitate the development of best-practice guidelines for future developments in and applications of CO_2 storage to best suit the needs of local communities, and also for future public engagement about the technology. The methodology required researchers to elicit questions and considerations about CO_2 storage, and so a mixed methods approach based primarily on focus groups and supported by written materials from participants and researcher notes was developed. To track how the meetings were progressing, participants were asked to complete a short questionnaire at the end of several of the meetings.
The aim of the researchers was to create an open and inclusive environment, in which our citizen participants would feel enabled to speak and question freely without feeling intimidated by the presence of 'experts' in the room. This involved careful consideration of the set-up of the first meeting, where some introduction to both CCS and the ENOS Project would be necessary. The meeting was established at a neutral venue, and after some initial ice-breaking activity, both ENOS and CCS were briefly introduced to the focus group. Immediately after the presentation, our focus group members were asked to work in groups (without expert input) to generate questions on flipcharts, with a commitment that future sessions would be shaped and guided by the questions that our participants had asked. This set the pattern for a collaborative approach to this research between the participants and the researchers that lasted throughout the eleven meetings, with the aim of being inclusive, being open to the sharing of knowledge from both sides, and ensuring that all of the questions about CCS that came from the participants would be deliberated upon before the end of the process.[52]

This approach is taken to have several advantages over 'conventional' forms of public engagement:

- It helps to mitigate 'expert bias' where participants don't engage because they are non-experts.
- It can be subjected to participatory confirmatory analysis – we tested the final outputs with participants to ensure they are valid.
- It encourages the translation of scientific language into language familiar to participants.
- It allows the citizen group to become better-informed abut CCS and CO_2 storage in a manner and at a pace that they, to an increasing extent as they become more informed, direct.

5.1 Management of Focus Group Meetings

This project complied with the University of Nottingham's School of Politics & International Relations ethical review requirements. In order to allow participants in this project to feel they could speak openly about their views and the topic, and to maintain best research practice, the data for all participants involved in the project (focus group transcripts, written materials, and questionnaires) are anonymised. In the first meeting, researchers outlined the confidentiality and ethics of the project which included participants' right to anonymity in all data analysis and written materials arising from this project. In addition to anonymity, participants were advised they could withdraw from the project at any time without having to specify a reason. If requested, their responses and data would be deleted, insofar as this was practicable. In the event, nobody asked to withdraw from the research project. All participants read through and agreed to sign an informed consent form.

Participants were recruited through a market research firm specialising in focus groups. The company was asked to find ten participants from a range of demographic backgrounds who lived within a ten-mile

[52] Frantzeskaki & Kabisch, 2016

radius of the GeoEnergy Test Bed site at Sutton Bonington near Nottingham. Participants were compensated with non-monetary gifts to thank them for their time and to encourage attendance.
Meetings were predominantly held in an independent Nottingham conference centre to reduce the potential for power imbalances between participants and researchers, which might arise from holding meetings on University of Nottingham property. The first nine meetings were held at the conference centre or were field trips. The final two meetings were held at the University of Nottingham, by which point it was felt by researchers and participants that there was a suitable level of trust to negate the risk of power imbalances.

Focus Group: Meeting 1

The first meeting, by necessity, had a different design to the majority of those which followed, but set the foundations for key aspects of the approach. The first meeting needed to convey significant information about the project, the background to both CCS and ENOS, and explain the aims of WP5 and of the meetings, in order to set expectations. Following the introductions, we held an icebreaker session with both participants and researchers to help the group familiarise with each other and encourage conversation. This also set expectations that the meetings would be collaborative with contributions from both participants and researchers. At the first meeting participants were also given printed materials, generated by the ENOS project, on CCS and onshore CO_2 storage. Reading these materials (jokingly referred to as 'homework' by our participants) would help to familiarise participants with the technology. Participants reported finding these documents helpful and easy to understand.[53]
Two field trips were arranged with participants to enable greater understanding of how CCS research is conducted, and what a CO_2 storage research site looks like. The trips were run to the British Geological Survey (BGS) in December 2018 for the third meeting, and the GeoEnergy Test Bed (GTB) in June 2019 for the eighth meeting.

The majority of meetings, excluding the two field trips and first two sessions, followed a similar design. The meeting would open with an introduction to the focal topic being discussed, and a justification for

[53] Documents given to our participants were (1) the CO_2 GeoNet brochure *What Does CO_2 Geological Storage Really Mean?* And (2) *ENOS: Participating in CO_2 Geological Storage Research.*

how this topic arose, for example, that the subject was critical to ENOS, or a topic which was discussed previously, and which participants requested more information about. A short presentation on the focal topic would then follow from one of the researchers or an invited expert, for example a geologist or economist. Participants were encouraged to ask questions at any time during these presentations. Following the presentation, participants would normally break out into groups to discuss the issue and compile further questions or comments. The groups would then come together to discuss their questions and the motivations for asking them.

In most meetings, a technical expert was on hand to present and discuss the geological and technical aspects of CCS and answer participants' questions. This was usually a CO_2 storage expert from the BGS. The fourth meeting was focused on the economics of CCS, and so an environmental economist from the University of Nottingham was invited to give the expert presentation. The presence of a technical expert at the majority of meetings reinforced the trust element between researchers and participants, in that their questions on the topic were taken seriously and responded to as soon as possible – normally immediately, or alternatively at the subsequent meeting.

5.2 The GeoEnergy Test Bed (GTB)

As previously noted, there has been limited CCS development in the UK, however, research continues to develop this technology in the UK and Europe. The GTB is a sub-surface research site located ten miles south of Nottingham. The site has eleven boreholes drilled to a depth of between 21m and 281m.[54] As part of the wider ENOS project, there were and are scientific experiments being conducted at GTB which develop and test sub-surface and above-surface monitoring equipment to help ensure the safe operation of CO_2 storage.[55]

Focus Group participants at the GeoEnergy Test Bed facility

[54] The Geo Energy Test Bed, 2019
[55] ENOS Project, 2019a

For this project, the GTB was used as a 'proxy' onshore CO_2 storage development and so provided an opportunity for participants to consider the implications of CO_2 storage locally. An expert from the BGS, who conducted research at the site, regularly attended the meetings to discuss and answer questions on CCS, and the work being conducted at the GTB. As the GTB is a research site, and as ENOS research focuses on ways to improve monitoring and understanding subsurface flows of CO_2, it was felt that experts from the site would possess the relevant knowledge and expertise for our participants, as their work aims to improve our understanding of the geology of onshore CO_2 storage and to ensure the safety of operations.

5.3 Data collection

A key element of the research approach was the generation of questions from the participants. In almost every session, participants were asked to consider (in groups) questions they had about the topic of the meeting, CCS, or the environmental landscape more broadly, and to either write them down or to ask them to the group. For the majority of meetings, these questions were written down in small groups, and then the wider group would discuss them. This enabled greater understanding of the issues participants felt were important, both positive and negative, about CCS, whether these be focused narrowly on, for example, the monitoring of stored CO_2, or more broadly on the role of CCS in attempting to mitigate the problem of climate change.

In order to track the questions and their corresponding justifications from participants, mixed data sets were collected from each meeting including recordings and transcripts of the meetings, photographs of posters or question lists produced by participants, satisfaction questionnaires, and notes taken by researchers.

Focus groups were selected as the primary data collection method in order to gather a variety of perspectives and questions on CO_2 storage, and to enable participants to work together and challenge each other in the development and consideration of questions and topics they felt to be the most salient. There is considered to be a risk in conducting focus groups in that certain member(s) of the group can dominate the discussions, whereby ultimately the collected data shows a narrow viewpoint, with some participants' views overlooked. For this research the risk of dominance by one or more participants was considered minimal in a small group that would meet upon multiple occasions, and as something which could be managed by the researchers' interactions with participants.

Furthermore, (a) longitudinal focus groups also have the added benefit of observing how a group of participants' views on CO_2 storage evolve over time as they explore the topic further, and (b) participants were asked to complete a questionnaire at the end of several meetings to enable periodic tracking of views on how participants felt the meetings were going, and to assess their self-identified knowledge about CO_2 storage. The questionnaire was collaboratively produced with the wider WP5 team to be used at all ENOS research sites.

