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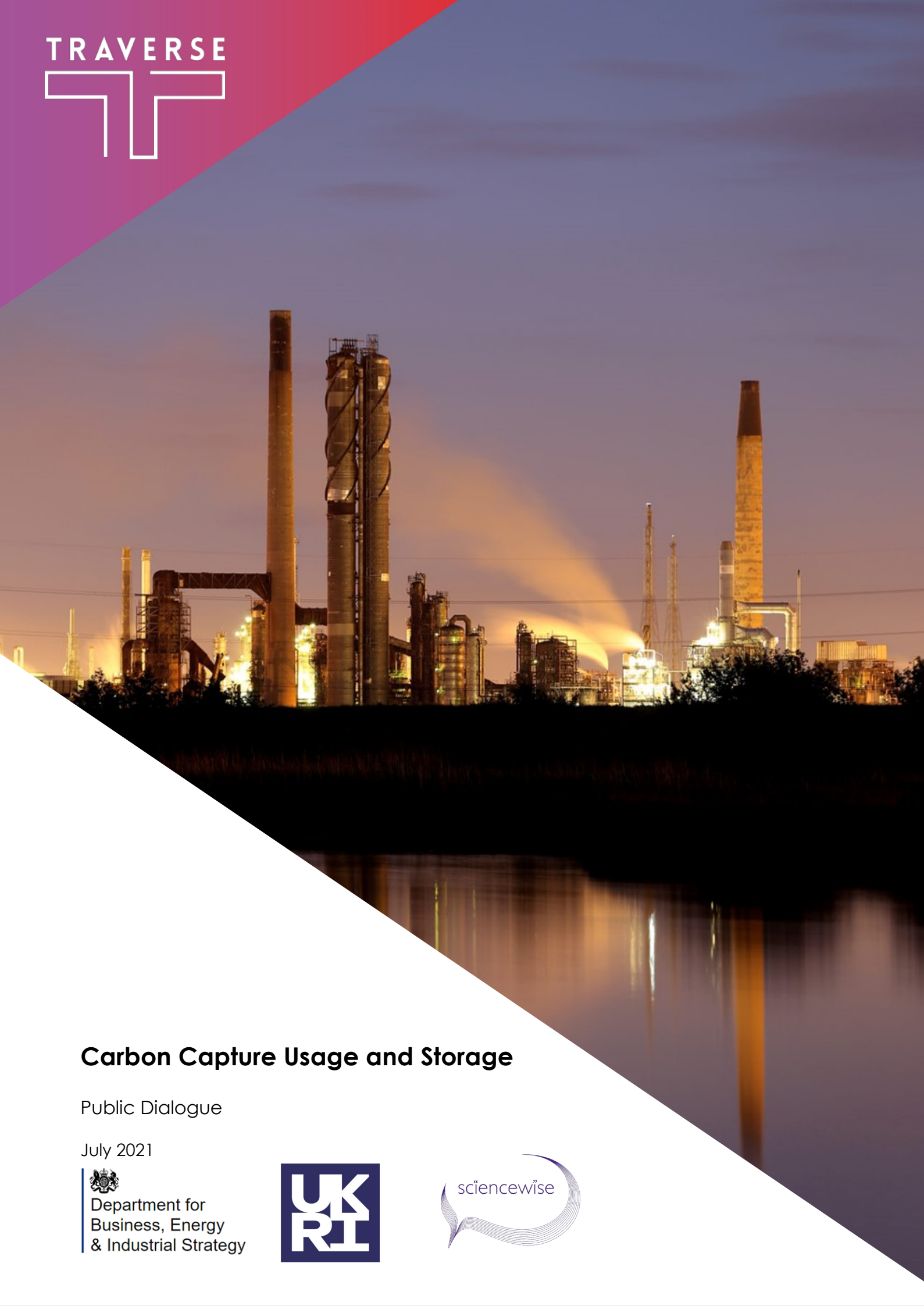

Carbon Capture Usage and Storage

Public Dialogue

July 2021

Department for Business, Energy & Industrial Strategy

UKRI

sciencewise

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Glossary

Table 1. Glossary of key terms used in this report.

Key word	Definition
BEIS	Department for Business, Energy & Industrial Strategy (BEIS)
BECCS	Bioenergy with Carbon Capture and Storage. BECCS combines the use of biomass for energy (e.g., using waste, straw, energy crops, etc.) and capture and storage of CO_2. The process can result in a net reduction in total atmospheric emissions, often called 'negative emissions'.
Blue Hydrogen	Natural gas is used in the production of hydrogen, and the carbon emissions generated through the production process are captured via Carbon Capture Usage and Storage (CCUS) technology.
Carbon footprint	A measure of CO_2 produced by an individual or organisations' activity or activities.
Carbon sink	A carbon sink is a natural or artificial reservoir that absorbs and stores the atmosphere's carbon with physical and biological mechanisms. A net carbon sink is anything that absorbs more carbon than it releases as CO_2. For example, European forests are currently a net carbon sink as they take in more carbon than they emit.

Carbon Capture Usage and Storage (CCUS)	CCUS is the process of: ▪ Capturing carbon dioxide emissions from large-point sources (such as power stations and industrial facilities). ▪ Transporting CO_2 in pipelines or via ships to very deep subsurface rock formations where it can be permanently stored. In some instances, the CO_2 captured can be utilised, for example in the food and drink industry. Carbon Capture and Storage (CCS) and Carbon Capture Usage and Storage (CCUS) are sometimes used interchangeably. Some organisations prefer to use CCS to focus on storage rather than usage, as storage is likely to play a more significant and critical role in meeting climate change targets.
CO_2/carbon dioxide	CO_2 is a colourless, odourless, greenhouse gas that is natural and harmless in small quantities. As CO_2 builds up in our atmosphere from burning fossil fuels, it has a warming effect that is changing the earth's climate.
DACCS	Direct Air Carbon Capture and Storage. DACCS is a process which captures CO_2 directly from the atmosphere. This can result in a net reduction in total atmospheric CO_2 concentrations, and therefore considered a 'Greenhouse Gas Removal technology (GGR)'.
Energy efficient	Using the least amount of energy necessary in products, services, and activities.
Fossil fuels	A fossil fuel is a fuel formed by natural processes, such as decomposition of buried dead organisms, that can be

	used to produce energy. Fossil fuels include coal, petroleum, natural gas, oil shales, bitumen, tar sands, and heavy oils. During combustion, they produce CO_2.
Global warming	Global warming is the long-term heating of the earth's climate system.
Green Hydrogen	Hydrogen as produced by the electrolysis of water, using only electricity generated from renewable technologies. This effectively eliminates emissions from the production process altogether.
Greenhouse gases	Any gaseous compound (such as CO_2 or methane) that absorbs infrared radiation, traps heat in the atmosphere and contributes to global warming.
Industrial clusters	Industrial clusters are areas with a number of industrial sites co-located and which typically produce a high level of CO_2 emissions. Alternatively, sites where 'cleaner' industries congregate can be referred to as low-carbon industrial clusters.
Net zero	The overall greenhouse gas emissions produced are balanced by greenhouse gases taken out of the atmosphere – so the net amount is zero.
Renewable energy	Renewable energy technologies are ways to generate electricity from theoretically unlimited sources, such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy technologies are also often referred to as "green energies" or "clean energies", since their use does not involve significant emissions of CO_2 into the

	atmosphere.
Zero carbon	Zero carbon means that no carbon emissions are involved in the production of a product/service or the activity of an individual/organisation.

Foreword

The world is facing the unprecedented challenge of global climate change: if we do not act to combat rising emissions, the impacts could lead to devastating consequences.

We must do everything we can to tackle climate change. The UK was the first major economy in the world to legislate to end its contribution to global warming, by targeting net zero emissions by 2050. Achieving net zero will require decisive action across the economy, and a range of methods and technologies will be needed to decarbonise.

Carbon Capture Usage and Storage (CCUS) is one technology which the Government sees playing an essential role to achieving this target. The Climate Change Committee describes Carbon Capture and Storage as a necessity, not an option, to achieving net zero. CCUS will help decarbonise our hardest to reach industrial sectors, provide low carbon power and a pathway to negative emissions. As set out in the Prime Minister's Ten Point Plan, CCUS will be an exciting new industry and will revitalise the birthplaces of the first Industrial Revolution. It could support up to 50,000 jobs in the UK by 2030.

The Government recognises that understanding public attitudes towards technologies such as CCUS is crucial to ensure effective implementation. We are committed to listening to members of the public to help inform policy development over the coming months and years. That is why, with support from UK Research and Innovation's Sciencewise programme, we commissioned this important deliberative dialogue study, to help build our understanding of public attitudes towards this technology and how it could be deployed.

I would like to sincerely thank the members of the public who took part in this dialogue. Your contributions and insights form an invaluable addition to the evidence base assessing public perceptions on CCUS. I would also like to thank members of the Oversight Group who helped shape the study, and the specialists for dedicating their time to take part in workshops.

As we continue to develop and progress policy on CCUS, we will consider how best to take account of the findings of this important study.

The Rt Hon Anne-Marie Trevelyan, Minister for Energy, Clean Growth and Climate Change

Executive Summary

The UK has a legally binding requirement to bring its greenhouse gas emissions to net zero by 2050.

There is widespread consensus among scientists and policy makers that a range of approaches will be required to achieve net zero by 2050. Carbon Capture, Usage and Storage (CCUS) is part of the UK Government's strategy to achieve this. CCUS could provide both emissions reductions and greenhouse gas removal options. The UK Government is aiming to deploy CCUS in two industrial clusters by the mid-2020s, and for two more clusters to be operational by 2030. The UK Government's Ten Point Plan for a Green Industrial Revolution, published in November 2020, identified areas such as the North East, the Humber, North West, Scotland and Wales as potential sites.[1]

The Department for Business, Energy & Industrial Strategy (BEIS), in partnership with UK Research and Innovation's Sciencewise programme, commissioned Traverse to deliver a public dialogue to understand citizens' attitudes towards Carbon Capture, Usage and Storage (CCUS). Public dialogues provide in-depth insight into citizens' views, concerns and aspirations on issues. The key objectives of the dialogue, which was conducted in line with the Sciencewise Guiding Principles,[2] were:

1. To engage a diverse and inclusive group of the public in dialogue about the future use of CCUS technologies and applications.
2. To explore participants' views on CCUS in principle and its different applications in helping to meet a net zero target.
3. To gain an understanding of participants' aspirations and concerns about CCUS, and how these may differ in areas where CCUS may be developed in comparison to areas where development is unlikely.
4. To gain insight into the conditions participants would wish to be met if CCUS technologies were deployed in a local area, and the benefits they would expect to accompany deployment.

[1] https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution/title#point-8-investing-in-carbon-capture-usage-and-storage
[2] https://sciencewise.org.uk/about-sciencewise/our-guiding-principles/

Methodology

- Over 100 participants participated in the dialogue.
- Participants were recruited from five locations – four in areas that may implement CCUS applications (shown in black), one where CCUS was not being proposed (shown in yellow).
- Seven online workshops and individual activities on an online platform were conducted to understand participants views.
- Workshops ran from 1 October – 10 November 2020.

The dialogue was held online, with over 100 participants from five locations (and surrounding areas) across the UK.

Four of these locations were chosen to engage with participants from areas that may implement a range of CCUS applications. The fifth location (Nottingham) was selected to provide insight into how people who do not live near a potential CCUS site view CCUS and its applications. The five locations were:

- Aberdeen
- Liverpool
- Port Talbot
- Teesside/North East[3]
- Nottingham

The dialogue took place between 1 October - 10 November 2020. The dialogue had originally been planned as a face-to-face exercise. Due to COVID-19 restrictions it was agreed to carry the dialogue out online and it was redesigned accordingly.

Participants took part in seven online workshops, where they had the opportunity to learn about and discuss CCUS with each other and specialists from industry, academia and independent bodies. Participants also used an online platform to complete individual activities and feedback tasks relevant to the discussions each week.

As part of the dialogue, participants were asked to develop criteria

[3] When recruiting in Teesside, recruiters could not fulfil the quotas without extending the search areas and so when this report refers to Teesside, it also includes the surrounding areas.

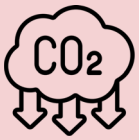
the Government should consider for the implementation of CCUS.

Summary of the key findings

The role of CCUS in reaching net zero

Participants generally accepted the need for a pathway to net zero and most thought CCUS could play a role alongside other solutions, such as renewable energy. However, broadly speaking, participant support for CCUS playing a role in the pathway to net zero was conditional on two key factors:

CCUS needs to be an effective strategy in reducing CO_2 emissions



CCUS must be safe

- **CCUS needs to be an effective strategy in reducing CO_2 emissions**, with its costs considered in light of its potential contribution to reaching net zero. Participants were concerned about how much CCUS would cost (and costs spiralling out of control) and many felt that CCUS must make a significant impact on CO_2 emissions in order to justify its cost. In the early stages of the dialogue, participants had many questions about how CCUS would work, both in terms of contributing towards net zero and how it actually operates. As an emerging technology, participants did not find CCUS easy to understand. Distinct examples grounded in tangible and local contexts helped people assess its efficacy as a strategy for reaching net zero. In evaluating the effectiveness of CCUS, some participants found it helped them to learn that Norway has been capturing and storing CO_2 for over 20 years and to hear about how much offshore storage capacity the UK has.
- **CCUS must be safe.** Safety was the most important criterion identified by participants and support for CCUS was explicitly predicated on it being safe. The storage of CO_2 under the seabed was the most disquieting safety concern for participants, but they also had worries about the safety of CO_2 being transported. Participants highlighted the risk of leaks and earthquakes, and the harm these might cause to marine life. Participants wanted the entire CCUS process (including decommissioning) to be safe, and for safety features to be explicitly and accessibly communicated, supported by a strong evidence base.

Participants felt that the pathway to net zero required multiple strategies and that this was the context in which CCUS should be seen. At the start of the dialogue, there was relatively low awareness of the implications of net zero, or the range of potential routes to achieving this goal. A few participants expressed concerns about CCUS potentially taking investment away from other strategies, particularly renewables.

A small group of participants, across locations, were strongly opposed to CCUS having any role in the pathway to net zero and their opposition hardened over the dialogue. They felt that CCUS would tackle the symptoms rather the causes of global warming by not reducing emissions, calling it a "sticking plaster." They viewed CCUS as unsafe and described it as "unnatural," reflecting their strong feelings that CCUS is undesirable.

Some participants had concerns about CCUS enabling the continuation of CO_2 emissions. They considered CCUS a "stop gap" solution to buy time to end CO_2 emissions through other means. These included the development of what participants described as "cleaner solutions" such as renewables.

Views on specific CCUS technologies and applications

Participants' reactions to the CCUS applications and technologies they learned about in the dialogue were shaped by views on the efficacy of CCUS applications in reducing CO_2 emissions and their potential cost.

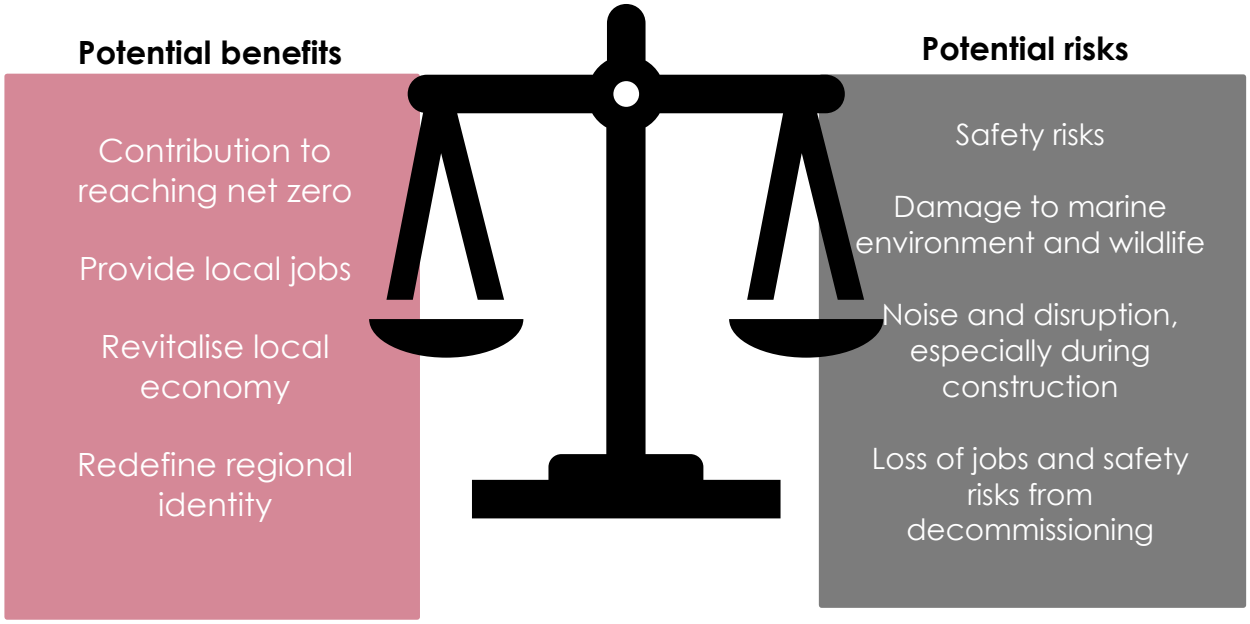
In addition:

- Participants had differing views on whether high-emitting industries should decarbonise or continue as now.
- Participants raised concerns about the scale of the carbon reductions achieved by CCUS in power generation.
- When talking about CCUS being used in the production of hydrogen as a fuel, participants focused more on hydrogen itself, particularly its safety, rather than on the role of CCUS.
- Participants felt uncomfortable about the possibility of the Bioenergy with Carbon Capture Storage (BECCS) process involving the burning of trees to produce bioenergy. They perceived this to be counter-intuitive in tackling climate change and, more broadly, found BECCS complex and difficult to assess.
- Participants found the concept of Direct Air Carbon Capture and

Storage (DACCS) easier to evaluate but expressed concerns that it was unproven at scale. Participants' views on CCUS as a solution to reaching net zero were not impacted by learning about BECCS and DACCS.

Deployment of CCUS projects

A majority of participants felt comfortable with CCUS being deployed in the UK generally and in their own local area. On both measures, the number of participants who were comfortable rose over the course of the dialogue. However, more participants were comfortable with CCUS being deployed in the UK generally than in their own local area. Participants' views on national deployment were shaped by opinions on whether or not CCUS is a desirable solution for reaching net zero, whereas views on local deployment were influenced by concrete local considerations.



Participants thought that local CCUS projects carried a number of risks in both the construction and operation stages:

- Environmental risks, in particular damage to the marine environment and wildlife.
- Safety risks because of leaks, accidents and unforeseen events.
- Noise and disruption, particularly from traffic, during construction.
- The loss of jobs and safety risks resulting from decommissioning.

Because of concerns about safety and costs, participants felt strongly that contracts for CCUS projects should be awarded openly and

transparently, preferably to what participants described as "ethical" companies with a proven record of delivery on similar projects. Some stated a preference for UK companies to deliver CCUS projects.

Participants thought there should be oversight and regulation of all stages of CCUS projects which is independent of both government and industry. In particular, this oversight should ensure that CCUS projects are safe and that wildlife is protected.

Participants wanted CCUS projects to create jobs for local people. Participants in Aberdeen and Teesside were generally more favourable than other locations to their local case studies because they felt CCUS would have a positive impact on local employment. In Aberdeen, some participants thought CCUS could have a role in replacing jobs that would be lost in the oil and gas industry. In Teesside, some participants felt that CCUS was potentially an opportunity to "get our identity back" following industrial decline.

In Port Talbot and Liverpool, the picture was less clear cut. In Port Talbot, some participants were concerned that the steel industry could not bear the cost of CCUS. In Liverpool, the location of the proposed CCUS project presented as a case study (which is located outside of Liverpool in Ellesmere Port on the south side of the River Mersey) made some participants doubt if it would benefit people from Liverpool. In all four locations, participants were cynical about patterns being repeated, where new jobs are announced only to disappear or be filled by workers from outside the area.

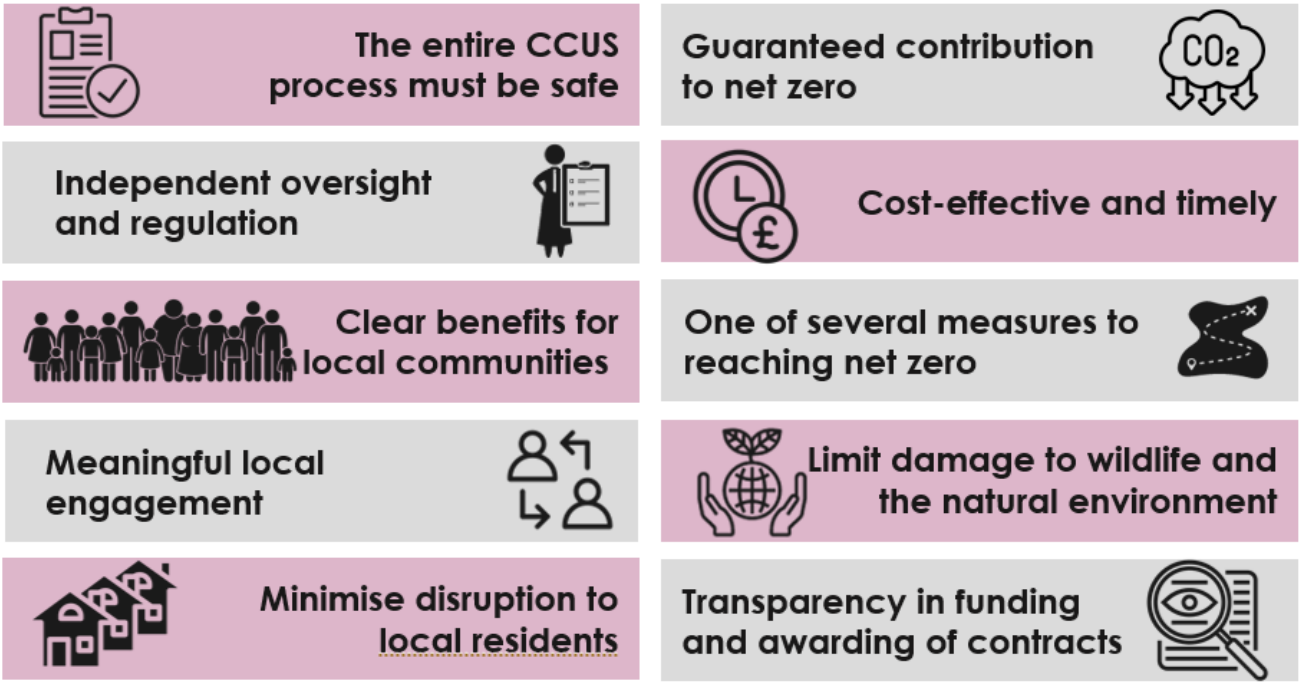
Key considerations in engagement on CCUS

Participants wanted there to be inclusive and meaningful engagement with local communities directly impacted by CCUS, with people's views listened to. They thought it was important to provide clear information, which explains risks as well as benefits, to enable local communities to have informed views on projects. In particular, they felt local communities should be given transparent information on safety, costs and funding, the role of CCUS in reaching net zero, local environmental impacts (to wildlife and the land) and economic benefits.