5.4 Data Analysis

Data analysis was mixed method to mirror the data collection. Written responses were collated and transcribed from the 'posters' created during meetings. The audio recordings of the meetings were transcribed and analysed by researchers to consider patterns and themes in discussions and perceptions of different aspects of CCS. This included:

- Grouping of questions and/or discussions into key themes.

- Analysis of how participant questions evolved over time to explore whether additional knowledge on the topic changed the nature of the questions and concerns. To this end an exercise was held in the first, sixth, and tenth meetings where participants were asked to list the questions they would have if a CCS development was coming to their area.

6. Results

In total ten citizen participants were initially recruited, and from September 2019, there have been eleven meetings, typically once every two months with an average attendance of six participants.

Meeting No.	Date	Topic Covered
1	Sept. 2018	Introduction to CCS, ENOS and WP5
2	Oct. 2018	Answering questions from 1st Meeting; further exploration of CCS
3	Dec. 2018	Site visit to British Geological Survey; presentation from BGS on sub-surface storage, including the Sleipner Project
4	March 2019 (1)	Economics of CCS and reflections on BGS site visit
5	March 2019 (2)	CCS and Local Communities; place attachment
6	April 2019	Site characterisation, monitoring and risk management
7	May 2019	CO_2 migration; ENOS Public Information Tool
8	June 2019	Site Visit to GeoEnergy Testbed
9	July 2019	Reflections on GTB site visit
10	Sept. 2019	Utilisation of CO_2 and discussion of potential content for final report
11	Jan 2020	Discussion of draft final report

Table 1 - List of Participant Meetings and Topics Covered

Below is a table listing the questions generated at the first meeting, and then again at the sixth meeting (by which time our participants had been taken through several meetings on technical aspects of CCS and had visited the BGS).

Meeting	Meeting 1 (Sept 2018)	Meeting 6 (April 2019)
Questions Posed	1. Is CCS safe? 2. How does the CO_2 get there? 3. Will it cause disruption? 4. Leakage? (Consequences) 5. Where exactly will it be stored? 6. How will it affect the environment? 7. How will it affect the economy? 8. How big is a storage plant? 9. How clean/pure is the CO_2? 10. What happens in a million years? 11. How long can it be safely stored? 12. [Picture] Scary Goldfish mutated by CO_2 13. Are surveys up to date? 14. Public/private money? 15. Employment? 16. Location – noise, smell? 17. Fracking cause other problems?	1. If leakage was to occur, what would be the prevention? 2. If CO_2 is harming plants what effect does it have on humans? 3. What steps are you taking to capture more natural gas / CO_2 leakage? 4. How can you ensure CO_2 doesn't escape the established predicted area/radius? 5. How much jobs will it create/impact? 6. What steps will you take to inform people of changes/updates? 7. How many sites are predicted to be built in the UK in the next 50 years? 8. Are the European Union interested/invested in these site projects? 9. How big an area would a leak

	18. Currently: a. Is the CO_2 to be stored offshore under the sea? b. Future? c. How far down will it be stored? d. Where will it be stored? e. How will it be capped? Can it? f. Will it affect water? g. If it affects water, how will it affect the environment? Esp. plants/animals? h. Enough room? 19. If it was at the end of our road? a. Earthquakes b. Sinkholes c. Property value d. Health – cancer risks? e. How will gas get here? f. How will it be regulated after Brexit?	affect? 10. How do we convince people it wouldn't explode or poison them or the water supply etc.? 11. Would the storage areas go under buildings etc. (even whole villages)? If so, what are the issues? 12. If a storage site was built on (for example with a housing development) at a later date – would any future leaks affect them? 13. How big is the whole storage site? 14. Big leak: too late to fix – what happens then? If damage, who compensates?

Table 2 - Questions raised by Participants in Meeting 1 and 6

Note that by the sixth meeting, questions have become significantly more specific. We move from questions such as 'Is CCS safe?', and 'How will it affect the environment?' to 'If a leak were to occur, what would be the prevention?', and 'How can you ensure CO_2 doesn't escape the established predicted area/radius?' We would suggest that the more focused questions from session six reflect the increased knowledge of CO_2 storage that has been gained by our participants during the intervening period.

While the questions at the later meeting are more informed, there is a thematic consistency in the questions asked about CO_2 storage across all of our meetings. Concern about possible leakage and the environmental and health impacts that this would have remain high priorities. Aside from that possibility, there are general concerns about the environmental and economic impacts for a local community in hosting a storage site. This covers both potential positive impacts (such as job creation) as well as negatives (e.g. impact on house prices). Questions about regulation and flows of information also feature, for example, how would people be informed about what is going on at the site?

7. Discussion

Here we discuss our participants' views of CO_2 storage and their development across eleven meetings, with some comparison to other work on public attitudes to CCS. We highlight the main themes that emerged from the questions that our focus group participants had, and reflect on what the researchers have learned from this engagement before discussing the validation of the report with participants.

7.1 Perceptions of CO_2 Storage

Here we briefly summarise the key perceptions of CO_2 storage which emerged over the course of the research. 80% of participants had no awareness of CCS at the first meeting, and those who were aware of the technology did not have a positive or negative view of it This relatively low level of awareness is consistent with other studies.[56] Throughout the process, participants' perception of CCS and onshore CO_2 storage became and remained broadly positive. This was noted by the participants themselves in the later meetings, who commented on how their views had changed now that they were 'educated' about CO_2 storage. In the course of the meetings the benefits of CO_2 storage were identified and considered by participants, although they did not view the technology as a 'silver bullet'. CO_2 storage was seen very much as something to be developed alongside a wider raft of changes to the economy and lifestyle to mitigate the effects of climate change.

Throughout the meetings, it was clear that the potential benefits of CCS were identified by the participants, with a general agreement about how the technology could benefit the environment and wider society. The positive considerations of the benefits noted by participants echoes previous studies in which found positive support for CO_2 storage in efforts to mitigate climate change.[57] Even though participants were generally positive towards CO_2 storage, they considered a number of limitations and expressed concerns about the technology. These fell broadly into similar categories identified in previous studies,[58] notably the economics of CO_2 storage, safety concerns, and local impacts.

Participants questioned the economics of CCS both at the macro and micro levels. There were concerns about whether compensation would be paid to local residents near a CO_2 storage site, and whether hosting a site would lead to job opportunities for locals. Numerous discussions were held throughout the process where participants questioned 'who' would pay for CCS? Would it be through general or targeted taxation on citizens or on big emitters such as oil companies, and what would be the economic effect of a taxation?

The potential local impacts of CO_2 storage were also frequently raised. Participants wanted to understand the potential visual and other environmental impacts of a CO_2 storage site, the risk of leakage, who has regulatory oversight, who will monitor the site, and where information about the site will be made available.

Participants also drew parallels with the recent attempts in the UK to develop shale gas through hydraulic fracturing, more commonly known as fracking, which had received significant public opposition in large part due to safety concerns regarding leakage.[59] The need to learn from other subsurface developments such as fracking in the UK was noted by Ashworth et al.[60] and reflects similar negative perceptions of CCS which have been attributed to public experiences of subsurface development internationally. Work

[56] Curry et al., 2007; Demski et al., 2013; Reiner, 2014 & Ashworth et al, 2015
[57] Demski et al., 2013 & Whitmarsh et al., 2019
[58] Ashworth et al., 2015
[59] Andersson-Hudson et al., 2019
[60] Ashworth et al., 2015

in the Netherlands found that negative public perceptions of CO_2 storage emerged after opposition to the Barendrecht project,[61] and contributed to the project being cancelled.[62]

Global concerns were also discussed, such as the need for international co-operation on CCS development and climate change mitigation techniques more broadly. Linked to these concerns were questions along the lines of 'what is the point?' and 'who else is doing this work?' Participants considered the mitigation of CO_2 emissions to be an international effort and the view was expressed that if big CO_2 emitting countries such as China and the United States weren't investing in CCS then the UK would be unwise to act alone. They felt it will make relatively little difference to global CO_2 if the UK acts unilaterally, and indeed it may put the UK at a competitive disadvantage internationally.

Overall, participants were broadly positive towards CO_2 storage, although they considered it be part of a wider solution and had initial reservations as to the safety of storage which declined through the process, and of the economic viability of development. This summary of the participants' perceptions introduces the key themes discussed during this process, which were developed and explored further through the extensive use of questions as outlined below.

7.2 Best Practice: Question and Answer

One of the main aims of this project was to understand from participants themselves what questions they had about CCS and what knowledge they required to understand the topic. To establish this information, the research approach focused on questions generated by citizen-participants. Questions were formulated by our participants after each presentation by a CCS expert, as part of discussions on a particular aspect of CCS (with a significant but not exclusive focus on CO_2 storage as per the ENOS remit), and where researchers were asked to clarify or expand on points raised by participants. Questions were a fundamental part of the approach to participant meetings, and all questions were recorded or noted down by the researchers. Asking participants to identify questions about CCS and the topic being discussed, enabled the recognition of what aspects or issues were salient to participants. This, in turn, enabled researchers to develop meetings tailored to participant interests on CCS and, therefore, allow for the collaborative production of knowledge.

In meeting ten, participants were asked to reflect on the previous meetings, and to identify the questions they felt were the most pertinent issues of CCS and which should be addressed in future public engagement on the topic and in any 'best practice' materials. The questions have been grouped into broad categories and are outlined in Table 3 below.

Theme	Questions to be considered in the best practice guidelines
Safety / Regulation	Who manages this? Is it a private sector or public sector responsibility? Who audits/regulates CCS activity? Who makes the rules? Is it safe -environmentally safe? What if something goes wrong? Are there examples of things going wrong elsewhere?
CCS Process	What is CO_2? How long does the CCS process take? How effective is it in helping to achieve climate change goals? Will it

[61] Terwel et al., 2012
[62] Ashworth et al., 2015

	work? What would a CO_2 storage installation look like?
Costs and benefits of CCS	Who pays? Will it create jobs? What will it cost? What [money] will it make? Are there any alternatives? Why is this important? What happens if we don't capture CO_2 and store it? Is it worth it? Where is the evidence it would benefit us? Why here? Why now? How long will CO_2 storage go on for? How can we measure long-term benefits to average person? How long will CCS take to make an impact on climate change?
Local Impacts	How does it affect me and how does it affect the local area? What will the installation look like? Roadworks and traffic movements? Noise pollution? Housing? Wildlife?
Best Practice for Public Engagement	How can the public access further information (such as hyperlinks, video files, multi-media presentations)? Education, is CCS taught in schools? How can we get involved? What examples are there of CCS working effectively elsewhere?

Table 3 - List of key CCS questions identified by Participants in Meeting 10

The questions are the result of ten meetings with a group of participants who explored and questioned the details of CCS throughout. These questions, therefore, represent the considered views of participants and are a good basis for improving and integrating social requirements in CO_2 storage best practice guidelines. The broad categories represent a framework of topics which should be considered and addressed in planning CO_2 storage development and specific CO_2 storage projects. This will allow for more efficient coordination of CO_2 storage site developments with the local communities. Within these broad categories, a number of important themes emerged, which had been developed over the course of the series of meetings, and which are discussed below.

1. Safety and regulation: This remains a key priority for participants. If there is a proposal to store significant amounts of CO_2 in the vicinity of a community, they will want to know who audits and regulates this activity, how the site will be monitored, and what the response will be if there is a leakage problem. Assurances that leaks are highly unlikely will not nullify this final question, participants want to know what the response will be to the detection of a leak. There is a significant risk to any future developments that onshore CO_2 storage could be seen as dangerous, especially given the low levels of existing public awareness. As one participant put it in meeting seven:

> *"Possibly we don't know enough about it…I think, generally, people would not want it anywhere near them, like they don't want fracking. Perhaps because we are not being educated enough".*

Linked to this, there is also a need to consider the long-term safety of a CO_2 storage site. Participants reflected on the potential for CO_2 to remain stored for thousands of years, and this raised concerns about

the monitoring and safety of the site over a longer period, as highlighted by this discussion between participants six and seven during meeting five:

> *"What's the lifespan of the thing [CO_2 storage site]?"...*
> *… "Yeah, what happens if the company goes bust? Is there a shelf life to these facilities, if the company has gone, who's going to maintain these facilities?"*

There is a clear need to consider the immediate safety and monitoring of the well both in the near and long-term. It is a certain irony of CO_2 storage, that whilst there is confidence in the scientific literature that CO_2 will remain stored in deep geological reservoirs for thousands of years, and this was recognised and accepted by participants, this positive safety message also creates additional concerns about safety precisely because of the long-term nature of storage.

2. The process of separating and storing CCS: Clear explanations of the processes involved in CCS are essential, with visual representations and 'hands-on' props especially useful. In particular, outlining which part of the process is the focus of local engagement (e.g. CO_2 storage site and/or CO_2 capture from source point) will support understanding.

3. **Costs and benefits of CCS:** There was significant scepticism in our participant group as to whether CCS would ever be economically viable, or scalable to the point where it could actually make a difference to global climate change. The economic case for Enhanced Oil Recovery was clear, but this was seen to militate against any potential impacts on climate change. There was also scepticism as to the wisdom of one country taking on the costs of CCS in the absence of extensive international co-operation. CCS was also seen as a 'stopgap' technology that would allow humanity time to develop new forms of energy generation and manufacturing processes. This was clear in a report from a small group participant discussion in meeting nine:

> *"The rest of us kind of felt that CCS was necessary as a stopgap measure, but that it should have a clear end date on it. It has to be made clear that this is a stopgap, that we are using that time to develop other technologies, and to kind of drive us toward renewable or different energy source, things like electric cars, although they have their problems as well."*

Throughout the process, participants considered CO_2 storage to be broadly positive, albeit with caveats around economic viability and the technology being part of a wider raft of lifestyle and economic changes. Participants also viewed CO_2 storage as a benefit for everyone and felt the process was not, as some argue in opposition to CO_2 storage, a means for fossil fuel companies to make additional income, or 'greenwash'. Participant six in meeting six succinctly highlighted this view:

> *"Also, the point that it's for our benefit actually, it's not actually about people making money like for oil and gas extraction. It's for the benefit of us all on the planet."*

4. **The wider context:** A consensus emerged within our participant group that CCS provides a net benefit to society by helping to mitigate climate change. The process was not seen as a 'silver bullet', in part because of questions of economic feasibility and scalability, and was placed into a broader picture of societal and economic changes needed alongside CCS to support decarbonisation and sustainable living in order to effectively mitigate climate change.

5. **Local impacts:** Participants expressed concerns about the local impacts of CO_2 storage, including visual impacts, noise, increased traffic movements, the impact on local businesses, and effects on local wildlife. We found significant concern about what a CO_2 storage installation would actually look like, and what kind of visual impact it would have on the local landscape. These concerns were highlighted during meeting five when participants were asked to write down their questions about the

local impacts of CO_2 storage (Appendix 9.2). The first issue raised, and one which participants placed particular emphasis on, was the question of what a CO_2 storage site would look like. Participants six and three in meeting six highlighted this:

"What's it going to look like? That's going to be the first question people ask" …
"… is that how it's going to look, or is it going to be a massive factory?"

It was clear there was uncertainty from participants, and they felt members of the public would have similar questions, as to both what a CO_2 storage site would look like, and indeed what aspect(s) of CCS would be included in any specific site. There was uncertainty as to whether there would be pipelines, convertors or capture facilities and what these would look like. There is a need to clearly communicate the whole CCS system, but then clearly highlight what aspect is being developed locally and what this will look like, with participants expressing a strong desire for visual representations.