Trust was seen as integral to communicating about CCUS, which is linked to the desire for transparency about risks as well as benefits. Participants trusted information from sources they perceived as having no vested interest in CCUS and which they thought had credibility to evaluate impacts.

Criteria for implementation of CCUS developed by participants

In developing criteria for the implementation of CCUS, participants were clear that safety is the most important. However, there are a number of other criteria that participants wanted the Government to take into account to ensure that CCUS effectively contributes to reaching net zero by 2050 and that risks are minimised.



1. Introduction

1.1 Context

In 2019, the UK became the first major economy in the world to adopt a target, by law, that requires the country to bring its greenhouse gas emissions to net zero by 2050. The UK's 2050 net zero target was recommended by the Climate Change Committee (CCC), the UK's independent climate advisory body.[4]

Achieving this target will require greenhouse gas emissions reductions across the economy and balancing any residual emissions by removing an equivalent amount of greenhouse gases from the atmosphere. There is widespread consensus among scientists and policy makers that a range of approaches will be required to achieve net zero and that no single technology can deliver this on its own.

There is broad agreement among scientists and policy makers that Carbon Capture Usage and Storage (CCUS) has an important role to play in tackling climate change.[5] The CCC has stated that carbon capture and storage "is a necessity, not an option" to achieving net zero by 2050.[6] The technology could provide both emissions reductions and greenhouse gas removal options. Policy makers believe that CCUS could deliver tangible results in decarbonisation, as well as contributing to industrial competitiveness and generating new economic opportunities in the UK. Organisations advocating this view include the Intergovernmental Panel on Climate Change (IPCC)[7], the Climate Change Committee (CCC)[8] and International Energy Agency (IEA)[9].

There is, however, concern in some quarters that CCUS might distract from growing renewable energy and improving energy efficiency.[10]

There is also a debate, explored by the CCUS Cost Challenge Taskforce, about how CCUS should be funded.[11] The taskforce consisted of over 40 leading experts from across industry and

[4] www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/
[5] See for example www.iea.org/reports/ccus-in-clean-energy-transitions
[6] /www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf
[7] https://www.ipcc.ch/report/ar5/syr/
[8] https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf
[9] https://iea.org/tcep/
[10] https://foe.scot/wp-content/uploads/2021/01/CCS-Research-Summary-Briefing.pdf
[11] Funding mechanisms have been explored by the CCUS Cost Challenge Taskforce (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727040/CCUS_Cost_Challenge_Taskforce_Report.pdf)

academia.

The UK Government is aiming to deploy CCUS in two industrial clusters by the mid-2020s, and for two more clusters to be operational by 2030. The UK Government's Ten Point Plan for a Green Industrial Revolution, published in November 2020, identified areas such as the North East, the Humber, North West, Scotland and Wales as potential sites.[12] Proposed CCUS sites in Teesside, Merseyside, South Wales and Grangemouth are based on existing industrial infrastructure and have potential routes to transport CO_2 to offshore storage sites.

As has been seen with onshore wind and hydraulic fracturing, public opinion can be a key factor in the effective deployment of new technologies. At present, public knowledge of CCUS is limited. In March 2020, over half (54%) of the UK public had never heard of CCS (although this is down from 64% in March 2012) and only 23% said they know at least a little about it. Among this 23%, 62% said they support carbon capture and storage, 6% were opposed and 31% were neutral. [13]

A public dialogue was commissioned to gain insight into the public's attitudes towards CCUS and its deployment in the UK. Traverse was appointed as the delivery contractor.

1.2 Aims and objectives

The dialogue explored attitudes towards carbon capture, usage, and storage (CCUS) as a strategy for removing greenhouse gases from the atmosphere or preventing their emission.

The dialogue was commissioned by BEIS, the Government department responsible for energy policy in the UK, and co-funded by UK Research and Innovation's Sciencewise programme. Sciencewise enables policy makers to develop socially informed policy and ensure that policy is informed by the views and aspirations of the public.

[12] https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution/title#point-8-investing-in-carbon-capture-usage-and-storage
[13] BEIS Public Attitudes Tracker: Wave 33 (www.gov.uk/government/statistics/beis-public-attitudes-tracker-wave-33)

Key objectives of the dialogue

1. To engage a diverse and inclusive group of the public in dialogue about the future use of CCUS technologies and applications, involving members of the public from areas where CCUS facilities are more likely to be developed (i.e. 'local') as well as areas less likely to be directly involved in CCUS deployment (i.e. 'non-local').
2. To explore participants' views on the role of CCUS in principle and its different applications in helping to meet a net zero carbon emission target.
3. To gain an understanding of participants' aspirations and concerns about CCUS, and how these may differ in areas where CCUS may be developed vs. areas where development is unlikely.
4. To gain insight into the conditions participants would wish to be met, if CCUS technologies and CO2 transport and storage infrastructure was deployed in a local area, and the benefits they would expect to accompany deployment.
5. To inform the development of principles to underpin the deployment of CCUS technologies and CO2 transport and storage.
6. To develop an evidence base which can be used to inform and refine development and delivery of future CCUS policy, including Government decisions on how any rollout of CCUS is managed, and to inform best practice for CCUS project developers.
7. To deliver a high-quality dialogue, safely and ethically, within the constraints of COVID-19.

For a detailed overview of the dialogue research questions, please refer to Appendix A: Research questions.

1.3 Methodology

1.3.1 Sciencewise approach

Public dialogues provide in-depth insight into citizens' views, concerns and aspirations on issues. Not only does a dialogue provide an insight into public opinion, but it also offers a window into understanding people's reasoning.

The dialogue was conducted in line with the Sciencewise Guiding

Principles[14] to allow for in-depth understanding of the views, concerns and aspirations of a diverse and inclusive sample that reflected the local population for each location included in the dialogue. Our aim was to understand both *what* participants thought about CCUS and *how* their views formed and changed through the course of the dialogue as they explored the topic.

For Sciencewise, a public dialogue includes:

- Involving specialists and policymakers in discussion with the public to help explore issues, concerns and aspirations when shaping policy.
- Talking with the public about ethical and societal issues related to public policy.
- Requiring the instigators of the dialogue to be potentially willing and able to change their minds.
- Ensuring that public insights can inform policy involving science and technology issues.[15]

1.3.2 Oversight Group

BEIS convened a group of stakeholders from industry, academia, Government, regulatory bodies and the non-governmental organisation (NGO) sector. The role of this Oversight Group was to support the project by providing independent advice and oversight to ensure the deliberative dialogue plans, evidence and materials were accurate and provided objective information about CCUS and its applications. Please see Appendix B: Oversight Group membership and Appendix C for the full membership list and the Terms of Reference for the group. The Oversight Group commented on the design of the dialogue. Final decisions on the approach and content of the dialogue were made by BEIS.

1.3.3 Dialogue workshops and impact of COVID-19

The original design of the public dialogue process was for all deliberations to take place face-to-face in venues across the UK in March and April 2020. Due to the COVID-19 pandemic, we were unable to conduct the sessions as planned. The dialogue was redesigned and delivered fully online.

We identified a risk that some people may be excluded from an online process because of a lack of access to or confidence in using digital tools. Support was therefore provided to participants before and

[14] https://sciencewise.org.uk/about-sciencewise/our-guiding-principles/
[15] Sciencewise & Department for Business, Energy & Industrial Strategy: The Government's Approach to Public Dialogue on Science and Technology

during the dialogue to ensure everyone felt comfortable using the technology. More details on digital inclusion can be found in Appendix E: Demographics and recruitment.

Redesigning the public dialogue to take place online also presented new opportunities and made it easier to facilitate certain elements. The online approach meant that specialists were able to attend both sessions in an evening and, as such, participants in all locations had access to the same specialists. This would have been more difficult in a face-to-face setting because of travel and time constraints. We were easily able to bring participants from different locations together for the last session of the dialogue. Finally, this was a more environmentally friendly exercise, with no travel required at any point.

Face-to-face deliberative processes typically run over two or more full day sessions. This was not practical with participants joining from their homes and working online so we split the dialogue into a series of seven shorter (90 minute) sessions.

A range of techniques were used to engage participants, through synchronous activities, whereby all participants take part in a session at the same time, and asynchronous activities, whereby participants are able to complete the tasks in their own time over a three- or four-day period. To deliver the synchronous sessions we used Zoom, the cloud-based video conferencing service.

To deliver the asynchronous activities we used Recollective, an online research platform which enabled the collection of qualitative and quantitative data through tasks and activities.

The dialogue took place between 1 October - 10 November 2020. Across the seven weeks of the dialogue, we engaged participants in four-weekly cycles of events and activities. These will be referred to as Weeks 1, 2, 3 and 4.

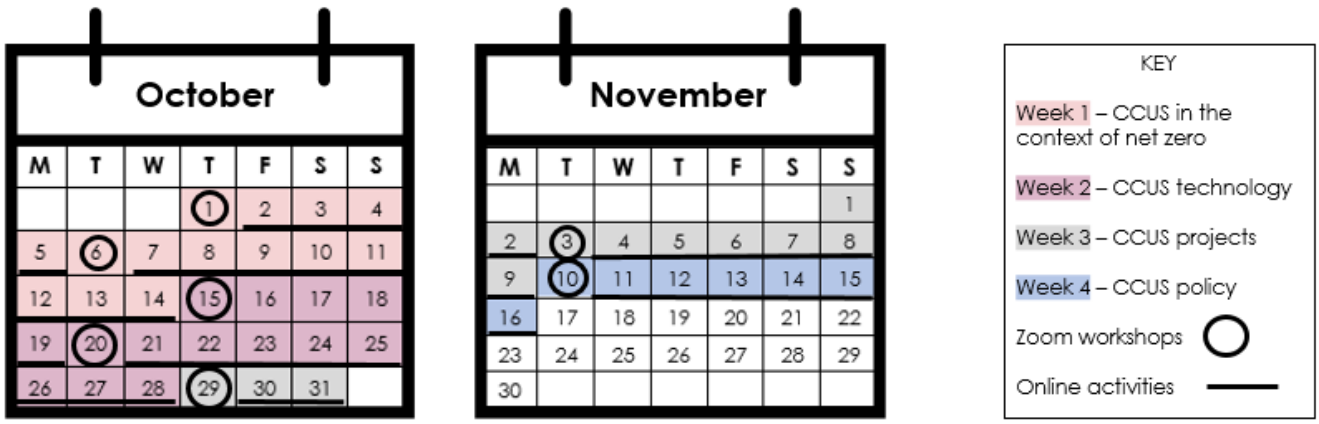


Figure 1. Dialogue calendar from 1 October - 16 November 2020

Each week followed the same format. Session one enabled participants to learn about the topic for the week; this was followed by reflective individual activities on Recollective and, in session two, deliberation in small groups. A number of specialists also attended the sessions. They answered questions put forward to them during the session or submitted ahead of the session via the online platform.

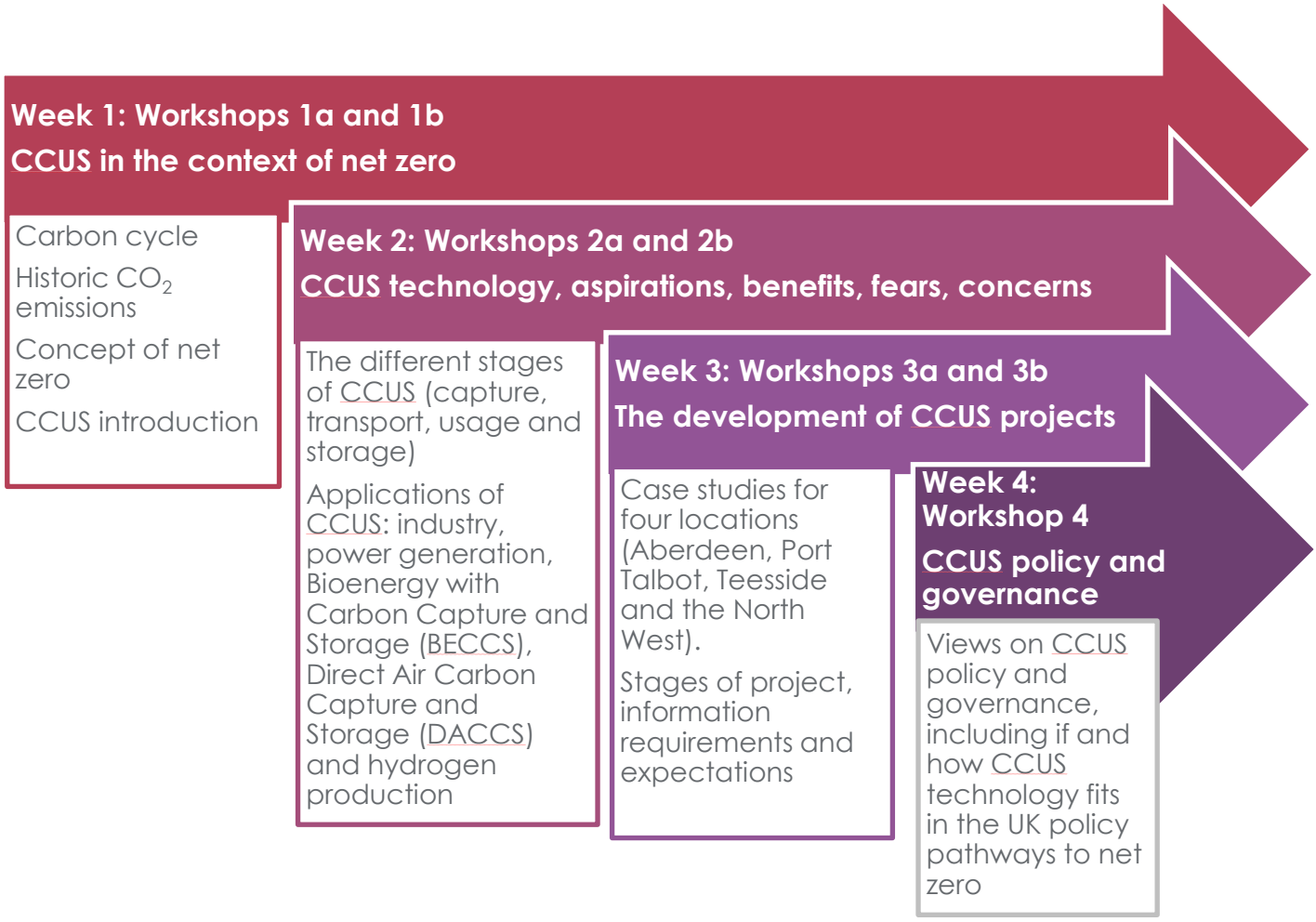


Figure 2. Breakdown of topics covered by participants throughout the 4-week dialogue

More detail on the dialogue process and activities can be found in Appendix F: Dialogue process and activities.

1.3.4 Workshop participants

Members of the public

We recruited 112 members of the public from England, Scotland, and Wales.

These participants were recruited from the following locations, and surrounding areas:

- Aberdeen
- Port Talbot
- Liverpool
- Teesside/North East[16]
- Nottingham

The first four of these locations were chosen to engage with participants from areas in, or close to, regions that may implement a range of CCUS applications[17]. These areas have the following characteristics:

Figure 3. History of industry in four potential CCUS locations

These locations also ensured representation from members of the public from England, Scotland, and Wales, in order to gain as much of a UK-wide perspective on CCUS as possible.

Nottingham was selected to understand how people who do not live near a potential CCUS cluster viewed CCUS and its applications. It was also chosen due to its diverse population.

The sample for each location was reflective of the local area and the total sample was broadly reflective of the UK as a whole.

Over the course of the dialogue not all 112 participants took part in all sessions and all activities. The vast majority of participants, however,

[16] We gradually expanded recruitment to the area surrounding Middlesbrough in order to achieve all the demographic quotas.
[17] The Humber was not selected because sufficient applications (CCUS for industrial use, CCUS for hydrogen production) existed in other clusters.

attended all of the sessions and completed all of the activities. Please see Appendix E for more detail about recruitment, demographics and attendance.

Specialists

Specialists recruited by Traverse, in collaboration with BEIS, attended workshops throughout the dialogue and joined breakout groups where they answered participants' questions. We took care to ensure a mix of specialisms and viewpoints on CCUS. In an evidence review conducted to help develop the dialogue process and materials[18], we interviewed several specialists who were of the opinion that CCUS was not a requirement to achieve net zero. These interviews also helped inform the materials and process. We were not able, however, to recruit any of these specialists to attend the sessions with participants. For a full list of specialists involved in the workshops, please see Appendix D.

1.4 Interpretation of findings

Public dialogues are an effective method to engage the public with complex policy issues in a meaningful and informed way. However, when interpreting the findings, it is important to bear in mind the potential limitations of the approach and how these have been mitigated.

The number of participants (112) and the qualitative approach taken mean that findings are illustrative of views held by the public and are not intended to be statistically representative. Deliberative methodologies are used to generate depth of insight rather than generalisable statistics.

- The recruitment process (see Appendix E) needed to be carefully managed to ensure participants with a broad range of views are included (people interested in a particular topic are more likely to want to attend). We intentionally did not provide much upfront information about the exact content of the dialogue and provided financial incentives to encourage participation in all the sessions and homework activities. We used quotas on age, gender, ethnicity, socio-economic grade, and rural/urban location. To ensure we recruited people with a range of opinions, the recruitment screener included questions to gauge participants' awareness of CCUS as a concept and their attitudes towards climate change. Although quotas were not set on this basis, attitudes were broadly in line with

[18] Please see Appendix F for more details

the general public as a whole.[19]

- Stimulus materials, specialists and activities influence participant views. This is both a strength and potential limitation of dialogue approaches because of their ability to shape opinions. The Oversight Group scrutinised all materials to check these were accurate and fair.
- We have not performed statistical analysis on sub-groups due to small sample sizes within each of them. Where we have found indicative differences between locations, these are highlighted in the report. Differences between locations should not be interpreted as geographical patterns, as they could be attributed to other variables, such as differing local samples, or location specific experiences.
- Throughout the report, we use the terms 'most', 'many', 'some' and 'a few' to give an indication of the weight of opinion. 'Most' or 'many' indicates where a clear majority of participants shared a similar view, 'some' a minority of participants and 'a few' a small number of participants. As this is qualitative data, these terms are indicative only and cannot be generalised to the wider population.
- As with all research, this report is a snapshot in time. People's views (both positive and negative) may change significantly in the future, particularly given the potential for advancements in the technologies under consideration. It will be important to refresh this work as CCUS applications develop.

1.5 Finding your way round this report

Findings are reported thematically looking at the outputs of the discussions across all sessions and across all research questions. Our analysis identified four overarching themes – feasibility (Chapter 4), safety (Chapter 5), deployment (Chapter 6) and the role of CCUS on the pathway to net zero (Chapter 7).

Summaries are presented at the start of chapters in blocks such as this.

[19] We used the BEIS Public Attitudes Tracker survey for this comparison. For more details of the questions asked in recruitment and the responses given, and how these compared with public attitudes overall, please see Appendix E.

Criteria

During the dialogue, participants were asked to develop criteria the Government should consider for the implementation of CCUS. Findings on criteria are included throughout the report in purple blocks such as this. A full list of the criteria generated can be found in Chapter 3.

Verbatim quotes *are used throughout the report to illustrate points, not replace narrative.*

2. Initial attitudes to CCUS and the wider context

Summary

- Before the dialogue, awareness of Carbon Capture and Storage was generally low.
- Almost all participants were concerned about climate change and most thought it is caused by human activity to some extent.
- In the first week of the dialogue, participants had many questions and concerns about CCUS, particularly on how safe it is, how and whether it would work, its environmental impacts and how much it would cost.
- In the first week, most participants thought that CCUS could potentially play a part on the pathway to net zero, in combination with other solutions. A few were opposed or too uncertain to have firm views.
- Participants were typically more comfortable with the idea of CCUS being deployed nationally than they were about the idea of having it near where they live. They raised concerns about the potential risks (economic and environmental) and were not convinced by the potential benefits.
- In terms of the wider context, the model of place identity suggests that emotional or affective responses to proposed infrastructure can be as influential as rational arguments about benefits and impacts. The creation or safeguarding of jobs, regional identity and a scepticism that promises made would be broken were important factors in Aberdeen, Liverpool, Port Talbot and Teesside. Participants in Nottingham did not focus on these issues.

This chapter examines participants' initial awareness of and attitudes to CCUS and the wider context including their attitudes towards climate change, and the factors in each location which shaped perceptions. It also includes views participants expressed and questions they raised in Week 1 of the dialogue, and participants' initial views on the role that CCUS should play in a pathway to net zero.

2.1 Initial attitudes to CCUS and climate change

2.1.1 Awareness of and attitudes to CCUS

All participants answered initial questions about CCUS and climate change when they were recruited to take part in the dialogue. This allowed us to establish their views on a small number of key areas before they attended any of the sessions or completed any of the asynchronous activities between Zoom sessions.

In total, 33 participants had some awareness about carbon capture and storage.[20] Another 39 had heard of it but didn't know what it was and 40 had never heard of carbon capture and storage.

Participants with some awareness of carbon capture and storage were broadly supportive (11) or undecided (20). Two participants opposed it. These attitudes were broadly in line with the general public as a whole[21].

2.1.2 Attitudes to climate change

Almost all participants said they were concerned about climate change, or global warming. A small minority said they were not concerned (6) or unsure (2). All participants (bar one who was undecided) felt that climate change is, to some extent, caused by human activity or, at least, not entirely by natural processes. Participants from Liverpool were more likely to think that climate change is mainly due to natural processes.

2.1.3 Questions raised at the start of dialogue

In the first week of the dialogue, the concept of net zero was discussed and participants were introduced to the concept of CCUS. Participants were given the opportunity to interact with and ask questions of a group of specialists.