6. **Further Information:** The last set of topics related to information, and the degree of engagement with the public around CCS. For example, is this taught in schools? Where could citizens find (authoritative) further information? Are there examples of CCS working in other parts of the world that could be used as case studies? This was exemplified during a discussion on possible communication tools for CCS, and participants wrote down the design of a website providing information on CO_2 storage (Appendix 9.3). It was clear from the proposed design, and from wider discussions throughout the process, that participants valued the opportunity and signposting of different information from a range of perspectives. One participant stressed the need for different levels of information:

   "I think with all this information you can just go deeper and deeper as much as you want, so there should be links for extra information, on the side or somewhere you know. Hyperlinks, where if you click on that you can go for further information."

Throughout the process, questions formed the cornerstone of the engagement approach. It was clear that establishing a culture of questioning in the first meeting enabled all subsequent meetings to take a discursive form. Participants were engaged with the topic, and it instilled a level of trust in the researchers which in turn enabled more effective dialogue. As the researchers were trusted to provide accurate and engaging information on CCS, and to listen to the questions and views of participants, the participants felt their input was taken seriously, and this further encouraged their active participation. A key approach is highlighted by the quote from participant two in the eleventh and final meeting.

"I think it's good that you came back in the following meeting saying 'these questions were asked, and we're doing our best now to give you the answers, because we didn't actually know what it was at that time'. Ceri did it, very well, at all times."
Participant 2, Meeting 11

If a question could not be answered in the meeting at which it was raised, a note was taken by the researchers and a response provided at the next meeting. In the case of economics of CCS, this meant bringing an environmental economist to discuss the issue. By ensuring all questions were carefully considered either during the meeting or in a subsequent one, a level of trust was established and underscored that participants' questions were important and taken seriously.

7.3 Researcher Reflections on Meetings

Through the course of the eleven meetings with participants, there were several areas which were of particular interest to the researchers and these are reflected on here.

These were interactive sessions, and we learned something about how to conduct these meetings in the research process itself. Our second meeting was designed to follow on from the first. Questions the participants had raised in the first meeting had been noted and answers were researched, and a presentation created to address their concerns. The presentation included the participant's question and the key points of the answer underneath. It had been hoped the approach would engender trust in the researchers, as it would show that participants' questions were being taken seriously and addressed. This would reinforce the co-production element of the process, with participants' questions leading the way. The approach was, however, only partially successful, with the meeting running more akin to a lecture than a discussion, with participants listening to answers in a more passive way than would be ideal. This approach created a one-way communication flow. This prompted further consideration by the researchers, and in later meetings, participant questions were answered as part of 'real-time' discussions, and this generated a much more interactive experience.

The CO_2 research project NEARCO$_2$ highlighted the asymmetry between members of the public and experts, and the risk of experts assuming a higher level of existing understanding of the topic than might be present in the group which can lead to misunderstandings at best, and potentially alienating members of the group at worst. This risk was just as much a feature of these focus group meetings as for any other forum that brings together experts and lay members, and it should be noted that one focus group member dropped out after the first meeting and did not return, although we do not know the reasons for their non-return. One advantage of the longitudinal nature of these meetings was that participants gained more confidence as all parties became more familiar with each other and became quite willing to challenge anything they believed to be expert 'jargon' or unexplained technical terms. For example, 'What is an "atmosphere"? You can't just assume that we know this'.

> *"But if you do that, you've got to make it very simple. I know this sounds ridiculous, but if it's too complicated they won't understand, and if they don't understand they possibly either won't bother or there'll be trouble. So, it's almost got to be a childlike way to show them what it is and how it does it."*
> Participant 2, Meeting 6

The use of jargon was a recurring theme throughout the meetings, where participants highlighted and later challenged the use of jargon or complex technical language by researchers. From the middle meetings onwards, when the researchers began to develop discussions with participants around how best to engage the public on CO_2 storage, the conversation expanded into simplifying and explaining the issues as clearly as possible. The quote from participant two reflects well the views of the group. Discussions around the best approach to public engagement focused on the need to make the information easily understood, and to go into the detail without jargon. The group reflected on the luxury of having multiple meetings to both delve into the detail of CCS, but also being able to immerse themselves slowly into the topic. It is difficult to imagine successful public engagement on any topic for which there are such low initial levels of public awareness, without an interactive information-sharing element taking a central role.

The request and subsequent effective 'ban' on jargon by participants was perhaps unsurprising given people's general animosity to buzzwords or language which they feel alienates them. The degree to which participants challenged the use of jargon and the push to ensure explanations were clear and simple was more surprising, however. It's clear from the eleven meetings that best practice public engagement should heed these views, but it's also likely that the trust established within the group enabled this outcome. By encouraging and answering questions, participants felt they could explore the detail of CCS on their terms, not on the researchers' terms.

Despite the desire for a jargon-free environment and the request for the simplification of technical processes, participants did not mean the content should be unchallenging. That is, the information should not be 'dumbed down', but rather made more accessible. This was highlighted through the meetings with participants asking increasingly complex and informed questions on the topic. These quotes from participant two come from the second meeting. They were asking one of the researchers about the extent of sandstone reservoirs and what impact this would have on safety.

> *"If you're saying that the plume is moving northwards, does that mean eventually it will come out again?*
> *"Technically, then, it shouldn't come out, but it could?"*
> *"Do you know that the Sandstone will go forever, and it won't come out?"* Participant 2, Meeting 2

Resistance to jargon was also illustrated in a discussion of 'highly dense liquid'. This from participant two: "*I'm not a scientist, as you talk about liquid filling…the CO_2 fills up the gaps in an old oil well as fluid…I don't understand what a dense fluid is against an ordinary fluid.*" This led to a discussion between the participants and the storage expert, as a result of which the expert decided to change her approach to communicating this particular aspect of CO_2 storage in future, referring to 'fluid' rather than 'dense fluid'. There were a number of such discussions about terminology throughout our participant meetings.

Questions like these, which were common throughout the meetings, highlights the need for questions to work with the audience as a reminder that there is not a homogenous public. Similarly, any public engagement approach should consider complex or technical questions and whilst 'simplifying' the topic is not a synonym for making it simplistic, or patronising participants, it is important to ensure the content is accessible to all participants while remaining technically accurate. This is highlighted both through participants' challenging of jargon, but also through the technical questions they asked, which demonstrated understanding of the topic. Both of these elements underscore the importance of questions in developing a level of understanding on the participants' terms, but also in developing the trust within the group to enable challenge.

Overall, there was strong pushback in the meetings against the use of 'jargon' and technical terms that had not been clearly explained. Clear communication and successful engagement with local communities will require the avoidance of unexplained technical language, and the use of certain concepts that experts can easily take for granted. Examples of the concepts our participants challenged include 'atmospheres', 'dense fluid', 'seismicity', 'CCS' and acronyms more generally, even 'kilometre' was highlighted as problematic (older participants in the UK group said that they thought in terms of miles). As one participant put it in meeting eight:

"*I had no idea what CCS stood for…you're coming out with all these acronyms. You know what you're talking about, but people like me, who don't have lots of technical knowledge, have no idea".*

A notable outcome of the eleven meetings was the degree to which other aspects of the environmental debate were discussed. For example, during meeting seven there was a lengthy discussion on alternative forms of transport, electric cars, and London's Ultra Low Emission Zone, with discussion about how these approaches could reduce our contributions to climate change. Similar conversations were held in several meetings on the technologies used in electricity production, and the need for a greater proportion of low-carbon technologies.

We consider that it was partly the design of the research approach - which did not adopt a strict formula or agenda but enabled participants to direct the discussions – something that allowed for these types of conversation. Such discussions allowed for CCS to be placed in wider context and potentially helped a

more favourable disposition towards the development of this technology, because participants could see it in broader context. This may not have been the case if discussions were solely focused on CCS, and wider considerations discouraged.

This again comes back to trust within the discussions, and the ways in which it can be developed. By enabling participants to lead the discussions without the placement of boundaries by researchers, a wider-ranging and richer discussion emerged. It also increased levels of trust within the group by underscoring that participants were increasingly leading the discussions as their knowledge developed, and that issues they considered salient would be explored and considered.

7.4 Validation of Approach

> *"You took our feedback on board and kind of developed it as you say. You know reading the report you definitely took our feedback into consideration and it was good to kind of see it all there. I felt quite important!"*
> Participant 1, Meeting 11

The second research question posed within this project considered what lessons could be learnt from members of the public leading their engagement with CCS. To ensure the approach which puts participants and their questions at its core was suitably validated, a complete draft of the final report was given to the participants in advance of the final meeting at which it was discussed. The aim of this was to ensure that the questions posed by the participants, and which formed the basis of the recommended public engagement topics, were presented as the participants had originally intended. Furthermore, the recommendations which form the best practice guidelines were also to be tested to ensure they reflected discussions and that participants agreed with them.

> *"You've given us information, made us aware of what it's all about."*
> Participant 4, Meeting 11

In this final meeting, participants were asked if they felt that the information that they had been given about CO_2 storage, and CCS more generally, had been objective and based on scientific evidence. It was never the intention of this project to 'sell' CCS to our citizen participants, but rather to collaborate with them to ensure that they developed an ability to ask informed questions about CO_2 storage technology and processes, in turn providing a scientific basis for future materials and practices around CO_2 storage to be informed by citizen input. To this end it was important to the researchers to ensure that they had not given the impression to the participants that they were acting as advocates for this new technology.

Participants stated that they did not feel the researchers had presented a biased view. There was agreement that CCS was not presented as an overarching solution, or as participant five noted "*It was never sold as 'you just need to do this, and everything will be fine'*". Participants felt that CCS had been presented as part of a wider range of solutions needed to tackle climate change. From this research, we believe that it is important that CCS should be presented in a neutral manner wherever possible, to help develop trust, with the technology also placed in the context of the wider technological and social changes needed to tackle climate change. Participants should also be enabled, and indeed encouraged, to discuss and question both positive and negative aspects of CCS development.

This is arguably easier in the context of these ENOS meetings, which were primarily research meetings aimed at exploring the 'public's' views on CCS, than it would be if an actual CO_2 storage proposal was on the table. If there are expectations of an underlying motive to generate a positive outcome, then achieving perceived neutrality would be more of a challenge. That said, it should certainly not be

impossible for a CO_2 storage developer to hold discussions that are perceived as based on objective evidence. In this case full transparency about motivations from the outset is key. For example, the ENOS project looks to 'enable' onshore CO_2 storage in Europe. This aspect of the project was highlighted in the first meeting and discussed with participants. An open approach was key in creating and maintaining trust with the participants.

Overall, by providing participants an opportunity to comment on the report and provide feedback it validated the research approach.

> *"I think you've done really well on putting everything together, with our comments. And I don't think you've ever tried to sell it to us as 'we must do this', ever."*
> Participant 2, Meeting 11

Having followed participants as they questioned and discussed CO_2 storage, it was important to ensure that they had final approval of the content. This research aimed to consider what questions and considerations the public had on CCS, so that both the technical aspects of future projects, and the related public engagement materials can be produced that are relevant to, and consider the actual needs of, the public, rather than their needs as perceived by researchers. It was, therefore, important to ensure that their views were accurately reflected in the final report and had not been distorted through analysis.

8. Recommendations

A primary aim of this research is to contribute to the production of best practice guidelines for the implementation of onshore CO_2 storage projects, integrating social requirements with further research and technical development. We also aim to advance the guidelines for public engagement with CCS, both in terms of approach to engagement, and in relation to the CCS topics or themes to be considered. Public engagement with energy and technology development is a wide and diverse field of study with numerous schools of thought and approaches. There are, however, a number of common themes within the existing literature, which have been used in this research as a yardstick against which to compare the findings of this project.

8.1 Indications for CO2 storage research and implementation

Our citizen participants were given presentations on multiple aspects of the technical side of CO_2 storage research as well as some of the broader aspects of CCS, including the dissemination materials developed in WP5.[63] These included the process of CO_2 separation and capture, site characterisation, monitoring technology, risk of CO_2 migration through faults or old wells, the regulatory framework in the UK and the EU, and site visits to the British Geological Survey (including a presentation on the geology of storage sites) and a field visit to the GeoEnergy Test Bed (which allowed participants to see monitoring equipment *in situ*), the economics of CCS, and the utilisation of CO_2. There was concern that any CO_2 storage activity should take place within a clear regulatory framework, and that within this framework there should be equally clear lines of accountability. There were persistent questions about 'who makes the rules?' and who would audit any storage activity. Monitoring and regulation should not be the responsibility of anyone who has a vested interest in the project. There was some concern that storage activity could fall between the regulatory responsibilities of different government agencies, and that regulatory bodies would not have teams of sufficiently expert staff to exercise effective oversight, particularly as staff are rotated in and out of roles in the UK civil service. When it was explained that much of this geological site monitoring work (in the UK context) would most likely be passed on to the British Geological Survey there was approval as this was seen as an appropriately expert and impartial body (it should be noted here that our resident expert was from the BGS, so this may have influenced responses).

[63] ENOS Project, 2019b

Focus Group: Meeting 1

There was also persistent concern about the local environmental impacts of CO_2 storage. This has several dimensions, one of which was about the visual and other local environmental impacts. The visual dimension of our environment is very important, and participants wanted from an early stage to gain a sense of what a CO_2 storage site might look like.. There were questions about what the site would look like in the pre-injection, injection, and post-injection phases. Participants also asked about the transport of CO_2 to any storage site and what form this would take, for example would there be multiple truck movements, bringing noise pollution and road congestion, or a pipeline? Another aspect is land value – will a storage site have a negative effect on local house prices? In any proposed onshore storage scenario in the UK this would be a significant concern for local populations, as for many people their home is their biggest financial asset by far. Possible effects on local wildlife were also raised. Participants would want to see a comprehensive environmental impact assessment for any storage site that covered these issues.

A third dimension was the possibility of leakage of CO_2 at the site, how would this be detected and what could be done to rectify any leak? Participants were keen that monitoring work should be conducted by disinterested third parties (such as the BGS) and not by those with a vested interest such as site developers. Given the expected longevity of storage sites, participants were keen that monitoring of the site should constitute a long-term commitment (over more than one generation). The participants felt it was important to make clear that CO_2 storage is not about straightforward commercial profit as it would be for an oil of gas field, but something for the general benefit of humanity and the environment. Despite the fact that much development in CCS is expected to be non-commercial, independent inspection was still preferred.

Another element of concern was what a CO_2 storage site would cost, and who would pay for it. Would the local population receive any financial compensation for accepting a CO_2 storage site in their vicinity? The participants accepted that there are costs involved in *not* mitigating the effects of climate change, but these would widely distributed, rather than concentrated on the specific locality being asked to host a storage site.

Finally, technical information should be made available at different levels of complexity. Basic communication on the technical aspects of CO_2 storage should be kept simple and in plain language, but further links should be available if local residents want to investigate technical information in more depth. For example, some local residents might be current or retired engineers with an ability to comprehend detailed technical information, or local wildlife enthusiasts.

8.2 Indications for CO_2 storage public engagement

The core recommendation from this research project is that public engagement with CCS should be led by those being engaged. Participants should be taken on a journey through CCS with the questions identified and presented in this report acting as signposts, but with open and frank discussion of the topic to enable participants to understand and consider CCS at their pace and on their own terms. This will lead to both greater understanding of the topic, and greater trust in the process of public engagement. This entails that each process of engagement will take its own path through the technical details of CCS in response to the actual questions that local lay-participants have. Of course, the framing of the topic and the initial presentations on CCS will be important factors in shaping the whole discussion, but as participants become more knowledgeable and confident, they will increasingly determine the direction of travel. For example, we did not expect, initially, to have a presentation from an economist, but regular questions about the economics of CCS, how it fitted with emissions trading schemes, what any commercial potential might be, and similar concerns eventually made this essential, and the participant feedback on that session was very positive.