Participants had queries and concerns about CCUS in four broad areas:

- Safety
- Cost
- Feasibility
- Environmental impact

Participants also raised wider points around the causes of climate

[20] We asked about 'carbon capture and storage' to replicate the wording used in the BEIS Public Attitudes Tracker survey. For more details of the questions asked in recruitment and the responses given, please see Appendix E.
[21] BEIS Public Attitudes Tracker: Wave 33 (www.gov.uk/government/statistics/beis-public-attitudes-tracker-wave-33). Please see Appendix E for more details of the survey findings.

change and possible alternative solutions to CCUS.

Safety

Safety was a major focus for participants in the first week in the dialogue. Participants wanted to know what the risks were and whether CCUS is a safe process. Participants framed safety not only in general terms but also specifically in terms of leakage and the possible impact on human and marine life as well as ecosystems more widely.

Participants drew comparisons with oil rigs (which they generally considered safe, but said that oil spills do happen), fracking (some participants said this could cause earthquakes) and nuclear waste (which some participants said risks contamination in the longer term). They queried whether the seabed and rock could withstand the pressure of stored CO_2. Participants also asked questions about who will monitor the process (and how) for long term safety.

> *"We need to know in detail why it's safe, what accidents can occur and how they were going to address those."*
>
> *Nottingham participant, Week 1*

For a detailed discussion of issues around safety throughout the dialogue, please see Chapter 5.

Feasibility

In the early stages of the dialogue, participants had many questions about how CCUS would work. They wanted to know how CO_2 would be captured and stored, and how it would be compressed, transported to storage and injected into the rock. Participants asked about the infrastructure needed (both type and scale), what pipes would be made of, how they would be put in place and where CCUS locations would be. Participants also raised questions around the need for drilling (which some associated with risk of earthquakes).

Participants also had broader questions about the scale of CCUS implementation, the time it would take to implement and the overall capacity the UK has for storage of CO_2.

For a detailed discussion of issues around feasibility, please refer to Chapter 4.

Cost

Participants wanted to know how much CCUS would cost, both in absolute terms and whether the costs justified the benefits. Participants

also questioned the cost in comparison to current processes of, for instance, electricity generation and how much more it would cost to add CCUS to the process.

For a detailed discussion of issues around cost, please refer to Chapter 4.

Environmental impact

From early on in the dialogue process, participants referred to the environment and environmental factors when considering CCUS. It is important to establish clearly what participants meant by this, as they often made general references to "the environment", or "environmental impacts".

When talking about the environment and referring to environmental impacts of CCUS, participants focused on both their own surroundings or conditions they live in (i.e. the physical, local environment) and the natural environment, which included things like wildlife, trees and marine life.

In terms of the local environment, participants asked questions about the visual impact of CCUS on the landscape, specifically with regards to laying pipelines in rural areas, and also potential impacts of construction (air pollution from vehicles and noise pollution) of CCUS projects.

Participants also asked questions that focused on the potential impact of CCUS on the wider natural environment, and damage to ecosystems.

For a detailed discussion of environmental concerns in the deployment of CCUS, please refer to Chapter 6.

2.2 CCUS and nature

From the first week and throughout the dialogue, participants juxtaposed CCUS with nature, "natural ways" or "natural solutions". There is evidence that courses of action which are described as natural are seen as more desirable than those defined as unnatural.[22] This attitude was widely observed during the dialogue.

Sometimes participants drew explicit comparisons between CCUS and nature, describing it as "unnatural." These participants were generally very opposed to CCUS, and by framing it as "unnatural" expressed their strong feelings that CCUS is undesirable.

[22] Bellamy, R., & Osaka, S. (2020). Unnatural climate solutions?. *Nature Climate Change*, *10*(2), 98-99.

2.3 The role of location, identity and a sense of place

Acceptance of new technology, particularly around energy generation, can be shaped by a sense of place. The model of place identity suggests that opposition to new developments is partially explained by a sense of disruption; where infrastructure would change the nature of the place in which people live by extension it could also challenge their sense of self. This suggests that emotional or affective responses to proposed infrastructure can be as influential as rational arguments about benefits and impacts.[23]

In Chapter 6, we will explore how local attitudes and sense of place framed participants' attitudes to CCUS over the course of the dialogue, but we summarise here the key factors shaping views in each location.

2.3.1 Aberdeen

Participants in Aberdeen displayed a sense of pride in the oil and gas expertise and skills that the city has. At the same time, there was a recognition that this industry is shrinking in favour of the renewable energy sector. This backdrop played a role in participants' initial responses to CCUS. They identified CCUS as a potential route to maintaining existing job opportunities and skills. Some participants also thought that being able to use existing infrastructure was a compelling argument in favour of CCUS.

> *"Oil in Aberdeen is in the decline and any new developments using the existing infrastructure would be a big plus."*
>
> *Aberdeen participant, Recollective comment, Week 2*

2.3.2 Liverpool

Participants in Liverpool felt the area had been historically left behind and needed jobs. The location of the proposed CCUS project presented as a case study (which is located outside of Liverpool in Ellesmere Port on the south side of the River Mersey) made some participants doubt if it would benefit people from Liverpool. Participants stated that promises about future jobs had often been made to the city of Liverpool and its residents, but that opportunities

[23] See for example Devine-Wright, P. (2011). Place attachment and public acceptance of renewable energy: A tidal energy case study. *Journal of Environmental Psychology*, *31*(4), 336-343 and Manzo, L. C., & Devine-Wright, P. (Eds.). (2020). *Place attachment: Advances in theory, methods and applications*. Routledge.

inevitably benefited other areas.

> *"In Liverpool, we've seen it all before. They promise jobs. This "powerhouse" we don't see it in Liverpool."*
>
> *Liverpool participant, Week 3*

2.3.3 Port Talbot

Participants in Port Talbot regularly mentioned the steelworks, which had been part of the area for over 100 years. As in Aberdeen, participants regarded the industry as in decline, with employment significantly lower than during the peak years and people continuing to be "laid off". They also thought CCUS could be a potential solution to save the industry and jobs, and potentially create new jobs. Some participants in Port Talbot felt the region had been ignored by the UK government.

> *"The steel industry is suffering; they might end production which might be devastating for Port Talbot."*
>
> *Port Talbot participant, Week 2*

2.3.4 Teesside/North East

In Teesside, participants displayed a strong sense that the area and wider region of the North East needed jobs and a new industry. Participants referred to the chemical industry in the area which, while still active, has seen a shift away from large scale chemical companies producing bulk chemicals, to small specialist companies producing high-value chemicals[24], and thereby reducing the number of jobs available. The idea that CCUS could result in the region being a leader in the technology and Teesside "getting our identity back" gave participants a sense of hope and optimism.

As in Liverpool, participants in Teesside felt that the area has been promised jobs and industry in the past, but these had either failed to materialise, were short-lived or did not lead to reinvestment in Teesside – instead going to other areas.

[24]https://static1.squarespace.com/static/5a941e5d4eddec67427063cc/t/5c5afc1fc830258ffda8af28/1549466921189/HG_Industrial+Heritage_v2.pdf

> *"In the North East jobs are hard to come by, so jobs are very important. Before, we've had quick fixes that don't last."*
>
> *Teesside participant, Week 3*

2.3.5 Nottingham

Nottingham was selected as a location to understand how people who do not live near a potential CCUS cluster viewed CCUS and its applications.

In Nottingham participants did not see CCUS in terms of specific local benefits (particularly jobs) or risks, as we saw in other areas. However, in more general terms, views on CCUS were similar to other locations, with the broad range of reactions in Nottingham reflecting what we found elsewhere. The views of participants from Nottingham in comparison to other locations are discussed in Section 6.6.

2.4 CCUS as part of a pathway to net zero

In the first week of the dialogue, after the first workshop, participants completed a task on the online platform Recollective.[25]

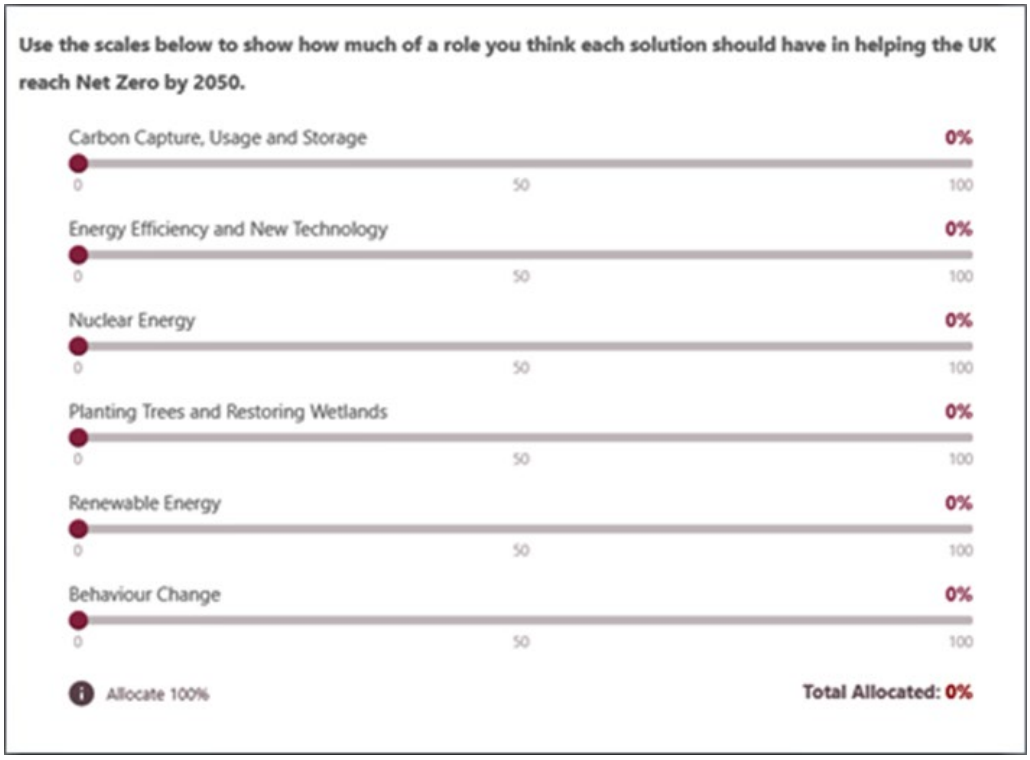


Figure 4. Screenshot from the online platform Recollective that was used by participants

Participants were asked how much of a role they felt CCUS, and a

[25] Please see Appendix F for more detail on the dialogue process and activities

number of other solutions, should have in helping the UK reach net zero by 2050. To this end, participants allocated a proportion (out of 100%) to each of the six solutions presented to them. In addition to CCUS, participants considered:

- Renewable energy
- Planting trees and restoring wetlands
- Energy efficiency and new technology
- Nuclear energy
- Behaviour change

This task was used to help understand how participant views evolved over the course of the dialogue. It is important to note that, while this process resulted in quantitative data, these should only be used as broad indications of how people felt.

Initially, most participants chose a combination of solutions to form their pathway to net zero. They allocated, on average, 24% to renewable energy as part of a pathway to net zero and 18% each to planting trees and restoring wetlands, and energy efficiency. Participants allocated CCUS 17% and behaviour change 16%. Nuclear energy received 7%.

Two themes became clear in the first deliberations about the pathway to net zero. Firstly, participants favoured solutions that they regarded as effective in reaching net zero.

> *"For CCUS I don't know much about it, but I don't think it will make a huge change to reaching net zero."*
>
> *Aberdeen participant, Week 1*

Secondly, participants felt it was best to have a range of solutions alongside each other, on the basis that having more than one strategy in place would spread the risk.

These issues are discussed in more detail in Chapter 7.

2.5 Levels of comfort with CCUS deployment

At the end of Week 1, participants were asked, on Recollective, how comfortable they felt about CCUS being deployed in the UK generally and in their local area.

2.5.1 CCUS deployment generally in the UK

Out of 94 participants responding to the question, 60 said that they were comfortable or very comfortable. Only nine indicated that they

were uncomfortable or very uncomfortable. The remainder were undecided.

The majority were generally comfortable with UK deployment, although raised several caveats about safety, cost and feasibility. Some expressed the view that, as a society, we should be doing everything we can to tackle climate change, and a few said they felt confident that implementing CCUS would substantially contribute to achieving net zero.

Participants who felt uncomfortable raised concerns about safety, negative environmental impacts and costs and a couple argued that other solutions such as renewable energy were preferable.

2.5.2 CCUS deployment locally

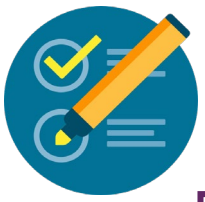
Participants displayed lower levels of comfort when asked about CCUS deployment in their local area. Out of 94 participants responding to the question, 47 said that they were comfortable or very comfortable while 16 indicated that they were uncomfortable or very uncomfortable.

The lower level of comfort with CCUS being deployed locally was largely driven by perceived risks and uncertainty over the benefits it would bring to the area – both economically and with regards to the local environment. These issues are explored in more detail in Chapter 6.

The main reason for supporting the use of CCUS at a local level was the local job opportunities it would create. Some participants felt it was important to consider the importance of CCUS in a global context, rather than rejecting it based on its potential negative impacts on a local area.

Views on the economic and environmental risks and benefits of CCUS at a local level are explored in detail in Chapter 6.

3. Criteria for implementation of CCUS developed by participants



During the dialogue, participants were asked to develop criteria the Government should consider for the implementation of CCUS. An overview of these criteria, and which chapter they relate to, is shown below:

Cost and timeliness

- CCUS technology needs to be cost-effective, with its costs weighed against how much of a contribution it can make in reaching net zero.
- There should be transparency about how much CCUS costs and how it is being funded.
- CCUS technology must be implemented in time to contribute to reaching net zero in 2050 but without compromising safety.
- Please refer to Chapter 4

Safety

- Safety was the most important criterion for participants as they evaluated the potential of CCUS to be deployed in the UK as part of the pathway to net zero. Support for CCUS was explicitly predicated on it being safe.
- The entire CCUS process (including decommissioning) must be safe, and safety features explicitly and accessibly communicated, supported by a strong evidence base.
- Please refer to Chapter 5

Pathway to net zero

- CCUS should be implemented alongside other measures as part of a pathway to net zero.
- CCUS should only be implemented if it is guaranteed (and can be demonstrated) to make a significant contribution to achieving net zero by 2050.
- The costs of CCUS must also be considered and there is a trade-off between cost and effectiveness.
- CCUS needs to be implemented in time to reach the goal of net zero by 2050.
- Please refer to Chapter 7

Local engagement

- Local communities need to be meaningfully engaged with decision making about CCUS projects and provided with transparent and easy to understand information which clearly sets out both the benefits and risks of CCUS projects.
- Please refer to Chapter 8

Deployment of CCUS projects

- There should be independent oversight and regulation of all stages of CCUS projects which ensures safety standards are upheld and wildlife is protected.
- There needs to be transparency in the funding and procurement of CCUS projects.
- Contracts for CCUS work should be awarded following an open and transparent tender process, with a clear method of identifying the best option. Contractors delivering CCUS should have a demonstrable track record as a reputable and ethical company. Preference should be given to UK-owned companies.
- Throughout the lifetime of a CCUS project, from construction to decommissioning, it should be sensitive to local residents and disruption should be minimised, particularly in the construction phase. Damage to wildlife and the natural environment should be limited.
- CCUS projects should clearly deliver benefits for local communities, particularly in terms of job creation. Jobs should be locally sourced in both the construction, operation and decommissioning stages. Jobs should be sustainable where possible. If jobs are lost as a result of CCUS projects, people should be given the opportunity for reskilling to benefit from jobs created by CCUS.
- Please refer to Chapter 6

Figure 5 Overview of participant generated criteria for the deployment of CCUS

4 Perceptions of the feasibility of CCUS

Summary

- Participants wanted to know how CCUS works and whether it would be effective in reducing CO_2 emissions.
- As a new technology, participants did not find CCUS intuitively easy to understand. Distinct examples grounded in tangible and local contexts helped people assess its efficacy as a strategy for reaching net zero. In evaluating the efficacy of CCUS, some participants found it helpful to hear that Norway has been storing CO_2 for over 20 years and how much offshore CO_2 storage capacity the UK potentially has.
- Participants' reactions to the CCUS applications and technologies they learned about in the dialogue were shaped by views on their efficacy in reducing CO_2 emissions and their potential cost. In addition:
    - Participants had differing views on whether high-emitting industries should decarbonise or continue operating as they do now.
    - Participants raised concerns about the carbon footprint required in using CCUS for power generation.
    - When discussing CCUS being used in the production of hydrogen as a low-carbon fuel, participants focused on hydrogen itself as a fuel rather than the role of CCUS. Some participants saw it as a cleaner form of energy, but many participants were concerned about its safety.
    - Participants were uncomfortable with BECCS where they perceived that the biomass used would be trees, as this seemed counter-intuitive in tackling climate change. They also felt the process is complicated. They found DACCS easier to understand but were concerned it was unproven at scale. Participants' views on CCUS as a solution to reaching net zero were not impacted by learning about these two technologies.

This chapter explores participant perceptions of the feasibility of CCUS, within the context of its role in the pathway to net zero. First, we explore what helped participants evaluate the efficacy of the technology. It is important to note here that CCUS is a developing technology, with no obvious parallels to existing technologies to help ground understanding. Second, we look at their views on its feasibility:

would it be prohibitively expensive and what contribution could it make to reaching net zero? Finally, we look at a range of CCUS applications and technologies, and the extent to which these influenced participants' views on the role of CCUS in the pathway to net zero.

4.1 Understanding the efficacy of CCUS technology

As discussed in Chapter 2, in the early stages of the dialogue participants had many questions about how the technology would actually work. A few participants described themselves as "puzzled" and found it difficult to grasp what CCUS is and how it operates.

There were four strategies that helped support participants to evaluate CCUS as an effective technology:

1) Examples of where CCUS has been deployed previously

When participants were introduced to the initial information about CCUS, attending specialists referenced that CCUS has been taking place in Norway for over 20 years. Some participants said they were reassured by the fact the technology had been tried and tested in Norway, while others wanted to know how the technology had been used there and what the experience was.

> *"We need to know more about the how and the where in the coming weeks. I heard this has been happening in Norway. Surely it must be OK then?"*
>
> *Port Talbot participant, Week 1*

2) Scale of potential storage capacity in the UK

Some participants found that having a sense of the scale of the UK's storage capacity was helpful in assessing the efficacy of CCUS. This was explained by specialists in terms of how many years of emissions could be stored, as well as the UK having the potential to store carbon captured in other countries. Participants' views on whether or not the UK's storage capacity should be utilised by other countries are explored later in this chapter (Section 4.4).

3) Visualising CCUS in a local area

Some participants said that being able to visualise how CCUS would actually work – and sometimes for participants local to a proposed CCUS site, imagining where it would go in their area – was a turning point in being able to evaluate it.

> *"If I'd have read this earlier on, I probably wouldn't have understood the importance of having the CCUS near to where the CO_2 was captured, but I think in learning about the transportation, that's probably more important now, because I'm more aware of how that happens."*
>
> *Liverpool participant, Week 4*

It is clear that, conceptually, CCUS is not an intuitive subject to understand. Distinct examples grounded in tangible, and ideally local, contexts are important to help people shape their views on the technology and assess its efficacy as a strategy for reaching net zero.

4) Learning about how CCUS works

As we would expect, learning more about CCUS influenced participants' perceptions of how and whether CCUS would work. When reflecting on the dialogue, a few participants commented that they had initially found CCUS a "frightening" concept but hearing more about it had changed their feelings about it.

> *"I was way against, it sounded horrendous…. I didn't have a clue what it was. The first session was frightening, piped into the ground and put into beds in the sea. Over the last few weeks I have learnt more about it, there has been a lot of research done. I agree there should be some part of the net zero challenge to be directed with CCUS."*
>
> *Teesside participant, Week 4*

Other participants commented that CCUS did not initially seem like "a real thing" but it had been brought to life for them over the dialogue.

> *"I didn't think it was a thing at first, I thought it was a project that just stays in development. But week after week it came across as something that will actually happen."*
>
> *Liverpool participant, Week 4*

There were a few participants who ended the dialogue feeling that there are no guarantees that CCUS would work, describing it as "experimental" or "untested". One participant cited studies they had

found in their own research outside the dialogue that questioned the efficacy of the technology.

> *"From some of the research I've been reading on CCUS – around studies in fuel plants in America within the last few years – it's not been hugely efficient at removing carbon dioxide. I think that it went down in one study from between 80 and 90 percent to about 50% and so it's not efficient from what I can see."*
>
> *Port Talbot participant, Week 4*

For some participants, how effective CCUS would be was a fundamental question that was not fully answered. In addition, participants' perceptions of the efficacy of CCUS in terms of reducing CO_2 emissions in the context of net zero and other potential solutions strongly influenced their views on what role it should play on the pathway.

4.2 Financial feasibility

Throughout the dialogue, participants raised queries and concerns about how much CCUS would cost. These questions were driven by a desire to assess whether CCUS is a financially viable and affordable option.

> *"The cost can't be prohibitive. Can't put something in place that's going to cost so much money that it's not going to be feasible."*
>
> *Nottingham participant, Week 2*

Some participants said that CCUS must be "affordable" or "low cost." Others talked more in terms of weighing costs against benefits, in particular considering how effective CCUS is in reducing CO_2 emissions. Participants wanted to avoid wasted expenditure on "white elephants" if CCUS is not an effective or long-term solution.

Another issue which a few participants raised was the opportunity cost of any CCUS expenditure. In the context of reaching net zero, these participants wanted to know that money is being spent effectively. In particular, participants argued that CCUS should not take away investment from renewable energy development.

> *"This is good in principle but opportunity costs, and by doing this we'd be taking away things from other sources of renewable energy that would be more friendly to the atmosphere. Is this the best use of our resources?"*
>
> *Aberdeen participant, Week 2*

Further questions about costs broadened out to include who would fund CCUS projects and who might profit (delivery and funding is discussed in Section 6.1). In Week 4, some participants expressed frustration that they still did not know how much CCUS would cost. Participants wanted transparency about how much CCUS would cost and how it would be funded.

> *"What it would cost, that should be public knowledge, all that information about where funding would come from and what it will cost the taxpayer."*
>
> *Teesside participant, Week 4*

4.3 Timescales

Participants felt that another key consideration was when CCUS would be able to contribute to reducing the UK's CO_2 emissions. Many felt if CCUS was going to be used, it would have to be implemented as soon as possible.

There were two elements to this view. Firstly, participants thought that CCUS should contribute to reducing CO_2 emissions as quickly as possible. A few participants directly linked the urgency of the climate crisis with the need to implement CCUS technology immediately.

Secondly, some participants assumed that CCUS would take some time to implement. They were concerned that the technology could not be installed in the timeframe needed to materially contribute to the reduction of CO_2. A few felt a particular sense of urgency because of the UK's track record on delivering major infrastructure projects.