It's important to note that the topics and questions which were developed through this research approach should be viewed as 'indications', as the title of the deliverable makes clear, rather than a definitive or exhaustive list. The methodology adopted of following a group of participants on their journey to understanding more about CCS, and CO_2 storage in particular, has produced a series of themes and discussion points which are more authentic and applicable to public engagement than themes decided externally by CCS researchers or developers based on assumptions of salience. That being said, it is important to remember that all participants are different, and it would be a mistake to consider the public to be homogenous. Morr et al. have done work highlighting that there are multiple 'publics' and that this should be accounted for in public engagement work.[64] The themes identified here should be used to guide conversation and constitute a useful and authentic starting point. The main approach is to apply the methodology of this research and provide the space for participants to be empowered by their own increasing knowledge.

From the analysis of the ten participant meetings held over nearly one and a half years, there are a number of key recommendations to be considered when engaging publics in CCS.

1. **Avoid Jargon –** this doesn't just mean technical language and the explanation of acronyms; it also means consideration of wider references made. For example, during discussions with participants around the processes of CCS, reference was made by a researcher to 'atmospheres' as a unit of pressure of gases. This term was questioned by participants and was followed by a discussion on the use of technical language within the process.

2. **Allow participants to guide the direction of travel –** the processes of CCS and CCUS are complex and discussion should fall where participants wish to know more. The questions presented within this report are guides to conversation, but participants should increasingly take the lead in developing conversations beyond these guidelines. Focusing on topics and themes

[64] Morr et al., 2013

which they find interesting will likely aid understanding the issue, and create trust in the process of engagement. At times this will have to be negotiated, as researchers will have topics they feel they have to cover in order to develop participants' understanding of the topic, but this negotiation should be between equals.

3. **Set Expectations –** to maximise the effectiveness of the previous recommendation, expectations should be set out early in the process to highlight the encouragement of questions and discussion on all aspects of the topic. This is particularly important in highlighting that participants' questions will steer the direction of the engagement process, and that their questions will be addressed directly and considered in full.

4. **Question Everything –** create and nurture an atmosphere within the group meeting(s) where questions and discussion are encouraged, and where the interests of lay-participants can open up new areas for discussion. This creates a more comfortable and engaging environment where participants feel their views and questions are important, thus improving trust. Furthermore, discussions and questions in such an environment can create opportunities for other viewpoints and considerations (positive and negative) to arise which may otherwise have been overlooked. It is also important to ensure any questions which could not be answered in a meeting are addressed in a future meeting to ensure trust and engagement are maintained.

5. **Meeting Variations –** designing meetings which encourage and enable conversation is important. An early meeting in this process focused too heavily on answering questions from the previous meeting, so became a one-way monologue similar to a lecture. The process was changed then for the remaining meetings with an expectation that participants could ask questions at any point, alongside more structured stopping points where the key themes raised could be discussed and debated in groups. We found a mixture of short presentations, combining speakers with multimedia, with stoppages for discussion, to be effective. We found it helpful, where possible, to respond to questions in 'real time', but some significant or persistent questions can become topics for future presentations. The use of field trips also helped to vary the meetings and retain the interest of our lay-participants. Particularly successful in this regard were the visit to the core store as part of the British Geological Survey field trip, and the trip to the experimental site at the GeoEnergy Test Bed.

6. **The Bigger Picture –** CCS could be *part* of the solution to climate change, and it is worth framing it in these terms. Participants discussed CCS in relation to global and local efforts to reduce emissions, in addition to required lifestyle changes. Consideration should be given to how CCS fits into the bigger picture (e.g. the switch to renewables, behavioural and lifestyle changes that might be required, and the need for international co-operation).

7. **Positives and Negatives –** the view of CCS presented by ENOS is that it has significant potential in tackling climate change, particularly in decarbonising industries where alternative low carbon processes are harder to develop. CCS does, however, have its critics and there are legitimate questions around, for example, the scalability of CCS and the financial models required. Discussion should not be orientated in favour of a particular viewpoint on CCS, but rather positives and negatives concerning the technology should be discussed freely and without bias to develop trust and richer, more nuanced conversations.

9. Conclusions and implications for Future Research

One of the main aims of WP5 was to how participants' views on CCS could contribute to future CCS and CO_2 storage development, particularly during the engagement of new research, or development of full-scale sites. As this research shows, citizens can provide interesting and useful inputs for the development and implementation of the technology in a way that is "societally friendly": the concrete answers to the questions in Table 3, to be verified case by case with local communities, could make the crucial difference for enabling decision making on this technology devoid of vested interests or other biases.

The contribution of participants has been particularly valuable in some areas, such as the complex issues of monitoring and regulation, the local environmental impacts of CO_2 storage in its various stages of development (pre-, during, and post-injection) and the need to get a comprehensive picture of cost issues.

The active role of the participants in the meetings was a key factor for the rich exchange and the production of their contributions. For future projects researchers should be careful to ensure participants are placed at the centre of discussions. Not just notionally, but genuinely. Highlight that no topics are off limits, that all questions are welcome and will be taken seriously, and that relevant experts will be brought in to address topics raised by participants. The issue of trust cannot be over-emphasised, and the clear communication of technical information in language that lay citizens can understand is part of the process of building a trusting relationship. Another aspect of this is independent monitoring and regulatory oversight. But an area we have also focused on, and in which the participants have provided detailed contributions, regards the approach to be taken in public engagement. In our final meeting we asked participants again, having got to the end of this process, how they believed that citizens should be engaged as part of a process around the development of onshore CO_2 storage sites. In addition to the points already discussed (keep jargon-free etc.) these were the three main points raised in the subsequent discussion:

a) The need for a multi-dimensional approach.

"Well there's lots of ways to approach the community aren't there"
Participant 3, Meeting 11

There was agreement in the group that communities are not homogenous, and that different cohorts (by age in particular) would be best addressed through different types of approach. Younger participants stressed the need to use television or social media, arguing that any media used (i.e. whether through Facebook, Twitter, Instagram etc.) would have to be 'really responsive'. "*Most people when they have a question go straight to the internet and it's usually your phone now*" (Participant 5, Meeting 11).

Older group members stressed the need for face-to-face contact and public meetings. This generation did not tend to trust on-line information – "*A lot of it's rubbish isn't it? And you don't know if it's the truth or not to be honest*" (Participant 2, Meeting 11) – preferring the opportunity to question people in person. These differences bring us back to the point that we are engaging with 'publics', not a homogenous 'public', and that different modes of interaction can be more or less appropriate for different cohorts.

b) Engage with community groups and leaders

The question of trust re-emerged, with a view that the levels of trust developed in this group over eleven meetings would be very hard to replicate with a 'real world' proposal for onshore capture and storage. One suggestion here that gathered support was to think of a local community as a 'community of communities'. What community groups are there based on shared interests or identities? Our

participants mentioned knitting circles, over-60's clubs, Women's' Institutes, Rotary Clubs, Round Tables, Ladies Circles, Freemasons, local sports clubs. All of these communities within the community offer avenues for engagement and the development of trust. Local community leaders would be trusted by local citizens, whereas politicians or those with a vested interest would probably not be. "*Teach them [i.e. community leaders] to talk about it*" (Participant 3, Meeting 11).

c) Engage early, and invest in engagement

Our group also stressed that engagement has to take place early in the process, while public views can still make a material difference to the outcome. Local people should not think that the development is a 'foregone conclusion'. There was recognition that a 'community of communities' approach would take time, but that such time might be necessary to gain social acceptance.