> *"The target is 2050, it should be in place 10 years before, so that only gives us 20 years, we don't have a record of doing things quickly in this country. It's imperative to get on with it."*
>
> *Teesside participant, Week 2*

Participants who thought CCUS could reduce emissions quickly and/or

more quickly than other solutions, tended to think it should be a significant contributor to the pathway to net zero.

As participants moved towards determining their criteria for implementation of CCUS in the UK, timescales were an important consideration. If CCUS was not able to deliver in time, participants thought that other approaches should be considered.

> *"I have 'timescale' written down, they need to know it's got to be fast enough to reach the targets that are set."*
>
> *Port Talbot participant, Week 4*

Some participants were concerned that a focus on speed could put the safe construction and operation of CCUS at risk. Participants regarded safety as trumping timeliness.

> *"We were talking about rather trading off the time and cost for it to be more safe and sustainable. Safety and sustainability are more important than speed and cheapness."*
>
> *Teesside participant, Week 4*

A few participants expressed concerns that CCUS technology may become outdated in the years ahead, which would mean the money spent on it would be wasted.

> *"We'll be spending so much money on the infrastructure but in twenty years' time there might be another technology that's more effective and means we don't have to produce as much carbon, and we'll have put that money to waste."*
>
> *Liverpool participant, Week 4*

The other element to timescales was for how long CCUS should be part of the pathway to reaching net zero. Some participants viewed it as a stop gap solution, buying time to develop cleaner solutions such as renewables and to stop CO_2 emissions altogether.

4.4 CCUS usage, technology and applications

4.4.1 CO_2 usage and use of storage capacity

Participants considered what captured carbon could be used for and how the UK's storage capacity could be utilised.

CO_2 usage

When participants discussed the usage of CO_2 after it has been captured, they were generally supportive of the idea. Before any information was given on CO_2 usage, some participants had already identified it as a potential area of interest.

> *"I am interested in the usage of the carbon. I've no idea what it could be used for."*
>
> *Aberdeen participant, Week 1*

Potential uses of CO_2 were outlined in Week 2. The small scale of potential usage and the fact that CO_2 is again emitted after its use meant it was rarely mentioned in later weeks.

Use of storage capacity

Once participants learned about how much storage capacity the UK potentially has, the discussion moved on to how to utilise this capacity. Participants broadly had three perspectives on this issue:

- Leave the storage sites as they are – do not store any CO_2.
- Utilise the storage space for economic benefits, by storing CO_2 generated by other countries.
- Only store CO_2 generated in the UK or, for a few participants in Aberdeen, only the CO_2 generated in Scotland.

The first group of participants were against CCUS altogether and rejected the idea of CO_2 being stored at all.

Some participants who felt that the sites should only be used for UK-generated CO_2 were concerned that the more CO_2 is stored, the greater the risks would be. There was also a perception of fairness at play, with a few participants saying it would not be fair to store CO_2 which had not been generated in the UK. Some participants were concerned that the UK would be taking on the risks of other countries, potentially becoming a "dumping ground."

> *"Once it is developed, they intend to import the carbon from other countries – does that make the UK a dumping ground?"*
>
> *Port Talbot participant, Week 4*

Some participants in Aberdeen viewed this issue through a Scottish lens. In part, they framed this as a point of national pride, as Scotland

has a more ambitious net zero target, more renewable energy generation and lower CO_2 emissions than England[26]. Despite the storage sites being hundreds of metres below sea level, they were concerned that this progress could be undone by an event that leaks large amounts of CO_2 into the atmosphere, impacting Scotland's CO_2 emissions.

The third group of participants felt there were clear economic benefits to storing CO_2 generated from other countries and that the amount of storage capacity the UK had was a clear competitive advantage.

> *"Perhaps we could charge for other countries to bring their carbon – we've got so much space. More than enough for our own…, perhaps put a levy on letting other folk use the storage."*
>
> *Aberdeen participant, Week 4*

There was, therefore, no clear consensus on how to utilise this capacity, and the extent to which the UK should develop CCUS as an industry in its own right.

For these participants, concerns regarding safety, and also the extent to which CCUS could disincentivise decarbonisation efforts, would need to be addressed before considering storing CO_2 from other countries.

4.4.2 CCUS applications

In Week 2 of the dialogue, participants learned about how CCUS could be applied to the following sectors: industry, power and blue hydrogen production.

Industrial CCUS

Participants were shown a brief outline of the process of the industrial application of CCUS. They were shown an example in the case study for Port Talbot later in the dialogue (please see Chapter 6 for more details).

Views on the industrial application of CCUS can broadly be split into two:

- Participants who were concerned that CCUS could support high emitting industries that should not have a role in a decarbonising future.
- Participants who felt CCUS could be used to decarbonise currently

[26] The Climate Change Act 2019 commits Scotland to net-zero emissions of all greenhouse gases by 2045. For more information: www.gov.scot/news/reaching-net-zero-1.

very high emitting industries to reach net zero by 2050 without creating mass unemployment.

These views were present in all the locations. One regional difference was the steel industry in Port Talbot, with some participants asking how CCUS would apply to the steelworks. Other participants from Port Talbot were concerned that CCUS could lead to additional operating costs which could result in the industry collapsing (this is explored in more detail in Section 6.5.4).

Some participants were concerned about the waste generated in the CCUS process and what happens with it. Participants wanted steps to be taken to ensure it is not dangerous to the environment.

> *"What happens to that solution then? Is that yet more waste? Or is it reusable in that process?"*
>
> *Liverpool participant, Week 2*

Participants continued to question what would happen with the waste product throughout the dialogue, although this was not specifically linked to industrial use of CCUS.

Participants' views on using CCUS for industrial applications were shaped by their views on decarbonisation more generally (discussed in Section 7.4 in more detail) and their views on industry itself and the jobs it provides, which were shaped by participants' specific local context (examined in Chapter 6).

Power CCUS

Participants' main question around CCUS in the generation of power focused on the efficiency of the process – specifically whether the CO_2 reduction achieved was undermined by the energy used to separate the carbon. For example, those who were more concerned or opposed to the use of CCUS pointed to the need to use energy in the capture process from power stations.

> *"When you're actually getting the CO_2 out of the solution it involves heating it. Where does that heat come from? Unless you're using heat that's already produced in the power station, it strikes me that you are using two lots of energy."*
>
> *Liverpool participant, Week 2*

As with CCUS in industrial use, some participants speculated that there would be additional knock-on effects from this process. These

participants were concerned that the inclusion of CCUS in power generation could add costs to the process, which would then be passed on to consumers.

Participants' views on CCUS being used in the generation of power were shaped by its potential efficacy in reducing CO_2 emissions. Some specifically argued in favour of using renewables to generate power.

> *"Why don't we just create less carbon dioxide? We've got loads of wind turbines in the North East round where I live - this needs to be looked at. We must be well on the way to producing lots of our power from renewables."*
>
> *Teesside participant, Week 1*

As we discuss in Section 7.7.1, where participants made direct comparisons between renewable energy and CCUS, they tended to describe renewable energy generation as greener and cleaner, or as a simpler, cheaper or more reliable manner of achieving CO_2 reductions.

Hydrogen production

Participants were shown an overview of the process for generating green hydrogen (which is made from non-fossil sources) and blue hydrogen (which is created from fossil sources and results in CO_2 emissions which are captured and stored). They were shown a potential project on blue hydrogen, as produced from CCUS, in the case study for Liverpool (examined in Section 6.5.3).

As discussed in the next chapter, some participants had concerns about the safety of using and transporting hydrogen, highlighting its flammable nature.

Some participants expressed support for hydrogen as a fuel on the basis that it is a cleaner form of energy. These participants generally preferred the concept of green hydrogen, powered by renewables, because of the smaller carbon footprint. However, they felt that the high cost of green hydrogen made blue more feasible in the short term. Some of these participants commented that hydrogen produced using CCUS is cleaner than natural gas or other fossil fuels.

Other participants were concerned about the use of fossil fuels in the process at all, which "we are supposed to be moving away from". Participants also highlighted the issue of cost.

> *"When I think of hydrogen, I think of bad things - but hearing what everyone's been saying about it being clean is reassuring. But another worry is the time period and cost. But yeah, it's definitely interesting."*
>
> *Port Talbot participant, Week 2*

Participants focused more on the use of hydrogen as a fuel rather than the role of CCUS in its production. As with CCUS, they wanted to know what the costs and benefits would be of producing blue hydrogen and what contribution this could make to reducing CO_2 emissions.

4.4.3 CCUS technologies

In Week 2, participants learned about two greenhouse gas removal technologies:

i) Bioenergy with Carbon Capture Storage (BECCS), and

ii) Direct Air Carbon Capture and Storage (DACCS)

For both BECCS and DACCS, participants expressed concern about their cost and not being proven at scale.

Bioenergy with Carbon Capture Storage (BECCS)

Participants described the BECCS process as "complicated" and raised a number of concerns. In particular, participants questioned the space and time that would be needed to cultivate the biomass if grown in the UK and the carbon footprint created by importing and transporting biomass. These participants felt that if BECCS is to be implemented, it should be done where biomass is already grown.

Participants were very uncomfortable with the possibility that BECCS may involve the burning of trees to produce bioenergy, describing it as "terrible" and "silly".

> *"Trees are planted to capture CO_2 right? So, we're planting trees to capture them, then we're going to burn them and capture that? Why don't we just leave the trees?"*
>
> *Liverpool participant, Week 2*

Some participants queried whether the net reduction in emissions would be truly achievable or even "worth the effort" if BECCS was to be implemented in the UK. A few participants also raised concerns about the ramifications on habitats and disease if monoculture tree

plantations were established to provide biomass for BECCS.

Participants who expressed support for BECCS did so on the condition that it works, is cost-effective and does not impact the development of other green technology, particularly renewables.

Direct Air Carbon Capture and Storage (DACCS)

Participants felt more comfortable with DACCS than BECCS. In comparison to BECCS, participants felt DACCS was a "smarter" way of capturing CO_2.

Participants also found DACCS easier to grasp, with one participant comparing it to a "giant Hoover." However, the simplicity of the concept led one participant to think it may be "too good to be true."

> *"I'd like to know more about the direct air capture storage - it seems less complicated. But does that mean it's going to be cost efficient? It seems too good to be true compared to the other options?"*
>
> *Teesside participant, Week 2*

Other participants were concerned that DACCS has not been proven at scale and could cost significantly more than other CCUS technologies. A couple of participants were concerned that it could potentially be powered by fossil fuels.

4.5 Cost and timeliness criteria

Participants' criteria [27]

- CCUS technology needs to be cost-effective, with its costs weighed against how much of a contribution it can make in reaching net zero.
- There should be transparency about how much CCUS costs and how it is being funded.
- CCUS technology must be implemented in time to contribute to reaching net zero in 2050 but without compromising safety.

[27] During the dialogue, participants were asked to develop criteria the Government should consider for the implementation of CCUS. A full list of the criteria generated can be found in Chapter 3.

5 Perceptions of the safety of CCUS

Summary

- Safety was a key concern for participants throughout the dialogue, and participant support for CCUS is contingent on it being safe.
- In comparison with other criteria principles (such as cost and urgency) safety was generally seen as the most important one.
- The storage of CO_2 was the most disquieting issue for participants, but they also had worries about the safety of transporting CO_2 to the seabed. Participants highlighted the risk of leaks and earthquakes, and the harm these might cause to marine life.
- By the end of the dialogue, some participants felt reassured about CCUS' overall safety, while others still had doubts. Those who were reassured drew on comparisons to existing infrastructure, international examples, and the presence of a research and evidence base to make their assessment.
- When participants were introduced to blue hydrogen production via CCUS, they focused on the safety of the hydrogen itself, rather than the process. Some thought hydrogen was dangerous to use as a fuel because of its flammability. For a few participants, their concerns about the safety of hydrogen as a fuel meant they did not support using CCUS to produce hydrogen.
- A few participants disagreed with the concept of CCUS altogether, believing it avoided the problem of producing CO_2 emissions in the first place. They raised concerns about safety from the start of the dialogue and their views tended to become more negative as the dialogue progressed.

This chapter examines the three key issues relating to safety arising in the dialogue: the storage of CO_2, its transportation and the production and use of hydrogen. Participants also brought up safety when discussing decommissioning (which is covered in Section 6.3.5). The chapter concludes with a consideration of participants' views on safety as a key criterion in the implementation of CCUS.

Participants talked about safety throughout the dialogue. The term 'safety' was used broadly, encompassing impacts on human and

marine life, as well as ecosystems more widely. Participants saw safety both in terms of sudden events and accidents (such as earthquakes or explosions) and damage which occurs over a longer term (such as leaks).

Concerns about the safety of CCUS informed participant discussions and reflections throughout the process. In our analysis, we found that, by the end of the dialogue, views on safety fell into three broad groupings. We include these groups in this report to explain how participants felt about safety. The three groups identified in our analysis were as follows:

- ***Cautiously Convinced*** – The dialogue process itself (particularly in Week 2, where CO_2 storage was discussed), and specialists' responses on specific issues, reassured participants that CCUS is safe. These participants, however, remained mindful of safety and felt it must be a key priority in the implementation of CCUS.
- ***Worried Pragmatists*** – These participants continued to have strong doubts around safety, particularly on storage. However, if it could be shown that CCUS is safe, they felt it has a place in reaching net zero.
- ***Strongly Opposed*** – These participants believed that safety cannot be guaranteed and there are too many risks involved with CCUS. This was linked to their opposition to CCUS more generally and their views on safety hardened as the dialogue progressed.

At various points, particularly in Week 4, participants considered the relative merits of different overarching criteria that had been established – cost, urgency and safety. Safety was generally the top choice in these trade-offs.

> *"Safety is the main thing. Safe storage, safe transportation"*
>
> *Liverpool participant, Week 3*

5.1 Safety of CO_2 storage

Participants' concerns about safety most often centred on the storage of CO_2 and the associated risks involved, particularly the possibility of leaks from underground offshore sites and the impact this would have on marine life.

Participants regarded storage as an unknown process. At the end of the first session, and again in the second session in Week 1, participants were shown a video explaining that CO_2 would be stored under the seabed, as part of a short introductory video on CCUS. This came as a shock to some people. A few thought injecting CO_2 under

the seabed is unnatural and therefore risky, with one participant commenting "you're playing with nature". Participants who were 'Strongly Opposed' raised these concerns throughout the dialogue.

As participants were engaging with an unfamiliar technology, safety concerns were often framed as 'what if' questions, particularly in Week 1. For instance, participants wanted to know what the impact would be of a sudden release of CO_2.

A number of participants referenced unrelated incidents which they had read about outside the dialogue. These examples made them question the safety of CCUS and a few also used them to argue that CCUS is unsafe, even though the events were not related to CCUS. One participant, for instance, mentioned in Week 1 the Lake Nyos disaster, which killed approximately 1,700 people when an eruption released a cloud of CO_2.[28] Other participants, who then researched this incident, brought it up as a concern later on in the dialogue. Similarly, another participant referenced a German town called Staufen,[29] which saw cracks appear in land and in properties when there was drilling through the water table. Participants who were strongly opposed to CCUS adopted examples given by other participants in their arguments.

Throughout the dialogue, the risk of stored CO_2 escaping was brought up by participants. A few participants expressed concern that this would make the sea "acidic" and "harm marine life". In Liverpool and Aberdeen some participants were worried about the potential knock-on effect of leaks on the fishing industry.

> *"It's never been done before, so no one knows what is going to happen. The fishing industry is quite important here. Anything leaks affecting the fish that would ruin it."*
>
> *Aberdeen participant, Week 3*

Some participants were concerned that leaks would have negative impacts, particularly on wildlife. In Week 4, some participants gave a positive response to a video where a spokesperson from WWF suggested CCUS can have a role as part of a pathway to net zero, alongside other measures. One participant said they thought that the

28 https://www.forbes.com/sites/davidbressan/2019/08/21/the-deadly-cloud-at-lake-nyos/?sh=ea9031c5dbf3

29 https://www.researchgate.net/publication/279963863_Damage_to_the_historic_town_of_Staufen_Germany_caused_by_geothermal_drillings_through_anhydrite-bearing_formations

organisation would make sure CCUS does not impact on wildlife.

Participants thought that earthquakes were another potential safety risk. There were two concerns. Firstly, injecting CO_2 into rock (the process of which was explained in a video in Week 2) could increase the likelihood of an earthquake. Some participants drew direct comparisons to fracking and its association with earthquakes. Secondly, the devastating impact an earthquake could have on stored CO_2. Participants voiced concerns about earthquakes predominantly in the first two weeks, as specialists responded to specific questions and the dialogue focused on the process to safely store CO_2.

In the final week, however, the 'Strongly Opposed' participants returned to the subject of earthquakes when explaining their concerns about CCUS, indicating they were not convinced by specialists' response on the issue.

In the Week 2 session which explicitly explored CO_2 storage, some participants became less concerned about risks after hearing from specialists how storage would be monitored and that the caprock at the top of rock formations provides an impermeable layer. In Week 2, participants were shown a video using chocolate bars as an analogy to explain differences in types of rock (porous, semi-porous and solid) and their suitability for CO_2 storage, which participants found helpful. One participant described how specialists' framing of CCUS as "putting carbon back" where it came from made them reappraise its safety.

> *"I was very sceptical about the safety of these underground storage places but when you think of it that way it feels a lot safer. Did gas escape before we drilled for it? No."*
>
> *Teesside participant, Week 2*

Elsewhere in the dialogue, participants queried what would happen to the "waste" generated by the process (see Section 4.4.2 above). This suggests that how the by-product of CCUS is dealt with shapes people's overall attitudes to the process.

Throughout the process, specialists answered queries about potential leaks from CO_2 storage sites. Comparison to existing infrastructure was a way to ground an unfamiliar technology in something that

participants were aware of and felt to be safe, like the gas pipelines used across the country. When one participant asked about the impact of an earthquake, they found it helpful to hear a specific example, from one of the specialists, of a CCUS storage test site in Japan. The site where CO_2 had been injected experienced a magnitude 6 earthquake and was unaffected[30]. Some participants answered each other's concerns by Week 4, illustrating their familiarity with and support for arguments in favour of CCUS' safety. This highlights that when people have difficulty assessing a new, still developing technology, examples of where it is being done elsewhere helps them to evaluate it.

Participants who were 'Worried Pragmatists', however, were at times sceptical about the information given to them during the dialogue and remained concerned about the risks of storing CO_2 under the seabed, asking 'what if' questions in Week 4. Both the 'Worried Pragmatists' and 'Strongly Opposed' participants cited examples of the oil industry, where leaks were described as inevitable, to explain their concerns. The other comparison these participants drew was with nuclear waste, saying that there would also be a "catastrophic" impact if something went wrong.

> *"My view on nuclear is no no no. I think it's very short sighted. Cheap clean power in the short term, but looking after the waste in the long term is a big deal. CCUS involves the same sort of storage of waste."*
>
> *Liverpool participant, Week 4*

Participants also used nuclear waste as a point of reference for CCUS when considering long-term storage safety, although it should be noted that the way nuclear waste is stored is different. Participants were concerned that CCUS could cause accidents for future generations, not only undoing the work in CO_2 reduction, but also posing a potential direct threat to the "grandchildren and great-grandchildren" of participants.

Participants also highlighted that long term storage required an ongoing commitment from the Government to safety. A few participants were concerned that safety may not be guaranteed if another government, with different priorities, was elected and oversaw the process.

[30] https://www.cslforum.org/cslf/sites/default/files/documents/Japan_CCS.pdf

> *"Who will ensure the storage sites would be kept safe? What if we had a future leader like Trump who just didn't care – who is responsible for monitoring in the really long term?"*
>
> *Port Talbot participant, Week 3*

5.2 Safety of CO_2 transport

Participants had similar safety concerns on CO_2 transport, particularly the likelihood of leaks in pipes and whether these would be identified. This was a general concern around pipes, rather than specifically focusing on offshore or onshore pipes. However, because the transport of CO_2 involved more familiar processes than storage, many participants were more comfortable with it. Notably, some participants explicitly made a connection between the transport of CO_2 and the existing gas network in the UK. This contrasted with the unfamiliarity and perceived unnaturalness of storing CO_2 under the seabed.

> *"We've always had pipelines and a lot of it is away from town centres, the technology is pretty robust, and I'm not worried about it, but burying this stuff under the sea, I'd like to see much more evidence for."*
>
> *Port Talbot participant, Week 3*

Similar to the storage of CO_2, participants wanted to know what would happen if offshore pipework leaked, and what impact this would have on marine life. While participants raised the issue of pipework leaking less often than the issue of leaking from storage, they felt it still required careful monitoring.

Some participants had questions around the life expectancy of the pipes and the risk of degradation and future leakage. While participants in Aberdeen in particular were generally positive about using existing infrastructure, a few participants expressed concern about its suitability. The fact that the pipes were designed to transport a different substance, and, in some cases, were up to 40 years old, meant that participants, again particularly in Aberdeen, wanted to be confident that they would not leak.

> *"Are the pipelines from St Fergus not up to 40 years old? Would this be safe to transport CO_2?"*
>
> *Aberdeen participant, Week 3*

Participants had far fewer worries about accidents in relation to CO_2 transportation, although when earthquakes were discussed in relation to storage, the pipe network was also mentioned by a few participants. One participant expressed concern over the vulnerability of the pipe network to a terrorist attack and the impact it could have.

Participants who were 'Cautiously Convinced' were initially concerned about the safety of the transport of CO_2 but became less concerned over the dialogue. A participant in Week 4 said their concerns were addressed by an explanation given by a specialist in an earlier week. Their question focused on the safety and maintenance of pipeline and the specialist explained that processes are in place on existing infrastructure (high pressure pipelines) that allow for continuous monitoring. Another participant, who initially doubted the safety of transporting and storing CO_2, reflected that the extent of the research that had been undertaken on the safe application of CCUS suggested to them that it was a credible option. This highlights that, for some participants, hearing about the breadth of research and evidence regarding the technology supported their evaluation of its safety.

> *"I was worried about leakage, but there's been studies in the UK looking at the effect of leakages from storage space, and it's not as bad as I thought. It's good to see that things have been done in real life and tested, and it's not all just theoretical."*
>
> *Aberdeen participant, Week 4*

5.3 Safety of hydrogen use

In Week 2, participants were shown an overview of the process for generating green or blue hydrogen. This section concentrates on perceived safety issues around the use of hydrogen as a fuel. Participants' views on using CCUS to generate hydrogen is explored in Section 4.4.2.

Participants' initial reactions focused on safety concerns of using hydrogen as a fuel, with some highlighting the flammable nature of

hydrogen and drawing associations with bombs and explosions. Participants were particularly concerned about hydrogen being used as a fuel in public and private transport. One participant commented it was far more flammable than petrol and highlighted how much worse a traffic accident would be for a vehicle powered by hydrogen.

> *"In order to use it to power a car, you'd have to liquefy it, it's flammable. So, wouldn't it be dangerous to store it in tanks and be particularly dangerous to store?"*
>
> *Liverpool participant, Week 2*

Participants described hydrogen as a high-risk option for fuel, with concerns raised about the impact an accident or explosion would have on surrounding areas.

> *"It has a frightening chill to it. You think of hydrogen and immediately you think of bombs – it's not something you can play about with. It's very high risk."*
>
> *Port Talbot participant, Week 2*

One participant talked about their personal experience of going on a tour of a hydrogen compression facility, where it was claimed an accident would have catastrophic effects on the nearby town. This was specifically cited by others in the group later in the discussion as a reason they were opposed to the use of hydrogen.

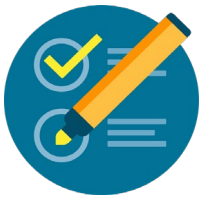
Participants who did their own research or came to the dialogue with some familiarity with hydrogen raised wider safety concerns, such as the fact hydrogen has no flame and can therefore be difficult to monitor.

Where participants looked at hydrogen through the lens of existing fuels, this could allay their fears. Participants raised the safe use of hydrogen for buses. The UK's first hydrogen bus refuelling station was opened in Aberdeen in 2015 so there was higher awareness in this location. Specialists highlighted that fuels such as petrol are also flammable. One participant wanted to compare the safety of hydrogen and gas currently used by domestic households.

> *"It would be interesting to see a comparison of safety with what we're already using."*
>
> *Nottingham participant, Week 4*

However, there were a few participants who continued to voice concerns about the safety of hydrogen as a fuel in the final week of the dialogue. In relation to plans for using CCUS technology in the production process of (blue) hydrogen, it is important to note that participants were opposed to it on the grounds of the safety of hydrogen, rather than considering it an attractive additional reason to pursue CCUS.

5.4 Safety criteria



Participants' criteria [31]

- Safety was the most important criterion for participants as they evaluated the potential of CCUS to be deployed in the UK as part of the pathway to net zero. Support for CCUS was explicitly predicated on it being safe.
- The entire CCUS process (including decommissioning) must be safe, and safety features explicitly and accessibly communicated, supported by a strong evidence base.

[31] During the dialogue, participants were asked to develop criteria the Government should consider for the implementation of CCUS. A full list of the criteria generated can be found in Chapter 3.

6 Attitudes towards the deployment of CCUS

Summary

- Participants wanted to know who will pay for CCUS projects and who will profit from them.
- Participants strongly felt that contracts for CCUS projects should be awarded openly and transparently, preferably to what participants described as ethical companies with a proven record of delivery on similar projects. Some stated a preference for UK companies to deliver CCUS projects.
- Participants thought that local CCUS projects carried a number of risks in the construction, operation and decommissioning stages:
    - Environmental risks, in particular damage to marine life and wildlife.
    - Safety risks because of leaks, accidents and sudden events.
    - Noise and disruption, particularly from traffic, during construction.
    - The loss of jobs and safety risks as a result of decommissioning.
- Participants wanted there to be oversight and regulation of all stages of CCUS projects which is independent of both government and industry. They thought there should be safeguards in place to ensure safety standards are upheld and to protect wildlife.
- Participants identified job creation as the most important potential benefit of local CCUS projects. Reactions to case studies in Aberdeen and Teesside were more positive than other locations because participants could see a clear link between the CCUS project and local jobs, which also fed into a sense of regional pride. Because of previous experiences of jobs being promised and then never materialising, many wanted assurances that CCUS projects would actually create local jobs.

This chapter explores participant views on the potential deployment of CCUS. Participants discussed CCUS case studies specific to their location as an entry point for these discussions, with the exception of Nottingham, which had been selected as a location to understand

the views of those who do not live near a potential CCUS site.

In Nottingham, participants discussed the Teesside case study because this was thought to be the case study most generalisable to an area which is not near a potential CCUS cluster.

This chapter begins by focusing on some of the overarching principles participants discussed for deployment, such as funding, awarding of contracts, and regulation, and then moves onto participant perceptions of impacts for deployment local to their area.

6.1 Funding and awarding contracts for CCUS projects

6.1.1 Funding CCUS

As we have discussed in Section 4.2, participants were concerned about how much CCUS would cost. A key question participants asked throughout the dialogue was 'who will pay?'. From early in the dialogue, participants generally assumed that infrastructure projects of this scale would have some level of government funding.

Participants used the terms 'government' and 'taxpayers' when talking about funding, with each term having slightly different connotations. Participants were more likely to use 'government' in more neutral terms to describe non-private sector funding but tended to talk about 'taxpayers' when expressing concerns about costs, with the implication that it would be the public footing the bill.

> *"It is a concern about the overall cost and who's going to foot the bill, that's a major thing. Will it be the taxpayer like everything else?"*
>
> *Aberdeen participant, Week 4*

Some participants, did however, envisage a role for industry in funding CCUS. Some participants thought that high-emitting industries have a responsibility to pay for the capture of the carbon they emit, with one participant commenting that whoever is creating CO_2 should have to pay the most. In Port Talbot, however, some participants thought it would not be financially viable for the steel industry to help fund CCUS.

As well as asking who will pay, participants wanted to know who would profit.

> *"Who will pay for it? Will taxpayers pay or will it be shared? Or will oil companies make huge profits from it?"*
>
> *Aberdeen participant, Week 4*

A few participants were concerned that businesses who they described as having created the problem, notably oil and gas companies, could profit from the solution. These participants, mostly from Liverpool and Port Talbot, were opposed to CCUS.

> *"It's coming to light now how the companies who got us into this mess are now selling us the solution – it sounds sinister."*
>
> *Port Talbot participant, Week 4*

In Port Talbot, participants discussed the feasibility of Tata Steel (the owner of Port Talbot Steelworks) funding CCUS. The local industry, so closely associated with the town, was considered by participants to be "on its knees", and a few participants feared that any additional costs could result in the steel industry having to close in Port Talbot. A project representative explained that CCUS could extend the life of the steel industry in the UK, as it looks to compete with low carbon steel produced across the world, and that the CCUS would be funded in part by government. Participants responded with cynicism, doubting that the Government, which "hasn't helped Port Talbot very much" would be willing to pay to protect the industry.

Some participants were worried that taxpayers would have to step in if projects ran out of funds or costs overran. Participants saw this as a very real risk and a number mentioned other major government projects, in particular HS2, where costs had mounted over time.

By the end of the dialogue, the majority of participants assumed that a combination of government and industry finance was the most likely way to fund CCUS projects. However, a number expressed frustration with the lack of concrete information on how much CCUS projects would cost or how they would be funded.

> *"What worries me is that people say what they want to do, but nobody mentions cost. It could end up like HS2 or Trident where it costs four times the initially quoted amount. We all want this, but we don't know what it's going to cost."*
>
> *Teesside participant, Week 4*

6.1.2 Awarding contracts for CCUS

Participants expressed strong views about the need for contracts for CCUS projects to be awarded fairly and transparently. This may have been a particular concern because the dialogue took place during a period where there was media coverage of undisclosed government contracts for Personal Protective Equipment. Participants were concerned that contracts could be awarded to companies "based on their connections" or who were "friends with politicians". This concern was particularly common with participants from Liverpool, reflecting the cynicism towards government expressed in those groups.

> *"We want to be certain that it is a fair competition process for who is awarded contracts."*
>
> *Liverpool participant, Week 3*

Participants thought that the companies which delivered CCUS projects should be ethical and have a strong track record of delivering other projects. Participants did not elaborate on what they meant by 'ethical', but this is likely to be linked to their strong desire for CCUS projects to be delivered safely without "cutting corners".

> *"You'd want to know how ethical the company was who was doing it is. The history of what they have done prior, what they've achieved before. To see if they've done a good job."*
>
> *Teesside participant, Week 2*

Throughout the dialogue, participants discussed what they saw as the benefits of CCUS being delivered by UK or British companies (participants used both terms). Participants felt that this would ensure that jobs created would remain in the UK and help minimise any job losses. A few participants thought that the successful development of

CCUS could be a point of national pride.

> *"I would like for once for this country to use British industries to do this instead of German, French etcetera. Then we can be leaders, creating it, making it … and show the rest of the world we can do it."*
>
> *Teesside participant, Week 2*

Being UK-owned also equated to a greater sense of job security for some, with references made to the workers at Tata Steel who face the threat of "layoffs" or "selling it off". This was given as a reason for ensuring that CCUS projects are carried out by a UK company.

When participants considered trade-offs on their emerging criteria, those in Aberdeen were keen to prioritise appointing a UK-owned company over keeping costs down. One participant queried the feasibility of doing this because of a skills shortage in the UK for work related to CCUS.

Participants in other locations did not make this explicit trade-off but fair and transparent procurement, preferably to UK companies, was felt to be an important criterion in implementing CCUS.

6.2 Regulation and oversight of CCUS projects

As participants learned more about CCUS, they wanted to know who would be responsible for monitoring and oversight. In particular, they wanted there to be independent oversight to ensure safety standards are upheld.

> *"The main thing for me is the governing body e.g. 'Ofcarb'."*
>
> *Port Talbot participant, Week 4*

The importance of any regulation being independent from both government and from industry became a more widely stated view amongst participants when developing their final criteria in Week 4.

Participants mentioned the need for both transparency and expertise to inform the regulation of CCUS projects.

> *"With a project this size it needs transparent independent governance. It may be funded by the Government but they cannot be seen to be governing this. It needs governing by world class experts from all different disciplines, with representation from all in a transparent manner."*
>
> *Liverpool participant, Week 4*

A couple of participants made specific points about regulation. One argued that a dedicated, regulatory body should oversee "the bigger picture" of reaching net zero. Another thought there should be some sort of international regulation because "the Norwegians are coming from the other direction from the North Sea."

When asked to think about safeguards for local CCUS projects, participants generally referred to the need for independent regulation. Some were keen to see effective safeguards in place to protect wildlife, rather than just a "box-ticking exercise".

A few also said that they would want any oversight to consider local concerns.

> *"It would have to be overseen by an independent body who knows what they're talking about and can relate to the local population and local concerns. For example, in Wales we are concerned about our coastline."*
>
> *Port Talbot participant, Week 4*

Participants' desire for independent and transparent regulation is linked to their concerns about the safety and efficacy of CCUS, and the negative impacts it could potentially have on local communities, which we discuss in the next section of this chapter.

6.3 Potential risks to local areas

Throughout the dialogue, participants identified a number of risks that a CCUS project could bring to a local area. Some of these were specific to their local area, and these are considered in Section 6.5. Others applied to any local area and we consider them in this section.

6.3.1 Environmental risks

Participants were concerned about environmental risks in terms of the natural environment, in particular wildlife, and the physical, local environment. As we have discussed in Chapter 5, participants were

worried about the impact of leakage or accidents on marine life.

Several participants were worried about the potential negative environmental impacts of construction, for instance the laying of pipelines, on land-based wildlife.

There was also concern about the potential visual impact on the landscape, in particular laying pipelines in rural areas. A few participants were worried about what capture facilities would look like and whether they would be "eyesores".

Participants across locations expressed a preference to avoid siting infrastructure near homes and populated areas (particularly for capture facilities), while also expressing concerns about disruption to green belt and farming land (particularly around transport via pipes).

> *"I would like to see using brownfield sites rather than an area of beauty."*
>
> *Teesside participant, Week 3*

When setting their criteria for CCUS implementation, many participants mentioned the environment. This was particularly important for participants who identified as "green" or "environmental", who generally thought that CCUS should not be implemented if there is any chance of it affecting ecosystems and wildlife.

> *"I'm very, very environmental, so I am considering any environmental cost, for example, disturbing wildlife in the sea."*
>
> *Teesside participant, Week 4*

Others situated environmental concerns in the broader context of the need to reach net zero, seeing both as important.

> *"Whilst I have concerns based around safety and environment, I acknowledge that unless something is done about this we will struggle to reach our commitment to be net zero by 2050."*
>
> *Port Talbot participant, Recollective comment, Week 3*

Many participants did not explicitly balance environmental impacts against the goal of reaching net zero. But participants felt that if

environmental damage occurred as a result of CCUS activities, this was a counter-intuitive way of tackling climate change (as discussed in Section 4.4.3, this was also seen in participants' reaction to BECCS).

> *"I can't understand why they want to dig up countryside again, when there's already land available and pipeline down the middle of the Wirral. It's just to ruin the environment to save the environment. I don't get it."*
>
> *Liverpool participant, Week 4*

6.3.2 Construction risks

As discussed above, participants were concerned about construction having negative impacts on the local environment. They were also worried about the risk of disruption to local residents and businesses because of the noise and dust pollution. Participants thought there would be an increase in traffic, particularly construction vehicles, which could disrupt local residents and commuters.

> *"I'd be worried about the noise and disruption – loads of construction and trucks would be really annoying."*
>
> *Aberdeen participant, Week 3*

In Aberdeen and Port Talbot, participants anticipated risks of increasing prices to both housing and certain goods as a result of an influx of workers and construction. Some participants also raised concerns about the safety of construction sites.

Some participants questioned the amount of CO_2 emissions that the construction stage would produce. Since the construction would involve a number of high emitting products (such as cement) and processes (transport to site), these emissions could end up increasing the project's overall carbon footprint.

6.3.3 Safety risks

Participants consistently raised the safety of CCUS when considering local deployment. Their general issues and concerns about safety are discussed in more detail in Chapter 5. Safety issues specific to particular locations are discussed in Section 6.5.

6.3.4 Economic impacts

At various points during the dialogue, but particularly when discussing

the case studies and the planning process, participants were concerned that the local economic benefits being discussed would not materialise. For some this meant that the jobs would be short-lived and restricted to the construction phase of the project, while others were concerned that CCUS deployment would end up only bringing local disruption while economic benefits landed elsewhere in the country. As we discuss in Chapter 2, these views are not confined to CCUS but are a more deeply embedded scepticism about the promise of new jobs and economic benefits due to regional history and experience.

6.3.5 Decommissioning

Participants identified two main concerns around decommissioning – the impact on local employment and the future of the site itself. In Aberdeen, the discussion was shaped by the decline of the oil and gas industry and the subsequent local economic impact of jobs and skilled workers leaving the area.

> *"Similar to decommissioning of oil and gas, when an industry starts to decline, the skills move abroad. There are challenges getting the personnel to do the decommissioning. The oil and gas industry is struggling with the same sort of issue."*
>
> *Aberdeen participant, Week 3*

There were similar concerns in other areas, particularly in Port Talbot, which like Aberdeen, has a close association to a single industry. A number of participants were worried about the impact of steel production leaving the area. This shaped some of the discussions around the impact an industry leaving an area can have. This was evidenced in discussing the hypothetical example of a cement factory using CCUS. One participant, who assessed CCUS in terms of its effect on the steel industry in Port Talbot, talked about the devastating impact decommissioning could have on the identity of the area.

> *"It will be sad because the business will be finished. This little town will be under great pressure ... Once it's all gone, what will all these unemployed people do then?"*
>
> *Port Talbot participant, Week 3*

Participants recommended engagement with the local communities and the setting of clear timelines as key parts of the decommissioning process. There was a sense it was important to give an area enough

notice of when operations would be coming to an end.

Some participants were also interested in what would become of the site once it had been decommissioned, including whether the land would be useable, with comparisons drawn with the nuclear industry. Participants wanted the safety of the site to be ensured after decommissioning, with monitoring of pipelines and storage sites.

6.4 Potential benefits to local areas

Participants also discussed the potential benefits of CCUS to local communities. Benefits which are specific to their local area are explored in the next section of this chapter. Here we look at the benefits which were identified across all locations.

6.4.1 Jobs and skills

Participants outlined the key local benefit of CCUS as the creation, and in some cases safeguarding, of jobs. This was suggested early in the dialogue, with some speculating that the jobs would be higher quality as well.

> *"It would create a lot of jobs would it not? High tech and blue collar jobs. It would just require investment."*
>
> *Liverpool participant, Week 1*

The prospect of job creation in their local area became a turning point for some participants in their attitudes towards CCUS – particularly in Aberdeen and Teesside.

> *"I'm really pleased it's actually coming. I'm very positive it's coming to this area if it brings the economy and jobs here."*
>
> *Teesside participant, Week 3*

While the prospect of new jobs in an area was broadly seen as a positive, a number of participants were keen to drill down into the specifics:

- **Job type**. Participants broadly understood there to be two types of jobs: construction and on-site jobs. While the latter of these were generally seen to be higher quality and longer lasting, a number of participants felt they would be much smaller in number.
- **Opportunities for local people**. Participants across locations raised concerns about contractors being brought in from outside the area or the contracts going 'down south'.

- **Job location**. Participants had questions about where the jobs would be. This was particularly prevalent in Liverpool. This was partly linked to the location of the case study, which is outside Liverpool and based in Ellesmere Port on the south side of the Mersey. However, these points were also made by participants in Teesside.
- **Employment sustainability**. Participants raised concerns about both the longevity of on-site jobs, but also the impact of decommissioning as discussed above. However, they were optimistic about the prospect of creating a green industrial hub where greener industries in future could replace the decommissioned CCUS sites.

Alongside general job creation and protection, participants also identified apprenticeships and reskilling as potential local benefits. In some locations, particularly Aberdeen, there was confidence that a skilled workforce was available locally, and that CCUS could have a role in replacing jobs that would be lost in the oil and gas industry. In other areas, participants wanted to see measures put in place to develop the skills of local people, or to allow for retraining from other sectors. Some participants felt that the introduction of CCUS in an area should not lead to any job losses, unless those people could be reskilled to benefit from jobs created.

Most participants expected CCUS deployment to create jobs locally but, to ensure this, felt it should be a criterion in its implementation. This was often described through local narratives, for example in Port Talbot there were some participants who wanted to see existing jobs in the steel industry protected.

> *"Obviously nobody has a job for life anymore, but I'd like to think it would last a long time. Not just flash in the pan."*
>
> *Teesside participant, Week 3*

Some participants were more specific about the importance of jobs being sustainable and long term, and not just associated with construction. However, other participants were of the opinion that any jobs would be welcome, and they were less concerned about the long-term economic impact. Overall, participants felt strongly that CCUS should bring job opportunities for local people.

6.4.2 Wider economic benefits

Some participants spoke about the wider impacts that local job creation could have, such as bringing more people to the area which in turn could support local businesses and property developments.

Participants articulated the wider economic case for CCUS as a "knock-on effect", where a new industry encourages people and businesses to relocate to the area, which in turn, can provide a boost to existing local businesses and suppliers. This view was particularly prevalent in Aberdeen, where participants cited the economic boost the B&B industry receives when "oil industry is at peak".

6.4.3 Environmental benefits

Participants were not told at any point that CCUS would lead to cleaner air in the local area. If they suggested during the course of discussion that it would, they were, where possible, corrected. However, a number of participants continued to feel that a reduction in carbon would lead to cleaner air and this was cited as a potential benefit of CCUS to the local community.

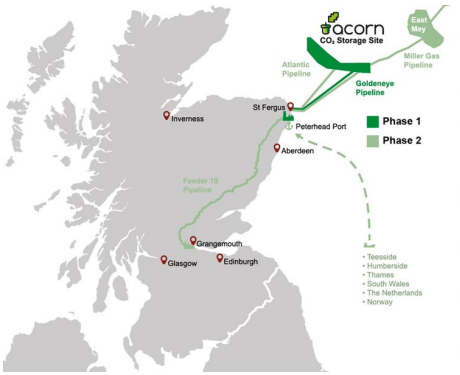
> *"For me it's about cleaner air and a better environment. Thinking of the children growing up and the industry around them not being damaging."*
>
> *Nottingham participant, Week 3*

6.5 CCUS case studies

Participants were asked to consider four potential CCUS projects in proposed CCUS cluster locations in the UK. Participants from Nottingham, which is not near a proposed CCUS site, were asked to consider the Teesside case study and what their views would be if a site were to be proposed in their area. The Teesside case study was judged to be the most generalisable to an area which is not near a potential CCUS cluster.

The local context framed participants' reactions to the case study in their area. The model of place identity, which we discuss in more detail in Section 2.3, suggests that emotional or affective responses to proposed infrastructure can be as influential as rational arguments about benefits and impacts. Jobs, regional identity and a scepticism that promises made may not be fulfilled were important themes in Aberdeen, Liverpool, Port Talbot and Teesside.

6.5.1 Aberdeen



Acorn Project – Aberdeen group case study

- A project which is establishing CO_2 storage sites off the coast of Scotland.
- Depleted oil and gas fields, and saline aquifers, offer large scale opportunities to store CO_2 in the region.
- The project will start by storing CO_2 from industrial areas like St Fergus.
- Industrial sites are already linked by a network of pipes to the oil and gas fields off the coast in the North Sea.
- The project has received funding from industry and UK and EU government funding.
- The project could include a repurposed onshore pipeline to transport Scotland's Central Belt emissions to offshore storage.
- There is also potential to import and store CO_2 from elsewhere.

Figure 6. Acorn Project snapshot summary

Participants' responses to this case study centred on its impact in the context of the declining oil and gas industry and the use of existing infrastructure.

> *"We will have no jobs once the industry is off, and we have 20-30 years left. We are going to need to replace these jobs with high paid jobs. When you are storing these things offshore, we can probably use and repurpose existing infrastructures."*
>
> *Aberdeen participant, Week 3*

In Aberdeen, described as an "oil capital" by one participant, there was a sense of pride in the oil and gas expertise and skills the city has. This was coupled with a recognition that the industry is shrinking as the renewables sector continues to grow. CCUS was seen by some in Aberdeen as an opportunity to retain and utilise these skills.

> *"There has been a lot of decline over the years in favour of renewables, it's done a lot of economic damage. We have a lot of skills here, and CCUS would answer a lot of those questions about jobs and skills."*
>
> *Aberdeen participant, Week 4*

One participant said CCUS would retain Aberdeen's position "as a global player for the energy sector".

A specific issue in Aberdeen that participants raised during the dialogue was the history of jobs being outsourced, where jobs are moved out of the area (for instance, call centre jobs). For participants, this underpinned their view that the creation of jobs from CCUS projects in their area should benefit local people and the local economy.

Some participants in Aberdeen had already found the use of existing infrastructure a compelling point in favour of CCUS by the time they considered the Acorn project in Week 3. They saw this as making CCUS projects more cost effective and quicker to implement.