"*They're just small groups aren't they? If you've got a lot of people to address it's going to take ages to get around them. But you could get around them*" Participant 3, Meeting 11

And any presentations would need to be carefully designed:

"*And then people doing the talks need to be people that can talk about it at the level that people will understand, not talking above them. It needs to be at whoever's level it is. Simple, or more simple*" Participant 2, Meeting 11

9.1 Conclusion

Our initial thought, as researchers, was that in this project we were in a unique situation, having the 'luxury' of multiple meetings with the same group of participants, allowing us the time and space to take them through technical details of CO_2 storage with storage experts, and study how their views may or may not change as they became better-informed. Our thought now, at the end of the process, is that this is not a luxury. CO_2 storage is a technology with such low levels of public knowledge at the outset, as shown by multiple surveys, that an educational element and collaborative mode of working is something that we now see as an *essential* element to any onshore CO_2 storage project, and this includes the technical as well as public engagement dimensions. Key elements include:

- Easy to understand environmental impact assessments.
- Assurance of independent monitoring and regulatory oversight.
- A clear plan for dealing with negative events such as CO_2 leakage.
- Transparent accounting of the costs and benefits of any project.
- A multi-dimensional approach to address differential 'publics' with different concerns and levels of knowledge.
- An account of any specific project in the broader context of environmental problems such as climate change.
- An open and responsive consultation approach that takes not only takes citizen concerns seriously but is at least partly shaped by those concerns.

10. References

Ashworth P, Wade S, Reiner D, & Liang X (2015) 'Developments in public communications on CCS' *International Journal of Greenhouse Gas Control*, Vol. 40, pp: 449–458

BBC News (2019) 'What is Extinction Rebellion and what does it want?', https://www.bbc.co.uk/news/uk-48607989

BBC News (2015) 'UK government carbon capture £1bn grant dropped', https://www.bbc.co.uk/news/uk-scotland-scotland-business-34357804

de Best-Waldholder, Marjolein; Dancker Daamen; André Faaij (2009) 'Informed and Uninformed Public Opinions on CO_2 Capture and Storage Technologies in the Netherlands' *International Journal of Greenhouse Gas Control*, Vol. 3, No. 3, pp. 322-332

BGS (2019a) 'How Can CO_2 be Stored?', https://www.bgs.ac.uk/discoveringGeology/climateChange/CCS/howcanCO2bestored.html

BGS (2019b) 'Removal of CO_2 from Natural Gas Processing Plant', https://www.bgs.ac.uk/discoveringGeology/climateChange/CCS/RemovalCO2NaturalGas.html

BGS (2019c) 'CO_2 storage — Sleipner field beneath the North Sea', https://www.bgs.ac.uk/science/CO2/home.html

Carbon Brief (2019) 'Analysis: UK renewables generate more electricity than fossil fuels for first time', https://www.carbonbrief.org/analysis-uk-renewables-generate-more-electricity-than-fossil-fuels-for-first-time

CCUS Cost Challenge Taskforce (2018) 'Delivering Clean Growth CCUS Cost Challenge Taskforce Report', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727040/CCUS_Cost_Challenge_Taskforce_Report.pdf

Committee on Climate Change (2019) 'Net Zero – The UK's contribution to stopping global warming', https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

Curry, T. E.; Ansolabehere, S. & Herzog, H.J. (2007) 'A Survey of Public Attitudes towards Climate Change and Climate Change Mitigation Technologies in the United States, Analyses of 2006 Results', MIT LFEE 2007-01 WP.

Desbarats, J.; Riesch, Hauke; Upham, Paul & Reiner, David (2010) 'Review of the public participation practices for CCS and non-CCS projects in Europe: Deliverable 1.2: NEARCO$_2$ - new participation and communication strategies for neighbours of C02 capture and storage operations', https://www.researchgate.net/publication/43656623_Review_of_the_public_participation_practices_for_CCS_and_non-CCS_projects_in_Europe_Deliverable_12_NEARCO2_-_new_participation_and_communication_strategies_for_neighbours_of_C02_capture_and_storage_op

Demski, Christina; Spence, Alexa & Pidgeon, Nick (2013) 'Transforming the UK Energy System: Public Values, Attitudes and Acceptability Summary findings from a survey conducted August 2012', http://www.ukerc.ac.uk/publications/transforming-the-uk-energy-system-public-values-attitudes-and-acceptability-summary-findings-from-a-survey-conducted-august-2012.html

Devine-Wright, Patrick (2010) *Renewable Energy and the Public: From NIMBY to Participation*, London: Earthscan.

Devine-Wright, Patrick (2015) 'Local Attachments and Identities', *Progress in Human Geography*, Vol. 39, No. 4, pp: 527-530

Edwards, Ryan W. J. & Celia, Michael A. (2018) 'Infrastructure to Enable Deployment of Carbon Capture, Utilization, and Storage in the United States', *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 115, No. 38, pp. 8815-8824

EnAppSys (2020) 'Renewables replace fossil fuels as Europe's main power source', https://www.enappsys.com/post/renewables-replace-fossil-fuels-as-europe-s-main-power-source

ENOS Project (2019a) 'Field Laboratories for Leakage Simulation', http://www.enos-project.eu/sites/field-laboratories-for-leakage-simulation/gtb/

ENOS Project (2019b) 'Participating in CO_2 Geological Storage Research', http://www.enos-project.eu/participating-in-co2-geological-storage-research/

European Commission (EC) CORDIS (2019a) 'H2020-EU.3.3.2.3. - Develop competitive and environmentally safe technologies for CO2 capture, transport, storage and re-use', https://cordis.europa.eu/programme/id/H2020-EU.3.3.2.3.

European Parliament (2019) 'Fact Sheets on the European Union Combating Climate Change', https://www.europarl.europa.eu/factsheets/en/sheet/72/combating-climate-change

European Parliament and Council (2009) 'Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the Geological Storage of Carbon Dioxide and Amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006' https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0031

European Parliament and Council (2011) 'Implementation of the CCS directive', https://ec.europa.eu/clima/policies/innovation-fund/ccs/implementation_en#tab-0-1

Furre, Anne-Kari; Eiken, Ola; Alnes,Håvard; Nesland, Jonas; Anders, Vevatne & Kiær, Fredrik (2017) '20 Years of Monitoring CO_2-injection at Sleipner' *Energy Procedia*, Vol. 114, pp: 3916-3926.

Fleishman, Lauren A; Wändi Bruine de Bruin; M. Granger Morgan, 2010, 'Informed Public Preferences for Electricity Portfolios with CCS and Other Low-Carbon Technologies' *Risk Analysis* Vo.30, No. 9, pp:1399-1410.

Flynn, Rob; Paul Bellaby, & Miriam Ricci (2011) 'The Limits of Upstream Engagement in an emergent Technology: Lay Perceptions of Hydrogen Energy Technologies' in Devine-Wright, P (Ed.) *Renewable Energy and the Public: From NIMBY to Participation* London: Earthscan, pp.245-260

Frantzeskaki & Kabisch, (2016) 'Designing a Knowledge Co-production Operating Space for Urban Environmental Governance – Lessons from Rotterdam, Netherlands and Berlin, Germany' *Environmental Science and Policy*, Vol.62, pp. 90-98

Geo Energy Test Bed, (2019), 'The Geo Energy Test Bed' (GTB), http://www.gerc.ac.uk/facilities/geoenergy-test-bed/gtb.aspx

Global CCS Institute,(2019a), Understanding CCS', https://www.globalccsinstitute.com/why-ccs/what-is-ccs/

Global CCS Institute (2019b) 'Global Status of CCS Report', https://www.globalccsinstitute.com/resources/global-status-report/

Grantham Institute (2018) 'What is carbon capture and storage and what role can it play in tackling climate change?', http://www.lse.ac.uk/GranthamInstitute/faqs/what-is-carbon-capture-and-storage-and-what-role-can-it-play-in-tackling-climate-change/

Health and Safety Executive (1974) 'Health and Safety at Work etc. Act 1974', https://www.hse.gov.uk/legislation/hswa.htm

Intergovernmental Panel on Climate Change (IPPC) (2005) 'Carbon Dioxide Capture and Storage', https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf

Intergovernmental Panel on Climate Change (IPPC) (2014) 'Climate Change 2014 Mitigation of Climate Change, Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change', https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf

Karimi, Farid & Arho Toikka (2018) 'General Public Reactions to Carbon Capture and Storage: Does Culture Matter?' *International Journal of Greenhouse Gas Control* Vol.70, March, pp:193-201.