As discussed in Chapter 5, participants had questions about the safety of existing infrastructure and specifically the safety of the existing pipes in St. Fergus. One participant queried whether there is sufficient pipe capacity from Grangemouth to the Central Belt for the CO_2 that will be pumped offshore.

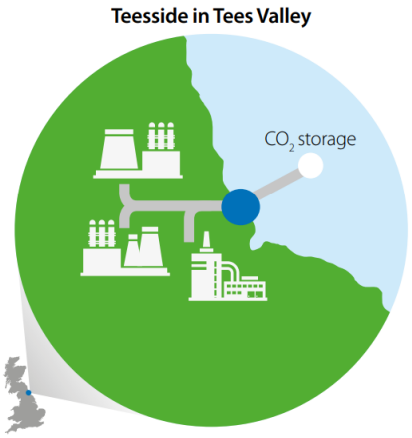
Participants in Aberdeen had specific concerns about any negative impacts on marine life of offshore CO_2 storage under the seabed and the knock on effects this could have on the fishing industry.

> *"I would hope that this wouldn't affect fishing or fishing grounds or the environment."*
>
> *Aberdeen participant, Recollective comment, Week 3*

One regional dimension specific to Scotland is its relationship with the rest of the UK. As we have seen in Section 4.4.1, a few participants in Aberdeen were uncomfortable with the idea of Scotland storing emissions from other areas, with one arguing that "the places which produce the CO_2 should store it". One participant wanted to know what would happen to any CCUS project if Scotland became independent in five years.

Overall, participants in Aberdeen generally reacted positively to this case study because of the potential for CCUS to safeguard the jobs and skills which are a source of local pride. Less often stated, CCUS could also help Aberdeen transition from the "oil capital" to a global energy player.

6.5.2 *Teesside*



Net Zero Teesside – Teesside group case study[32]

- Industry on Teesside is a large emitter of CO_2 and is important to the local economy.
- Industry on Teesside will work with oil and gas companies to capture CO_2 from industrial sources.
- CO_2 pipelines would be added to a pipeline corridor (an area with existing pipelines).
- The CO_2 captured will be stored in either an old gas field or a saline aquifer in the North Sea.
- The project is also planning to build a natural gas with CCUS power plant.
- The storage site in the North Sea may also store CO_2 from another industrial site in the Humber.

N.B. This case study was discussed by Nottingham participants as well

Figure 7. Net Zero Teesside snapshot summary

As in Aberdeen, Teesside participants focused on jobs and regional benefits when considering this case study. They expressed optimism about job creation, with one participant saying that jobs are "hard to come by" in the North East. However, participants were concerned about the sustainability of jobs and being promised jobs in the past that had not materialised.

[32] Please note that at the time of developing the workshop materials for the project the northern endurance partnership had not been announced. https://www.netzeroteesside.co.uk/northern-endurance-partnership/

Some participants in Teesside were excited at the prospect of CCUS being established in the region. They felt it was an opportunity to restore a sense of pride and to "get our identity back".

> *"Quite exciting really, in North-East we've lost our identity a bit with industrial sites closing. Sounds like the infrastructure is in place, it's just getting off the ground with it. Quite exciting, we would get our identity back in Teesside."*
>
> *Teesside participant, Week 3*

A couple of participants explicitly linked this sense of pride to Teesside playing its part in tackling global warming.

> *"I would feel proud to have it in my area as it's helping the environment and it's good for industry too."*
>
> *Teesside participant, Week 3*

One participant, however, disagreed, saying that the region needed to move on from being the "dumping ground of every industry that's been going" and should focus instead on developing other sectors, such as digital companies.

Although this point came up less strongly than in Aberdeen, participants saw the use of existing pipelines and reusing old oil sites and pipes as a benefit.

> *"All that wasted land can now be used. It's the lift this area needs, what with the steelworks shutting down."*
>
> *Teesside participant, Week 3*

Participants' specific local concerns mainly centred on the cost of deployment, as funding was not clearly outlined, with one saying "we're not affluent compared to the South".

Unlike Aberdeen, participants rarely mentioned specific industries when considering this case study. However, the view that CCUS could create jobs and benefit the region in more intangible ways was found in both regions.

6.5.3 North West

HyNet Project - North West/ Liverpool group case study

- HyNet aims to produce hydrogen fuel, which can replace the natural gas used by industry in the North West.
- The hydrogen will be produced from natural gas, with the CO_2 captured and stored in old gas fields in the East Irish Sea.
- The project will also capture CO_2 from industrial processes that can't be replaced with hydrogen.
- The project is also exploring using hydrogen in homes, mixed with the natural gas we use currently. Mixtures with more than 20% hydrogen would require new boilers.
- The project is also considering how hydrogen could be used as fuel for transport like cars, buses and trains.
- It has the potential to protect energy intensive industry jobs and create thousands of jobs for the region.

Figure 8. HyNet Project snapshot summary

Two factors shaped participants' reactions to this case study; participants' feelings about hydrogen and their views on what impact it would have on job creation in Liverpool.

Like those in Teesside, participants in Liverpool felt the area had been historically left behind and needed jobs. One participant felt that focusing on job creation CCUS could "warm [people in Liverpool] to the idea" of CCUS. This was heavily tempered for some participants in Liverpool who felt the city had been promised jobs in the past, only for them to not appear or be outsourced – to "the South" or the areas around Liverpool, like the Wirral, Cheshire or North Wales.

Some participants thought that the location of the HyNet project (based in Ellesmere Port on the south side of the River Mersey) meant that the project would not benefit the city of Liverpool.

> *"That side of the Mersey, the opportunities aren't going to be given to them, the jobs aren't going to be for Liverpool people."*
>
> *Liverpool participant, Week 3*

However, this view was not universal, and a few participants were positive about the potential for jobs.

> *"It could be a success for net zero, and could be good for the economy as well. If it's bringing jobs to the area I can't disagree, as long as it's safe."*
>
> *Liverpool participant, Week 3*

Participants' reactions to this case study were also shaped by their views on hydrogen. Some found the fact that hydrogen was being proposed as part of the site very concerning – and for a couple the turning point in their overall views of CCUS. Their concerns echoed those expressed when hydrogen was discussed as a technology in detail, particularly the transportation and storage of what was regarded as a highly volatile substance (see Section 5.3 for more details), compared by one participant to "living next to a bomb".

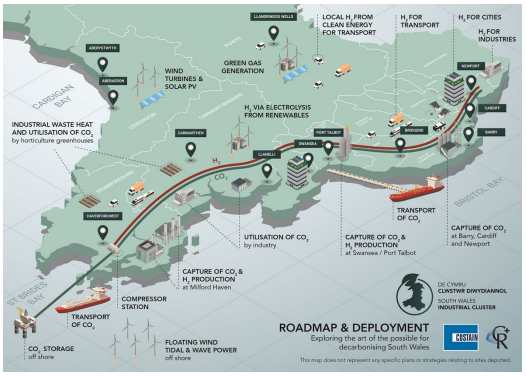
> *"I was excited about it at first, but it took a shift when they started talking about hydrogen."*
>
> *Liverpool participant, Week 4*

The infrastructure required for the project received less attention. One participant wrote in Recollective that an advantage of this project was the "repurposing of existing pipework to distribute hydrogen."

However, others said that it would be expensive and disruptive to produce the hydrogen network and lay the necessary pipelines. Some participants said they preferred for existing infrastructure to be reused. One participant was concerned about the main pipeline going through the Welsh countryside and then into the Irish sea and argued that the project should use existing pipelines through the Wirral peninsula.

In contrast to Aberdeen and Teesside, participants were less likely to see clear benefits from this case study of job creation and using existing infrastructure. Concerns about the safety of hydrogen was another factor in attitudes being less positive than in Aberdeen and Teesside.

6.5.4 Port Talbot



South Wales Industrial Cluster - Port Talbot group case study

- Industry, government, and researchers are working together in Port Talbot to develop a holistic decarbonisation strategy.
- As part of this strategy, a steel company could capture CO_2 emissions from their production process.
- The project is also exploring hydrogen production.

Figure 9. South Wales Industrial Cluster

In Port Talbot, the steelworks, run by Tata Steel, were a fundamental consideration running through any discussions of the local area – including the local impact of CCUS.

While there was some focus on job creation, the majority of discussion centred around the impact the CCUS project under consideration could have on the steelworks. For some, this offered an opportunity to extend the life of the industry, while others thought it would result in more costs for the steelworks, which would eventually result in it becoming unviable.

> *"Without Tata in Port Talbot, there would be no Port Talbot. Nothing. We would be devastated as a town. It would be the end of us."*
>
> *Port Talbot participant, Week 3*

Participants debated how CCUS would be funded because they thought Tata Steel could not afford it and were cynical about the prospects of government funding. One participant was concerned that if the steelworks were sold to Swedish steel company SSAB, the

new owners may not want to implement CCUS.

Another key concern for participants was the impact on the surrounding environment and natural world, already heavily polluted by the steelworks. A couple of participants were particularly concerned about the impact on the Pembrokeshire coast and one argued that the project could "devastate our ailing tourist industry".

Participants had differing views as to the suitability of the Port Talbot site for CCUS. For some participants, being able to transport CO_2 by ship was an advantage because this removed the necessity for building pipes, and waste products were already being piped to the docks. When listing what they described as "pros" to the Port Talbot project in Recollective, one participant wrote:

> *"Situated in an area with a very large docks easily equipped to take ships to carry the carbon to other places in the UK."*
>
> *Port Talbot participant, Recollective comment, Week 3*

Others felt Port Talbot is too far away from where the CO_2 would be stored, with one participant describing it as "totally unachievable".

A few participants in Port Talbot were very opposed to CCUS in principle because they thought it was not tackling the root of the problem (see Chapter 7 for more details). This shaped their reaction to the case study, with one saying that shipping CO_2 from Port Talbot and storing it elsewhere is "like kicking the can down the road".

Of all the local case studies, reaction was most mixed in Port Talbot and this is probably partly due to the potential advantages for local industry and jobs being less clear cut than in Aberdeen and Teesside in particular.

6.5.5 Nottingham

Participants in Nottingham did not have a proposed local site to discuss. Instead, they examined the Net Zero Teesside project in detail as this was thought to be the case study most generalisable to an area not near a potential CCUS cluster.

When discussing the case study, participants made little comment on the specific project, instead focusing on general arguments around CCUS, particularly in comparison to what they described as more

natural solutions. It is likely that participants' interest in CCUS more broadly rather than the case study is due to there not being a proposed CCUS site near Nottingham.

One participant was interested in whether CCUS was ever likely to come to Nottingham, and in particular, if the old mine shafts could be used to store CO_2. When discussing what might happen if CCUS was proposed in Nottingham, such as with the Ratcliffe-on-Soar coal power station, a participant expressed concerns about the distance captured CO_2 would have to travel and the fact it would be supporting a fossil fuel industry.

> *"Even if they were able to capture the carbon from Redcliff area power station it will be extraordinary expensive, and we should not even consider its existence for that much longer."*
>
> *Nottingham participant, Week 3*

A sense of local identity did not come through very strongly from Nottingham participants. This could either be because there is less of a distinct local identity, or because they did not have a site local to them to consider and so were less invested in the topic.

6.6 Attitudes towards local and national deployment

In Week 1 of the dialogue we asked on Recollective how comfortable participants felt about CCUS being deployed nationally or in their local area. Participants said they were more comfortable with CCUS being deployed in the UK than locally. This remained the case when participants were asked this question again in Week 3 after they had considered the local case studies.

As the table below illustrates, most participants who answered this question in both weeks felt comfortable with CCUS being deployed in the UK and locally and the numbers rose between Weeks 1 and 3. We also see a reduction in the numbers saying they feel uncomfortable about UK deployment but there is a slight increase for the local area.

Table 2. Results from participants in all locations on how comfortable they felt about CCUS being deployed nationally or in their local area. This was answered through Recollective.

Number = 94	Comfortable	Uncomfortable	Neither/don't know
UK			
Week 1	60	9	25
Week 3	74	5	15
Your local area			
Week 1	47	16	31
Week 3	58	18	18

In answering this question, participants generally considered national deployment in broad terms – the perceived effectiveness (and safety) of CCUS in reducing CO_2 emissions, the urgency of reaching net zero by 2050 and how far CO_2 emissions should continue at all (this is explored in more detail in Chapter 7).

Participants' views on local deployment were influenced by these considerations but were also clearly shaped by local factors. As we have seen, for some participants in Aberdeen and Teesside in particular, the prospect of job creation and utilising existing infrastructure underpinned a desire to see CCUS deployed in the local area. For other participants, local safety and environmental concerns made them feel uncomfortable about CCUS in their local area.

> *"I would be uncomfortable with it being stored in my local area until I am convinced about the absolute security of underground CO_2 storage and pipelines."*
>
> *Aberdeen participant, Recollective comment, Week 3*

When we look at participants from Nottingham, where there is no CCUS site being proposed, their attitudes towards national and local deployment were broadly in line with the rest of the participants. However, two in five were neutral or unsure about local deployment in Week 3.

"Although I think we need to use this option in a limited way, I'm not sure if I might feel differently if I lived in one of the areas where it will be deployed. Nottingham will be well away from this."

Nottingham participant, Recollective comment, Week 3

Unlike participants from other locations, their responses to the question about local deployment are more general, although a few said they thought the Midlands was too far from the coastline for CCUS to be feasible.

Participants' differing responses to the question of national and local deployment illustrate that national deployment is seen in terms of whether or not CCUS is a desirable solution for reaching net zero whereas views on local deployment are shaped by concrete local considerations such as job creation, as well as more intangible factors such as regional pride.

6.7 Criteria for deployment of CCUS projects

Participants' criteria[33]

- There should be independent oversight and regulation of all stages of CCUS projects which ensures safety standards are upheld and wildlife is protected.
- There needs to be transparency in the funding and procurement of CCUS projects.
- Contracts for CCUS work should be awarded following an open and transparent tender process, with a clear method of identifying the best option. Contractors delivering CCUS should have a demonstrable track record as a reputable and ethical company. Preference should be given to UK-owned companies.
- Throughout the lifetime of a CCUS project, from construction to decommissioning, it should be sensitive to local residents and disruption should be minimised, particularly in the construction phase. Damage to wildlife and the natural environment should be limited.

[33] During the dialogue, participants were asked to develop criteria the Government should consider for the implementation of CCUS. A full list of the criteria generated can be found in Chapter 3.

- CCUS projects should clearly deliver benefits for local communities, particularly in terms of job creation. Jobs should be locally sourced in both the construction, operation and decommissioning stages. Jobs should be sustainable where possible. If jobs are lost as a result of CCUS projects, people should be given the opportunity for reskilling to benefit from jobs created by CCUS.

7 The role of CCUS in reaching net zero

Summary

- Participants generally accepted the need for a pathway to net zero.
- While most saw CCUS playing a role, this support for CCUS was conditional. Safety was the highest priority for participants, and they considered that policy governing CCUS should prioritise clear cost benefits: the technology must make a significant impact in order to justify the cost.
- Some participant support for CCUS was based on views that the pathway to net zero requires multiple strategies. CCUS should not be prioritised above other strategies, but rather alongside efforts such as planting trees and renewables.
- Some participants were more open to CCUS as a short-term "stop gap" solution to buy time to stop CO_2 emissions and develop what they described as cleaner solutions such as renewables. This highlights the need to be clear with the public about the specific role CCUS has to play in reaching net zero.
- A small group of participants were strongly opposed to CCUS and their opposition hardened over the dialogue. Some members of the public are unlikely to support CCUS, regardless of what information or interactions they have, as they see it as failing to address the problem of producing CO_2 emissions.

This chapter examines participants' views on the role of CCUS as part of the pathway to reach net zero by 2050. It explores their opinions and feelings about the concept of net zero and the effectiveness and desirability of CCUS as a strategy in reaching net zero. The chapter also considers views on CCUS in the context of multiple approaches to reaching net zero and how participants related CCUS to other key strategies.

7.1 Overall views on CCUS

At the end of Week 3, we asked participants to write down in the online platform Recollective three words that described their views of CCUS (Figure 10). "Hopeful" was the most common word (16 participants) followed by "optimistic", "happy" and "concerned" (each mentioned by 7 participants). The majority of words participants used were positive, such as "confident", "intrigued" and "excited" but

there were also words expressing doubts and concerns. The most frequently used terms expressing doubts and concerns were 'cautious' (by 5 participants), followed by "sceptical", "unsure" and "worried" (each mentioned by 3 participants).

Figure 10. What three words would you use to describe your views of CCUS?' Results of Recollective activity completed at the end of Week 3.

As discussed in Section 2.4, in the first week of the dialogue, participants considered the contribution of CCUS, and other strategies, in reaching net zero by 2050. In a Recollective task, they were asked 'How much of a role do you think each solution should have in helping the UK reach net zero by 2050'? Participants were asked to allocate percentages to six strategies. This question was asked again in Week 3. See the figure below.

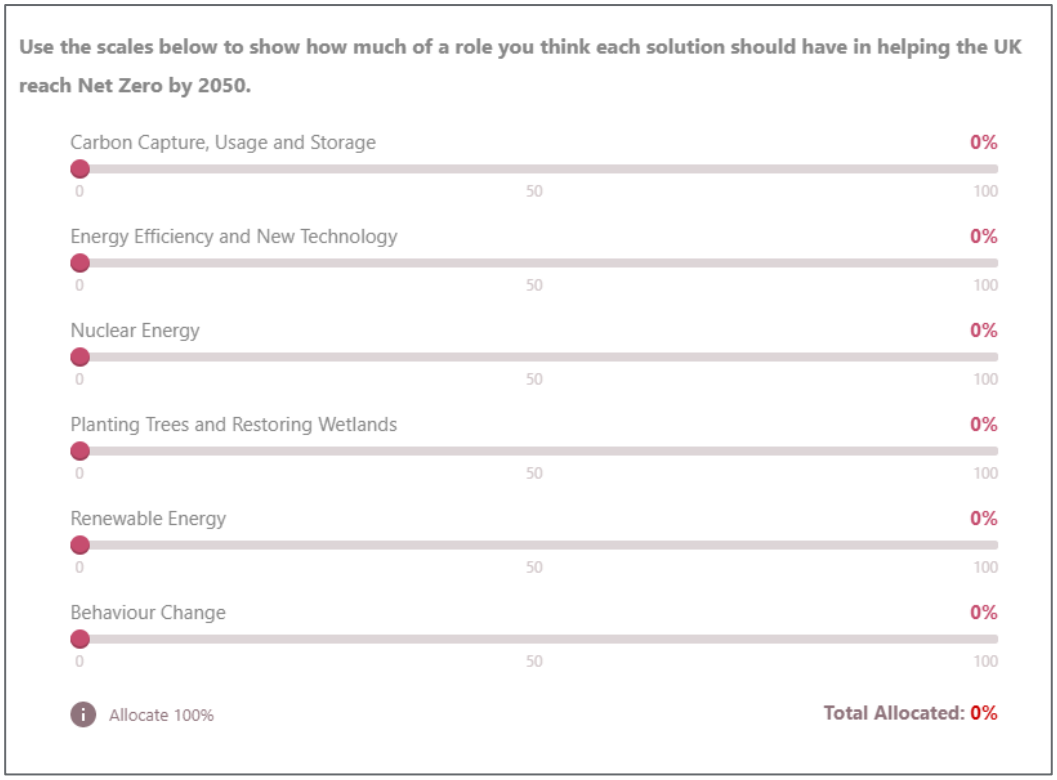


Figure 11. Screenshot from online platform Recollective

In Week 3, almost seven in ten of participants giving a response in both weeks allocated a higher percentage to CCUS than in Week 1. One in ten gave the same percentage as Week 1 and just over two in ten allocated CCUS a lower amount. In Week 3, on average each strategy had slightly less priority allocated to it and CCUS saw its average allocation increase, from 17.5% to 25%.

It is important to note that CCUS was the only technology explained in any detail during the dialogue, and this is very likely to have been a factor in its average allocation going up. So, while it is not possible to draw firm conclusions about the relative appeal of CCUS in comparison to other strategies, the dialogue does illustrate that people became more confident about the role of CCUS in achieving net zero when they are more familiar with the technology.

Most participants allocated at least some role to CCUS in both Weeks 1 and 3. Of those 11 participants who allocated 0% to CCUS at the start of the dialogue, most changed their view over time. However, there were a small number of participants who in Week 1 of the dialogue thought that CCUS should have a role but later allocated it 0%.

In Week 3, six participants allocated CCUS 0% (it should be noted that not everyone completed this task). Of the four participants who

reduced their allocation to 0% in Week 3, two were in a Port Talbot group which included two vocal critics of CCUS. Everyone in this particular Port Talbot group reduced the contribution they gave to CCUS over the course of the dialogue.

The small group of participants who were opposed to CCUS from the start of the dialogue hardened their opposition as the dialogue progressed. As we discuss in Section 8.3.1, they did not trust what they heard from specialists and tended to do their own research. For instance, one participant in the Port Talbot group referred to in the previous paragraph watched the Netflix documentary 'Kiss The Ground' between workshop sessions. They argued that it showed that regenerative agriculture is a better alternative to CCUS. This prompted another participant in the same group to watch the documentary, also strengthening their views against CCUS.

7.2 Views on net zero

Participants accepted the premise that there needs to be a pathway to net zero by 2050. There were very few comments on the pathway itself, aside from a single suggestion that 2050 would be too late and a few expressions of concern about the feasibility of achieving net zero by 2050.

Participants talked about the need to tackle climate change for the benefit both of future generations and the planet itself. Some participants used examples such as ice caps melting as reasons for the need to act.

> *"It's for the future and our children, we need to roll back the effects of climate change like areas becoming inhospitable, the ice caps melting. It's protecting the planet for future generations."*
>
> *Liverpool participant, Week 2*

Some participants said that it had been helpful to consider net zero, and the scale of the challenge to decarbonise by 2050, and a few were hearing about both the concept and the 2050 target for the first time. Some participants explicitly linked the need for CCUS to the scale and the urgency of the task in tackling climate change.

> *"I put CCUS as the most important thing on the slider, we need to act fast, planting trees takes time 20, 30, 40 years. Other ways help, but all CO_2 emissions we are making right now can be stopped and reduced, that's the best way to do it. We have to act now; the climate is changing quite fast and we don't have much time."*
>
> *Aberdeen participant, Week 4*

There were a few participants who argued that other priorities, such as the financial impact of the COVID-19 pandemic, were more important than reaching net zero. We saw this in Liverpool, where there was a higher degree of scepticism towards human-made climate change at the start of the dialogue. One participant, in particular, when reflecting on the dialogue argued there are more pressing issues in Liverpool to focus on, such as feeding children.