Morr, Alison; Raman, Sujatha & Gibbs, Beverley (2013) 'Which 'publics'? When? Exploring the Policy Potential of Involving Different Publics in Dialogue Around Science and Technology.', https://webarchive.nationalarchives.gov.uk/20170110130952/http:/www.sciencewise-erc.org.uk/cms/assets/Uploads/Which-publics-FINAL-VERSION.pdf

L'Orange Seigo, Selma; Simone Dohle; Michael Siegrist (2014) 'Public Perception of Carbon Capture and Storage (CCS): A Review' *Renewable and Sustainable Energy Reviews* Vol.38, pp:848-863
Owens, S., (2000) 'Commentary Engaging the Public: Information and Deliberation in Environmental Policy', *Environment and Planning*, Vol. 32, pp. 1141-1148

Reiner, David (2014) 'Written Testimony to Carbon Capture and Storage inquiry', http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/energy-and-climate-change-committee/carbon-capture-and-storage/written/1644.html

Reno, Joshua (2010) 'Science, Technology & Human Values: Managing the Experience of Evidence: England's Experimental Waste Technologies and their Immodest Witnesses', *Science Technology Human Values*, Vol. 36, No. 6

Rochelle, Gary T. (2009) 'Amine Scrubbing for CO_2 Capture', *Science*, Vol. 325, No. 5948, pp. 1652-1654
Spence, Bill; Horan, Denise & Tucker, Owain (2014) 'The Peterhead-goldeneye Gas Post-combustion CCS Project' *Energy Procedia*, Vol. 63, Pg. 6258-6266

Terwel, B.W.; ter Mors, E. & Daamen, D.D.L. (2012) 'It's Not Only About Safety: Beliefs and Attitudes of 811 Local Residents Regarding a CCS Project in Barendrecht' *International Journal Greenhouse Gas Control*, Vol. 9, pp: 41-51

UK Government (2008) 'Energy Act 2008', http://www.legislation.gov.uk/ukpga/2008/32/contents

UK Government (2009) 'Carbon Capture Readiness', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/43609/Carbon_capture_readiness_-_guidance.pdf

UK Government (2012) 'CCS Roadmap Supporting Deployment of Carbon Capture and Storage in the UK', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48317/4899-the-ccs-roadmap.pdf

UK Government (2018) 'Clean Growth Strategy', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

UK Government (2019a) 'UK becomes first major economy to pass net zero emissions law' https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

UK Government (2019b) 'UK's largest carbon capture project to prevent equivalent of 22,000 cars' emissions from polluting the atmosphere from 2021' https://www.gov.uk/government/news/uks-largest-carbon-capture-project-to-prevent-equivalent-of-22000-cars-emissions-from-polluting-the-atmosphere-from-2021

United Nations Framework Convention on Climate Change, (2019) 'The Paris Agreement' https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

United Nations Sustainable Development (2019) 'Finland will Achieve Carbon Neutrality by 2035' https://sustainabledevelopment.un.org/partnership/?p=33186

Whitmarsh, Lorraine; Xenias, Dimitrios & Jones, Christopher R., 2019 Framing Effects on Public Support for Carbon Capture and Storage, Palgrave Communications, Vol. 5, No. 17

Wiersma, Bouke & Devine-Wright, Patrick, 2014, Public Engagement with Offshore Renewable Energy: A Critical Review, WIREs Climate Change, Vol. 5, No. 4

Wolsink, M., (2007) 'Planning of Renewable Schemes: Deliberative and Fair Decision-Making on Landscape Issues Instead of Reproachful Accusations of Non-Cooperation', *Energy Policy*, Vol. 35, No. 5, pp. 2692-2704

11. Appendices

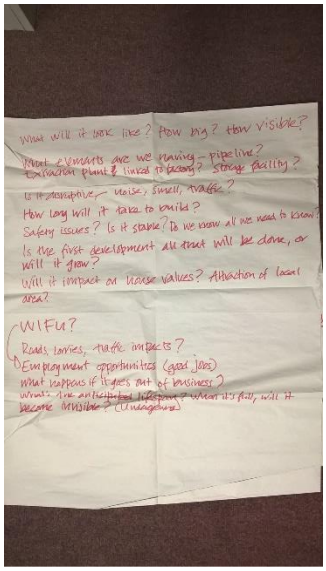
11.1. Appendix 1 – Table of Participant Meetings

Meeting No.	Date	Researchers/Participants Present	Theme
1	Sept. 2018	WK | MH | CV | SR I AS Participants: 10	Introduction to ENOS and WP5
2	Oct. 2018	WK | MH | CV I SR Participants: 9	Answering questions from 1st Meeting
3	Dec. 2018	WK | MH | CV Participants: 7	Site visit to British Geological Survey
4	March 2019 (1)	WK | MH | CV Participants: 6	Economics of CCS
5	March 2019 (2)	WK | MH | CV Participants: 4	CCS and Local Communities. Place attachment
6	April 2019	WK | MH| CV Participants: 6	Site characterisation, monitoring and risk management
7	May 2019	WK | MH | CV Participants: 3	CO_2 migration/Public Information Tool
8	June 2019	WK | MH | CV Participants: 7	Site Visit to Geo Energy Testbed
9	July 2019	WK | MH Participants: 6	Reflections on GTB site visit
10	Sept. 2019	WK | MH Participants: 4	Utilisation of CO_2 and discussion of potential content for final report
11	Dec 2019	WK | MH | CV Participants: 5	Discussion of draft final report

Average attendance of participants: 6.09

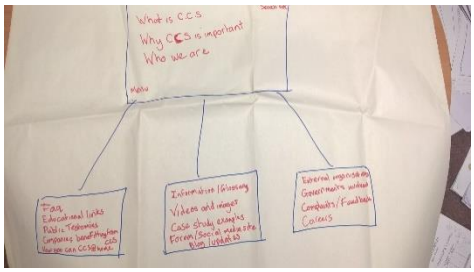
Researchers Key
CV – Ceri Vincent (BGS)
MH – Mathew Humphrey (UoN)
SR – Sean Rigby (UoN)
WK – Wil Knight (UoN)
AS – Adeel Sohal (UoN)

11.2. Appendix 2 – Written Questions from Meeting 5 (example)



- What will it look like? – How big? How visible?
- What elements are we having? Pipeline? Extraction Plant linked to factory? Storage facility?
- Is it disruptive? – Noise, smell, traffic?
- How long will it take to build?
- Safety Issues? Is it stable? Do we know all we need to know?
- Is the development all that will be done, or will it grow?
- Will it impact on house values? Attraction of local area?
- Road, lorries, traffic impacts?
- Employment opportunities (good jobs)?
- What happens if it goes out of business?
- What's the anticipated lifespan? When it's full, will it become invisible (underground)?

11.3. Appendix 3 – Written Potential Website Page Headings from Meeting 7 (example)



Main Page

- What is CCS?
- Why is CCS important?
- Who are we?
- Search Box

Page 1

- FAQ
- Educational Links
- Public Testimonies
- Companies benefitting from CCS
- How you can CCS at home [by this our participants meant that it would be useful to have some tips on how to reduce one's own carbon footprint domestically. Although this might not be the appropriate site for this information, it helps to show how our participants tended to link CCS to wider concerns about lifestyle change. The thought was that if citizens do more themselves, CCS itself becomes less necessary].

Page 3

- External Organisations
- Governments Involved
- Complaints / Feedback
- Careers

12. Acknowledgements:

We would like to thank all of those who helped with the generation of this report. In particular Ceri Vincent of the British Geological Survey, who attended nearly all of our focus group meetings, and who has read through and commented on more than one iteration of this document. Also Sean Rigby and Adeel Sohal from the University of Nottingham. Bouwe Dijkstra (University of Nottingham) for the lesson in environmental economics. Samuela Vercelli and all those involved in ENOS WP5. Most of all we would like to thank our citizen-participants for sticking with us throughout eleven meetings on CO_2 storage, and for providing such thought-provoking and insightful feedback.

This deliverable is prepared as a part of ENOS project
More information about the project could be found at http://www.enos-project.eu

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The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653718