> *"It hasn't got a cat in hell's chance in Liverpool. We can't even get the electric car sorted out. We have enough problems in Liverpool and Merseyside. We can't even feed the children. We have problems with the hospital. Do you think we could care less about this carbon thing?"*
>
> *Liverpool participant, Week 4*

7.3 Efficacy of CCUS in reaching net zero

As discussed in Chapter 4, participants who thought CCUS is capable of making a significant contribution to net zero supported its inclusion in the pathway.

> *"I think it has to be, because otherwise we're never going to get to net zero, it has to be included. There's no way with production and using less fossil fuels, we're never going to get to net zero, so it has to be."*
>
> *Aberdeen participant, Week 4*

A couple of participants rejected CCUS playing any role in the pathway to net zero at the end of the dialogue because they did not think it would be feasible, describing it as "experimental" and "untested".

As we explored in Section 4.2, participants also judged CCUS' efficacy in terms of whether its costs would be justified by its contribution to net

zero.

> *"The criteria should always be how much impact any CCUS project has on getting us to net zero by 2050. These criteria should ensure: 1 - Implementation cost versus CO_2 reduction. 2- Low-cost vs high impact is favoured."*
>
> *Port Talbot participant, Recollective comment, Week 2*

The other element participants included in this trade-off is time (discussed in Section 4.3). Participants who thought CCUS could reduce emissions more quickly than other solutions tended to give it a higher allocation on the pathway.

> *"50-70% [contribution to net zero] for CCUS and then I did planting trees and other efficient technology, but when I started it was 20% for CCUS and then equally distributed, but then if we are to reach net zero by 2050 then CCUS looks the quickest and easiest with all of the existing technologies that are there."*[1]
>
> *Teesside participant, Week 4*

A few participants pointed out that it is important to consider CCUS' entire carbon footprint when considering its contribution to net zero.

> *"We don't want to get in a worse position than we're in now. If you're using more carbon in the long run to capture carbon, it'd need to be proven that that's not the case."*
>
> *Liverpool participant, Week 2*

7.4 CCUS and decarbonisation

Participants' attitudes towards decarbonisation, and their views on how long CO_2 emissions should continue, shaped their views on CCUS. Some participants expressed support for CCUS because they thought any approach to reducing CO_2 emissions is valuable.

> *"I still believe that any initiatives to cut down on CO_2 emissions will be beneficial in tackling climate change and so I will support CCUS. I think the risks are still there but many of my worries have been discussed in the calls and the experts have provided me with reassuring explanations and helpful references."*
>
> *Aberdeen participant, Week 2*

Other participants had concerns about CO_2 emissions continuing. A few strongly opposed CCUS having a place in the pathway to net zero on this basis. They argued that developing CCUS represented a continuation of a harmful trajectory and a failure to address the root cause of the problem: CO_2 emissions. Participants used a number of analogies to make this point, such as a "sticking plaster", "kicking the can down the road" and a "get out of jail free card."

> *"You have to think why we're in this situation in the first place: because we're producing too much carbon and we're destroying the lands/woods that absorb carbon. So, capture is treating the symptom not the cause."*
>
> *Port Talbot participant, Week 4*

Other participants framed CCUS as a stop gap solution (one participant used the phrase "stepping stone") which buys time to reduce CO_2 emissions, while developing other solutions. The terms "stop gap" and "stepping stone" indicate a different underlying attitude than "sticking plaster" and "kicking the can", which imply that a problem is not being faced up to.

> *"I still think it's just a stop gap to actually stopping the production of carbon and CO_2 and the other nasty things industry produces. But I do think it has a role to play."*
>
> *Nottingham participant, Week 4*

A few participants explicitly supported CCUS because they believed industries such as the steelworks in Port Talbot, would continue to emit CO_2.

> *"At the end of the day we have a dirty steelworks two miles from where I'm sitting that will continue to emit pollutants. It doesn't matter how much renewable energy we invest in – we still have the steelworks chucking muck up into the air. I don't see how you can ignore CCUS."*
>
> *Port Talbot participant, Week 4*

A couple of participants who were strongly opposed to CCUS having any role in the pathway to net zero expressed specific concerns about industry continuing to emit CO_2 and "big dirty industry jobs". As the two preceding quotes illustrate, other participants also used words such as "nasty" and "muck" to describe industrial emissions. The framing of CCUS as a stop gap solution is perhaps a way for some participants to reconcile the ongoing existence of industry with its one of its key negative environmental impacts.

7.5 CCUS, nature and technology

Throughout the dialogue, participants juxtaposed CCUS with nature, or natural ways of tackling climate change. As discussed in Section 2.2, there is evidence that courses of action which are described as natural are seen as more desirable than those described as unnatural.[34]

A few participants explicitly described CCUS as unnatural and therefore undesirable.

> *"I think the 'sticking plaster' analogy is very apt. We should be looking at more natural ways of combatting carbon emissions. CCUS seems to me to be yet another unnatural process which is fraught with problems."*
>
> *Nottingham participant, Week 2*

These participants compared CCUS with nature or natural approaches to frame it as dirty, expensive and dangerous. As we have discussed in Chapter 5, these participants depicted CCUS as unsafe because it is "playing with nature" and putting nature itself at risk. This was an important factor in these participants strongly rejecting CCUS having any role in the pathway to net zero.

[34] Bellamy, R., & Osaka, S. (2020). Unnatural climate solutions? *Nature Climate Change*, *10*(2), 98-99.

Other participants stated a preference for what they described as "natural ways", with the implication that natural is better. These participants balanced the desirability of what they saw as natural solutions with the effectiveness of CCUS (this is discussed in more detail in Sections 7.7.1 and 7.7.2. which explore views of renewables and planting trees and restoring wetlands).

Only a couple of participants expressed an explicit preference for CCUS on the grounds of favouring technology based approaches for reaching net zero.

> *"I think the driver for net zero needs to be technology based. Trees won't do it. Behavioural change will be very difficult. I started off thinking the sheer scale of what had to be done was a bit pie in the sky but with my technology brain in gear it did seem doable, as a sizable part of the mix."*
>
> *Liverpool participant, Week 4*

Where participants did talk positively about CCUS as a technological solution to meeting net zero, this tended to be more in terms of a means to an end, the creation of jobs and enabling the UK to be a world leader in the technology.

> *"We could be world leaders in this, create millions of jobs. We could spread it throughout the rest of the world… It has to be done - something has to be done."*
>
> *Teesside participant, Week 1*

7.6 CCUS and multiple approaches to net zero

From the first week of the dialogue, the majority of participants preferred a pathway to net zero with multiple approaches. On average, participants allocated between 16%-18% for all strategies, with the exception of nuclear (7%) and renewables (24%).

Participants' views on the scale of the task of decarbonisation informed support for multiple approaches. Throughout the dialogue, participants made this point to each other in discussions on CCUS, but this was particularly prominent in Week 4, as participants were reflecting on the dialogue.

> *"It's almost impossible. We need to all do our bit. Not enough is being done to produce electric vehicles, or use hydrogen safely. We're not doing enough with our wetlands, planting enough trees. We're all wasting energy. We need to change. Carbon capture is a great idea, but it can only work alongside everything else."*
>
> *Port Talbot participant, Week 4*

Several participants appreciated the way the WWF representative who appeared in a video in Week 4 framed CCUS as one potential decarbonisation strategy of a number, including strategies which WWF view as more certain in their contribution to tackling climate change, such as renewable energy and behaviour change.

> *"I agree with [participant name] and [participant name], great to get a different angle from WWF. I also thought it was interesting, positive that they mentioned it's not going to be the solution for all problems, we need to look at different approaches to maximise overall benefits of cutting emissions."*
>
> *Aberdeen participant, Week 4*

Some participants felt that pursuing several strategies reduced the risks involved if things went wrong with one strategy or it was less effective than hoped. One participant described this as a multi-pronged approach.

> *"A multi-pronged approach, as we can't rely on one, as there can be failures, as there will be some people out there who will be resistant, and that would hold back progress. So, to make up for that you can push for another prong in the approach."*
>
> *Liverpool participant, Week 4*

Overall, participants found it useful to consider CCUS in the context of other solutions. For the public to be able to evaluate CCUS as an effective solution on the pathway to net zero, it is important to situate CCUS within a spectrum of solutions and to be clear about the specific

role that it plays.

7.7 How CCUS relates to other strategies for reaching net zero

Throughout the dialogue, participants considered the use of CCUS in relation to other strategies to reach net zero. As the dialogue focused on CCUS, it is worth reiterating that none of these other strategies were discussed in detail. However, participants' views on other strategies and the use of other technologies in reaching net zero gives us further insight into participants opinions on what role CCUS should play.

7.7.1 CCUS and renewable energy

Dialogue participants were consistent in their support for renewable energy as a strategy contributing to the pathway to net zero. Where participants made direct comparisons with CCUS, they tended to describe renewable energy generation as greener and cleaner, or as a simpler, cheaper or more reliable manner of achieving CO_2 reductions. Several participants positioned renewable energy as 'natural', implying, as discussed in Section 7.5, that natural is preferable.

> *"It [CCUS] wasn't going to be the only thing we were doing. I would like to think they would focus on natural things like replanting trees and renewables as well."*
>
> *Teesside participant, Week 4*

There were some participants who cautioned that investment in CCUS should not displace efforts to increase sources of renewable energy and one participant argued that a range of renewable energy options should be explored before making decisions about CCUS.

> *"I am not against having it in my area but wonder if there are simpler solutions such as the tidal barrage which would produce energy instead of capturing carbon. Also, rivers could produce energy for small numbers of people. Plus, heating local homes from the hot water produced from mine shafts. I would prefer that these were all looked at first."*
>
> *Port Talbot participant, Week 3*

As discussed in Section 4.2, a few participants expressed concern that investment in CCUS could divert resources from developing more sources of renewable energy.

A few participants had reflections on where energy to power Direct Air Carbon Capture and Storage (DACCS) is sourced from. Some believed that renewable energy should be used exclusively to reduce the carbon footprint of the process. Others expressed the view that if the bulk of the nation's energy needs were met through renewable energy, then the role of CCUS technologies (including DACCS) would be limited, as there would be "less carbon to capture".

7.7.2 CCUS and trees and wetlands

As with renewables, participants framed the option of planting trees and restoring wetlands as natural, with a few explicitly describing CCUS as unnatural when discussing the two together. Some participants thought that using trees and wetlands would be a cheaper and more sustainable option for capturing and storing carbon from the atmosphere.

> *"It still seems unnatural to create a man-made contraption to capture carbon when nature does it naturally. It would be far cheaper to plant more trees/hemp and look after our land rather than destroy it."*
>
> *Port Talbot participant, Week 3*

In a few instances, participants deployed moral arguments to express a preference for planting trees and restoring wetlands over CCUS. They would stress humanity's culpability for climate change and biodiversity loss on the one hand, and humanity's responsibility to address these crises on the other.

Several participants highlighted broader advantages of this approach, with trees and wetlands contributing to restoring nature and biodiversity, which they saw as an important objective in its own right.

Some participants discussed CCUS and planting trees/restoring wetlands achieving the same purpose – reducing CO_2. Initially, this resulted in participants expressing a strong preference for planting trees and restoring wetlands, which they saw as a safe and natural process, while they considered CCUS to be a less secure and artificial equivalent.

As the dialogue process evolved, some of these participants retained their original views, preferring to use these approaches over CCUS on the pathway to net zero, while others changed their opinions, believing that both CCUS and planting trees and restoring wetlands

can contribute to the UK's pathway to net zero.

> *"My mind's changed a lot through this process. At first, I just wanted to plant more trees, but now I think this will be great for Teesside – it will create lots of jobs and be good for the area."*
>
> *Teesside participant, Week 4*

A few participants raised doubts about the efficacy of planting trees and restoring wetlands, arguing that CCUS could deliver greater benefits. They thought that planting trees / restoring wetlands would take too much land and/or time to substantially reduce the UK's CO_2 emissions. Others thought that tree planting and wetland restoration in the UK would not suffice to offset the destruction of carbon sinks elsewhere in the world.

> *"Planting trees and wetlands just seems like a gargantuan task. There's no way us planting a few trees will offset the damage in places like the Amazon - I don't think it's the solution."*
>
> *Liverpool participant, Week 1*

7.7.3 CCUS and behaviour change

Participants disagreed on fellow citizens' willingness and ability to adjust their lifestyles to cause fewer CO_2 emissions. Where participants were confident that people could and would make a difference through behaviour change, they often favoured it over CCUS. The opposite was true for participants who were more sceptical; they doubted that behaviour change could substantially contribute to the pathway to net zero. Some of these participants explicitly linked this to their support of CCUS, which they described as an easier, faster or more reliable manner of reducing net CO_2 emissions, and as such would contribute more to the pathway to net zero.

> *"I now have a better understanding of CCUS and how effective it is. It can provide jobs and it also doesn't rely on a behavioural change from everyone meaning it will be easier to implement."*
>
> *Liverpool participant, Week 2*

A few participants believed that CCUS could undermine efforts to

bring down emissions through citizens' lifestyle choices. They felt the idea of CO_2 emissions being captured might desensitise people to the impact of emissions and make them less motivated to reduce their carbon footprint.

> *"I think behaviour as a whole, in terms of recycling, buying an electrical car, people might think that in their lifetime, carbon won't affect them so why should they do it. And if they know about carbon capture they might think 'why bother?' even more."*
>
> *Nottingham participant, Week 2*

7.7.4 CCUS and nuclear power

Participants did not generally discuss nuclear power in the context of other decarbonisation strategies. Where participants did draw comparisons between nuclear power and CCUS, this was in terms of the long-term safety of the waste (see Section 5.1 for more details).

A few participants thought that nuclear power should be prioritised over CCUS. One argument was that large-scale low-emission energy generation through nuclear technology would remove the need for CCUS; another that the development of new nuclear power stations in the UK was well underway and that the potential carbon saving benefits of these stations were already factored into the pathway to net zero.

A few others arrived at different conclusions and said that the dialogue process had prompted them to shift their priority from nuclear power to CCUS on the grounds of safety and cost.

> *"I was probably more traditional, with nuclear and renewables. I was under the impression they would be easier to implement. With CCUS and knowing more about it I can think we can get similar results for safer to cheaper and better. So, I went from 5% [contribution to net zero] to about 25%."*
>
> *Teesside participant, Week 4*

7.7.5 CCUS and energy efficiency and new technologies

While most participants included energy efficiency and new technology in the strategies they saw as important for achieving net zero in 2050, they did not discuss this option in detail. Participants did not explicitly compare energy efficiency and new technology to

CCUS. One aspect that was implicit in some participants' overall reflections on CCUS was that addressing the level of emissions "at the source" was preferable to addressing emissions by capturing and storing them. One of the key reasons for supporting the energy efficiency strategy is that it focuses on emissions reduction.

7.8 Pathway to net zero criteria

Participants' criteria [35]

- CCUS should be implemented alongside other measures as part of a pathway to net zero.
- CCUS should only be implemented if it is guaranteed (and can be demonstrated) to make a significant contribution to achieving net zero by 2050.
- The costs of CCUS must also be considered and there is a trade-off between cost and effectiveness.
- CCUS needs to be implemented in time to reach the goal of net zero by 2050.

[35] During the dialogue, participants were asked to develop criteria the Government should consider for the implementation of CCUS. A full list of the criteria generated can be found in Chapter 3.

8 Key considerations for CCUS engagement

Summary

- Participants thought it is important to engage with local communities directly impacted by CCUS. Participants wanted this engagement to be inclusive and meaningful, taking on board people's views.
- Participants felt the public should be better informed about CCUS. Participants suggested a variety of methods, including educational approaches, to reach a wide range of people.
- Trust was seen as integral to communicating about CCUS. Participants trusted information from sources they perceived as having no vested interest in CCUS and which they thought had credibility to evaluate impacts.
- Participants wanted information on CCUS for local communities and the general public to be transparent, balanced and to explain the risks as well as the benefits. Participants regarded transparency as particularly important on safety, costs and the environmental impact of CCUS, both in terms of reaching net zero and the local environment.
- Participants thought information should be easy to understand, as many regarded CCUS as complex and difficult to comprehend. As people may want different levels of detail, participants suggested a tiered approach, with a high level, simple overview for those who wanted a basic understanding, supported by more in-depth information which could answer more detailed questions and concerns.
- Participants found it helpful for CCUS to be framed in the context of the pathway to net zero, both in terms of the scale of the task and the variety of approaches required.

By the end of the dialogue, there was broad consensus that the public should know more about CCUS and that engaging with impacted communities was particularly important. This chapter explores views on local engagement and what people wanted to see at a national level. It also looks at how and by whom information on CCUS should be provided, and in particular the importance of transparency and trusted messengers.

8.1 Local engagement with local CCUS projects

Participants wanted to see broad and inclusive processes in engagement on proposed local projects. Participants tended to be less trusting of private companies and were concerned that they would not have the best interests of communities at heart, so were keen to see other organisations, for instance environmental NGOs, involved. Local councils and MPs were mentioned, but others (particularly in locations where participants had less trust in government) felt that independent local groups should also have a role in any engagement.

Some participants stressed the importance of any consultation process actually engaging with the local community and taking on board people's views.

> *"We want to be kept in the loop and we want them to listen to us and not just tell us what's going to be done."*
>
> *Teesside participant, Week 3*

Participants felt clear information and transparency was needed throughout the process to enable local communities to have informed views of the project.

> *"The public being informed, transparency, that should be on the part of the local authority. Step by step, the process of pre-planning, construction and so on. There should be details of how this process will be beneficial."*
>
> *Nottingham participant, Week 3*

Participants thought that without a good understanding of the costs, risks and benefits of CCUS, local people would not be able to meaningfully respond to proposals that might impact them. Consequently, some participants advocated for information to be provided directly to households near a proposed site.

In general, participants were keen for local communities to have access to reliable information about any potential CCUS application in their area covering:

- Safety of the proposed installations.
- Costs and funding.
- The role of CCUS in reaching net zero.
- Local environmental impacts (to wildlife and the land).

- Economic benefits.

Some thought that written materials would be appropriate, but others felt that the complexity of CCUS meant intermediaries would be needed. Suggestions included local panels with independent experts (see Section 8.3.1 below about trust and transparency) who would be able to review the information about the proposed CCUS project and communicate it to local communities.

Participants wanted information to be timely so that they could ask questions of those involved in implementing the projects and have time to influence plans. They asked for wide publicity locally, not just "signs on lampposts" to ensure the information was widely accessible. There was recognition that the implications for people in the areas where CCUS infrastructure would be sited are different depending on the location, and any information should be tailored to the local priorities and proposed project.

> *"In order that the path to deploying CCUS in my local area be as smooth as possible I would like to see, published prior to introduction, a clear set of inputs and outputs that articulates the benefits and shortcomings thus keeping the communities onboard with any CCUS deployed initiatives."*
>
> *(Port Talbot, Recollective comment)*

Aside from local residents, there were recommendations for project developers to engage with local stakeholders. Suggestions ranged from apprenticeship providers and colleges, to local businesses, environmental groups and landowners. Participants felt it was important that those who might benefit were informed of the opportunities, and those who might be affected negatively understood the reason for the development.

8.2 CCUS at a national level

There was broad consensus that the public need to know more about net zero and the potential role of CCUS in meeting this target. A few participants made an explicit distinction between the local and national level. At a local level, participants wanted meaningful engagement which enables people to voice their views, whereas on a national level, participants talked more about informing people about the role of CCUS.

> *"I think there could be more room locally as the disruption to communities it is fair to give opportunity to voice their views… But on a national level it is less about permission but them understanding why it is important."*
>
> *Liverpool participant, Week 4*

Participants emphasised the importance of building awareness and knowledge in the wider population, using a range of channels such as social media, national news and billboard advertising.

Reflecting on their experiences in the dialogue, participants felt that the wider population needs to be educated on the key facts about CCUS.

> *"A comprehensive, bigger picture and explanation about why this is so important. I was sceptical at the beginning, but we now know what should be done. There's got to be a lot of education."*
>
> *Teesside participant, Week 3*

When thinking about how best to educate people about CCUS, many participants focused on the importance of informing younger generations about the need for this technology and how it works, particularly so they can "take that information home" and tell their family and peers about it. Some suggested implementing programs in schools to educate young people about CCUS and its potential role in achieving the net zero target.

Others felt that this education could be tied to apprenticeships in an effort to both educate and offer young people opportunities to pursue careers in areas where CCUS is going to be deployed.

8.3 Information about CCUS

Throughout the dialogue, participants shared their thoughts and suggestions on how and by whom information on CCUS should be provided.

8.3.1 Trust and transparency

Participants wanted information provided about CCUS to be transparent and delivered by trusted messengers.

Both government and industry were seen to have a particular interest in achieving public approval for CCUS and as such neither were seen

to be trustworthy sources of information. Instead, participants wanted to hear from "experts" who had no perceived agenda and who would not "profit" from the decision.

> *"I'd still worry. The government only tells you what it wants you to know and hear than what is the truth. I'd rather that other countries or ethical companies tell us whether it's safe or not."*
>
> *Port Talbot participant, Week 3*

During the dialogue, a number of different specialists gave presentations and answered questions (the full list can be found at Appendix D: List of specialists). These specialists included academics, regulatory bodies (including the Health and Safety Executive and the Environment Agency), independent bodies (including the Climate Change Committee), and industry (including National Grid). Some gave presentations, while others provided support to the groups as they discussed the issues. As we have explored in more detail in Chapter 4 on feasibility and Chapter 5 on safety, some participants found specialists' answers to their questions and concerns very helpful.

However, some participants were initially sceptical about the information they were being presented with in the dialogue. Although the information provided in the dialogue had been reviewed by the Oversight Group[36] to ensure a range of views had been communicated, some participants thought it sounded "too good to be true" and therefore some were looking for "the catch".

> *"I'm a proponent of CCUS, however I would have liked to have seen more two-sided discussions from experts, i.e. experts with valid reasons for supporting and valid reasons for opposing."*
>
> *Liverpool participant, Week 3*

A few participants who were or became strong critics of CCUS felt that they had been presented with a "one-sided" view of CCUS. Their opinions were shaped their own research and what they heard from

[36] Details of the Oversight Group's membership and Terms of Reference can be found at Appendix B and C

each other rather than the information provided in the dialogue.[37]

> *"Even in today's sessions there's things I've never thought about – leaks earthquakes, Staufen[37]. We've only heard one-sided things - alarm bells go off. Why are they pushing that it's such a wonderful thing and that it's so safe?"*
>
> *Port Talbot participant, Week 4*

In the final week, participants were shown vox pops from spokespeople from three organisations: The Committee on Climate Change, the Carbon Capture and Storage Association and WWF. As we have explained earlier in this report (Sections 5.1 and 7.6), some participants were drawn to the views of the WWF spokesperson. These participants appreciated hearing what they regarded as a different perspective on CCUS and its role in the pathway to net zero.

> *"Interesting to get a more balanced view from independent people. The WWF is well-respected."*
>
> *Liverpool participant, Week 4*

Participants tended to trust WWF more on this question as:

- It was not perceived to directly benefit from the decision to proceed with CCUS.
- It was perceived to be equipped to evaluate the evidence and assess the likely impact on wildlife (and consequently the safety of CCUS).

Participants named other people and organisations they would trust to educate the public about CCUS. These included:

- Well-known people associated with science and the environment e.g. David Attenborough.
- Independent experts from established charities.
- Experts including academics with experience or knowledge of implementing CCUS in other countries or other relevant empirical experience. Some participants wanted to know that the appropriate research had been done.

37 https://www.researchgate.net/publication/279963863_Damage_to_the_historic_town_of_Staufen_Germany_caused_by_geothermal_drillings_through_anhydrite-bearing_formations

> *"The ground moves due to subsidence; how will that affect gas storage? The expert said that they have done research into this and this won't happen. I have confidence in the technology if they have done the research."*
>
> *Teesside participant, Week 4*

- Local communities who had actual experience of CCUS projects.

> *"I think we could have heard from people in Norway where this has been used. We could have heard the pros and the cons from them, rather than just what people think it'll be like."*
>
> *Port Talbot participant, Week 4*

8.3.2 Framing CCUS in the context of net zero

As we have discussed in Section 7.6, participants thought it is important to frame CCUS in the context of reaching net zero. At the start of the dialogue there was relatively low awareness of the implications of net zero, or of the range of potential routes to achieving this goal.

> *"I think as long as people are reminded of the catastrophic effects of global warming, possible solutions will always garner support. Climate change will do more to damage fishing stocks than CO_2 pipelines surely?"*
>
> *Liverpool participant, Week 3*

As discussed in Section 7.4, some participants had concerns about CO_2 emissions continuing, with some describing CCUS as a stop gap solution which buys time to find other ways to reduce emissions. This suggests that it will be important to explicitly communicate what sort of role CCUS is intended to have in reaching net zero and the extent to which it is a long-term solution or an interim measure.

8.3.3 Level of detail required

All participants agreed that the information provided should be simple and easy to understand. However, there was variation in the level of

detail they thought was necessary.

> *"They need to keep it simple. We've taken on a lot of information and I'm only just starting to get to grips with it. There are so many papers written about it, so much information. I looked on the Committee for Climate Change, and the bit I understood best was the diagram on there."*
>
> *Nottingham participant, Week 3*

Some only wanted the basic information they thought was necessary to assess what was planned. Specifically, this should include assurances that CCUS was safe, information about the cost and other potential risks and benefits.

> *"Don't know if I'd want to know nitty gritty but I'd want to know that it is safe and assurances about certain things."*
>
> *Aberdeen participant, Week 3*

Others wanted to be able to delve deeper into the evidence but with the information still presented in an accessible way so that it could be read and understood by the general public, rather than just by experts in the field. They hoped this would help them to evaluate the issues in more detail so they could have a more informed viewpoint.

> *"It's important to stress how safe the project is using clear examples, e.g. I was worried about leakage, but there's been studies in the UK looking at the effect of leakages from storage space, and it's not as bad as I thought....it's good to see that things have been done in real life and tested, not all just theoretical."*
>
> *Aberdeen participant, Week 4*

Overall, to meet the needs of all audiences it will be important to provide layered information, from a high-level summary, through to more detailed documents with further information and assurances about the underlying evidence to reassure people. In the absence of this more detailed information, people who want this level of detail may then mistrust the high-level information and consequently will seek out their own evidence.

8.3.4 Making concepts accessible

As discussed in Chapters 2 and 4, some participants initially found CCUS hard to understand. Participants found it particularly helpful when they were given relevant analogies that they could relate to, notably the chocolate bar analogy discussed in Section 5.1.

As we have discussed in Section 4.1, participants also valued real-world examples such as the existence of an established carbon capture and storage site in Norway.

Some suggested using pictures and diagrams was helpful to build people's knowledge.

> *"It does need to be pictorial for a lot of people. I switched off during the talking. Flyering local areas and getting the kids interested in diagrams will help."*
>
> *Nottingham participant, Week 3*

8.3.5 Providing answers to questions

Some participants felt they were not able to get satisfactory answers on key issues over the course of the dialogue. These questions were:

- Whether all the processes involved in CCUS are safe for local communities and the environment?
- What can go wrong and what would happen if something did go wrong (e.g. a CO_2 leak during transit or storage)?
- How much will CCUS cost to install and run and who will pay?
- What will the carbon footprint be of CCUS, and will it justify the emissions required to build the infrastructure and to transport the CO_2?

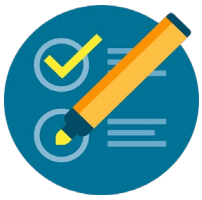
> *"I feel like I've learned a lot but there are so many ifs and buts. They do talk about safety, but things like hydrogen seem unanswered."*
>
> *Port Talbot participant, Week 3*

As noted above, participants liked tangible examples and evidence that CCUS is tried and tested. Some of these questions may be difficult to answer while CCUS technology is being developed. However, some participants were uncomfortable with uncertainty and a few remained concerned that their questions were not fully addressed. This

underlines the importance of the public being able to engage with trustworthy messengers who are honest and transparent.

> *"We need to know the information warts and all, not just the good stuff."*
>
> *Teesside participant, Week 4*

8.4 Criteria for local engagement



Participants' criteria [38]

- Local communities need to be meaningfully engaged with decision making about CCUS projects and provided with transparent and easy to understand information which clearly sets out both the benefits and risks of CCUS projects.

[38] During the dialogue, participants were asked to develop criteria the Government should consider for the implementation of CCUS. A full list of the criteria generated can be found in Chapter 3.

9 Conclusions

Most participants thought that CCUS has a role to play in the pathway to net zero. However, this support was conditional, above all, on CCUS being safe. Participants were concerned about the safety of both the storage and transport of CO_2, in particular the perceived risks of leaks and earthquakes, and the harm these might cause to marine life.

Participants' support was also conditional on CCUS making a significant and timely contribution to reaching net zero by 2050. They wanted its costs to be weighed against its impact on the net zero goal. A small group of participants were strongly opposed to CCUS because they saw it as not addressing the problem of producing CO_2 emissions and they regarded it as unsafe and unnatural.

Because of their concerns about safety in particular, participants felt that there should be oversight and regulation of all stages of CCUS projects which is independent of government and industry.

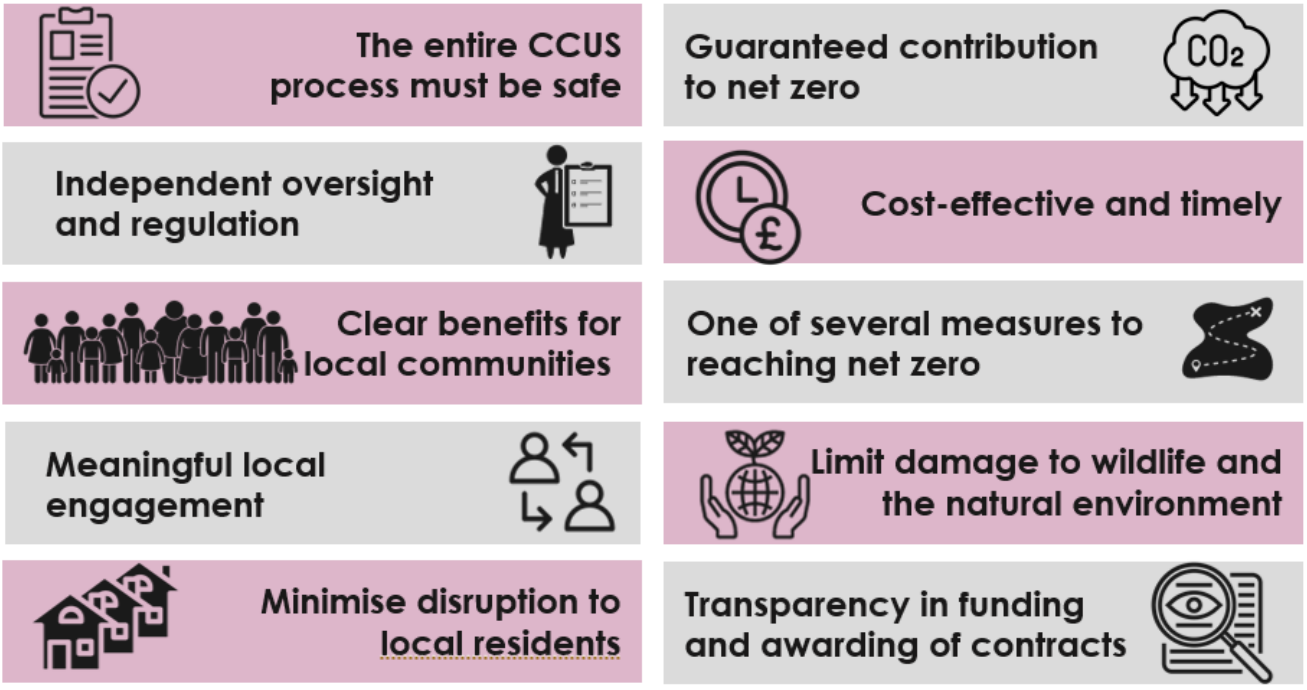


Figure 12. Participant views on CCUS and the pathway to net zero

Participants were more comfortable with the idea of CCUS being deployed nationally than in their local area. Participants thought that job creation was the key benefit of local deployment and participants in Aberdeen and Teesside were more positive than other locations because they could see a clear link between the CCUS project they considered in the dialogue and local jobs. Participants felt CCUS projects must deliver benefits to local communities, particularly in terms of job creation.

Participants wanted it to be clear how CCUS projects were being funded and for contracts to be awarded transparently and fairly to what they described as ethical companies. Participants placed high importance on engagement with local communities impacted by CCUS and on this engagement being inclusive and meaningful.

Appendix A: Research questions

For more information on 'weeks', please see the dialogue calendar in Appendix F

Table 3. Dialogue Research Questions

Research Theme	Research Questions
A) What do people think about **CCUS technology**, aspirations, benefits, fears, concerns? **Week 2**	What are participants' broad aspirations and concerns regarding CCUS technologies, including transport and storage infrastructure? Do these differ in local/ non-local areas?
	What issues does CCUS raise for participants? Environmental, economic, social, safety, and permanence of transport and storage?
	What aspirations do participants have for the deployment of CCUS? What does this mean for Environmental, economic, social, safety and permanence of transport and storage?
	What views, if any, do people hold towards different applications of CCUS (industrial, power, hydrogen, negative emissions)?
B) What do people think about CCUS in the context of **net zero**? **Week 1 and 4**	What are participants' views around different CCUS applications and their role in helping to meet zero carbon emissions?
	What role do participants see for CCUS in terms of helping to meet zero carbon emissions?
C) What are participant views on the **development of CCUS projects**? What conditions need to be met? **Week 3**	What conditions would participants expect to be in place if CCUS technologies were to be developed in a local area? Do these differ in local/non-local areas?
	What benefits would participants expect to derive from local developments?
	What safeguards and assurances would participants expect to be in

Research Theme	Research Questions
	place if CCUS technologies and the associated infrastructure were deployed in a local area?
	What role would participants expect to have around decisions for CCUS developments in their local area?
	What/when/how would they want to be informed about, and engaged on, any new development?
	What is most important for participants to find out about when thinking about CCUS developments? Does this vary between 'local' and 'non-local' participants?
	What can CCUS actors do to demonstrate their competence at operating CCUS facilities and their subsidiary operations?
D) What are participants views on **CCUS policy and governance**? **Weeks 3 and 4**	What suggestions do participants have for the principles which should underpin the deployment of CCUS technologies and CO_2 transport and storage?
	What expectations do participants hold of the organisations and institutions which could deliver CCUS policy and projects?
	Would anything further be desirable to develop trust in developers and government on this matter? (Environmental regulation, assurances, demonstrable local economic benefits etc.)
	What do people think about the Government supporting power and industrial companies to install and operate CCUS equipment?
E) What's **best practice** for **communicating about CCUS**?	How can we ensure that communications regarding CCUS are widely accessible? What language and terms do the public use in association with CCUS?

Research Theme	Research Questions
Explored throughout the dialogue	

Appendix B: Oversight Group membership

Table 4 – Oversight Group Membership

Name	Organisation
Prof. Nick Pidgeon (Co-Chair)	University of Cardiff
Dr David Reiner (Co-Chair)	University of Cambridge
Alastair Welch	Department for Environment Food and Rural Affairs
Chris Littlecott	E3G
Dr Clair Gough	The University of Manchester
Iain Macdonald	Oil and Gas Climate Initiative (OGCI)
James Smith CBE	Co-chair, CCUS Council
Kate Hearnden	Welsh Government
Kristina Dahlstrom	Oil & Gas Authority
Lawrence Donaldson	Health & Safety Executive
Liz Parkes	Environment Agency
Luke Warren	Carbon Capture & Storage Association
Margo Maciver	Scottish Government
Matthew Taylor	Department for Business, Energy & Industrial Strategy
Nick Kardahji	Prospect
Roz Bulleid	Green Alliance
Shirley Matheson	World Wildlife Fund
Tom Glyn-Jones	Environment Agency

Name	Organisation
Will Lochhead	Department for Business, Energy & Industrial Strategy

Appendix C: Oversight Group Terms of Reference

Overall Aim of the project:

The CCUS policy team at BEIS wish to sponsor a public dialogue to further develop our understanding of public attitudes towards CCUS. The output of this dialogue may be highly informative to the strategic coordination of CCUS deployment over the coming years.

The objectives of the project are:

1. To engage a diverse and inclusive group of the public in dialogue about the future use of CCUS technologies and applications, involving members of the public from areas where CCUS facilities are more likely to be developed (i.e. 'local') as well as areas less likely to be directly involved in CCUS deployment (i.e. 'non-local').
2. To explore participants' views on the role of CCUS in principle and its different applications, in helping to meet a net zero CO_2 emission target.
3. To gain an understanding of participants' aspirations and concerns towards CCUS, and how these may differ in areas where CCUS may be developed vs. areas where development is unlikely.
4. To gain insight into the conditions participants would wish to be met, if CCUS technologies and CO_2 transport and storage infrastructure is deployed in a local area, and the benefits they would expect to accompany deployment.
5. To inform the development of principles to underpin the deployment of CCUS technologies and CO_2 transport and storage.
6. To develop an evidence base which can be used to inform and refine development and delivery of future CCUS policy, including Government decisions on how any rollout of CCUS is managed, and to inform best practice for CCUS project developers.

1. Funding and delivery

The dialogue is jointly funded between the Department for Business, Energy & Industrial Strategy (BEIS) and UKRI's Sciencewise Programme. It will be delivered by Traverse, and the project will be independently evaluated by Ursus Consulting.

2. Role of the Oversight Group

The role of the Oversight Group is to support this research project by providing advice and oversight to ensure the deliberative dialogue plans, evidence and materials are accurate, balanced and unbiased. The group is expected to use their expertise to help ensure the research is as accessible and far reaching as possible, and targets relevant stakeholder groups.

Members are asked to:

- Bring diverse views and perspectives to the framing of the dialogue
- Bring intelligence from their own organisations to help shape the dialogue
- Disseminate and promote findings through their own networks
- Help select appropriate experts to inform the dialogue process, materials and speak at events, where necessary

It is expected that the Oversight Group will comment on the following:

- Overall methodology and approach
- Selection of workshop locations
- Background/stimulus materials
- Communications strategy
- Language and framing
- Questions asked during the dialogue
- Sampling and recruitment
- Outputs from the dialogue exercises (reports, videos, presentations, etc)

Whilst approval of the Oversight Group will be actively sought throughout the project, their role is advisory.

BEIS and UKRI's Sciencewise Programme will have the final responsibility for the dialogue process, materials and disseminating the project outcomes within BEIS and its stakeholders.

3. Time commitment

The project will take place over approximately a 7-10-month period, commencing in November 2019. Members will be asked to attend a limited number of formal meetings and give advice on their areas of expertise on an ad hoc basis.

The first Oversight Group meeting will be convened on 14th November 2019. At this meeting you will:

- Put forwards your, and/or your organisation's perspective towards

CCUS in the UK
- Agree upon these Terms of Reference
- Meet with the dialogue delivery contractor and independent evaluators
- Review initial delivery approach and agree on format for further input comment

2 - 3 further meetings will take place:

1. To review dialogue materials, stimulus and overall approach presented by dialogue delivery contractors
2. To review the emerging findings at the conclusion of dialogue workshops
3. (If there is sufficient desire) To review and comment on the final report

The purpose and timing of these follow-up meetings will be discussed during the 1st Meeting.

Every effort will be made to find dates when all Oversight Group members can attend meetings, ideally in person if not via conference call. For key items of business where the group's opinion is sought, but all are not able to attend, those not attending meetings will be invited to submit comments and views in advance and these will be presented to the rest of the group.

4. Transparency

Oversight Group meetings will be minuted; minutes will be sent to members after each meeting.

5. Criteria for selection of members

The Group will be comprised of approximately 15 members, excluding chairs, with a range of views and expertise including but not limited to the following;

- Energy and climate policy, UK and international
- Energy research and social science
- Environmental regulation
- Local economy and employment
- Public dialogue/science communication/media/public affairs

Members should represent a range of different perspectives and be committed to the following:

- Open dialogue
- Mutual respect

- Tolerance of other views and
- Willingness to see their own and others' opinions reviewed and discussed on their merits.

6. Chairs

- The Group will be co-chaired by:
  - Nick Pidgeon, Professor of Environmental Psychology, Director of the Understanding Risk Research Group, Cardiff University, and;
  - David Reiner, Judge Business School, University of Cambridge

Appendix D: List of specialists

Table 5 - Specialists

	Name	Organisation	Workshops attended
Specialists	Mike Hemsley	Climate Change Committee	Week 1 Session 1
	Indira Mann	Scottish CCS	Week 1 Session 1
	Dr Aaron Goater	Climate Change Committee	Week 2 Session 1 Week 2 Session 2
	Professor Martin Blunt	Imperial College London	Week 2 Session 1
	Dr Samuel Krevor	Imperial College London	Week 2 Session 1
	Professor Stuart Haszledine	The University of Edinburgh	Week 2 Session 1
	Dr Susana Garcia Lopez	Heriot-Watt University	Week 2 Session 1
	Dr Julia Race	Strathclyde University	Week 2 Session 1
	Dr William Joyce	Innovate UK	Week 2 Session 2
	Professor Peter Taylor	University of Leeds	Week 2 Session 2
	Professor Nick Pidgeon	University of Cardiff. Co-Chair of the Oversight Group.	Week 3 Session 1
	Tom Glyn-Jones	Environment Agency	Week 3 Session 1

The project representatives in the table below attended the first session in Week 3 where participants were presented with case studies of projects that were local to them.

Table 6. Project Representatives

	Name	Organisation	Job title	Project represented
Project Representatives	Kirsty Lynch	Pale Blue Dot	Communications Director	Project Acorn
	Chris Williams	Industry Wales	Head of Industrial Decarbonisation	South Wales Industrial Cluster
	Colin McGill	BP	Project director, Net Zero Teesside	Net Zero Teesside
	David Parkin	Progressive Energy	Director	HyNet Project

The specialists in the table below were interviewed over Zoom and these interviews were combined to create the Vox Pops video shown in the final session in Week 4.

Table 7. Vox pops specialists

	Name	Organisation	Specialism
Vox Pops Specialists	Luke Warren	Carbon Capture and Storage Association	CCS policy and CCS regulations.
	Chris Stark	Climate Change Committee	Climate change and net zero
	Shirley Matheson	World Wildlife Fund UK	Climate change

Appendix E: Demographics and recruitment

Demographics

We used a stratified sampling approach[39] to ensure that the dialogue participants were broadly reflective of the UK population. Our focus was on ensuring that we heard from the broadest range of voices. It is important to note that this was a qualitative process, and a sample of 112 people is not large enough to generalise results to the UK as a whole. We oversampled when recruiting based on ethnicity to ensure that there were no single participants speaking on behalf of an entire ethnicity. The rationale for each demographic quota is explained in the table below.

Table 8. Rationale for each demographic quota acquired through stratified sampling

Criteria	Basis for quota	Rationale
Age	Nationally reflective	Diverse sample
Gender	Nationally reflective	Diverse sample
Ethnicity	Locally reflective	Religious and cultural practices can influence environmental views, ethnicity is a simple if crude proxy for this
Socio-economic grade	Locally reflective	Economic benefits are a key part of the debate on CCUS in local areas
Urban/suburban/rural	Locally reflective	The type of location where people live can influence views on infrastructure siting
Exclusion and additional criteria	The following groups were excluded: 1. anyone directly employed or with family employed in developing CCUS 2 anyone employed in market research We measured but did not quota for concern	

39 Stratified sampling is a type of sampling where the total population is divided into smaller groups to complete the sampling process. In this case, the smaller groups were based on demographic characteristics such as gender, age and ethnicity.

Criteria	Basis for quota	Rationale
		about climate change and knowledge of CCUS, using questions from BEIS' Public Attitudes Tracker. Responses were monitored to ensure there was no significant skew in recruitment based on the topic/location.

For age and gender, we recruited a nationally reflective sample. Quotas for ethnicity, socio-economic grade, and rural/urban location, were tailored to each of the locations, so that each group was broadly reflective of the local population. We did, however, recruit slightly higher numbers of participants from minority ethnic groups. This ensured that no individual was reflecting an entire ethnicity or felt isolated and ensured that a wide range of views were heard in the dialogue. The full sample breakdown is below.

Table 9 - Urban/rural breakdown

Urban/Rural		Urban	Rural	Undisclosed
England and Wales	National average	81.5%	18.5%	
	Our sample	84.1%	13.6%	2.3%
Scotland	National average	70.8%	29.2%	
	Our sample	66.66%	33.33%	

Table 10 - Socioeconomic grades

SEG	AB	C1	C2	DE
National average	15.9%	30.5%	20.1%	33.6%
Our sample	21.4%	36.6%	18.7%	23.2%

Table 11 - Ethnicity

Ethnicity	White British	White Other	Mixed Carib-bean	Mixed Other	Asian Indian	Black African	Mixed white and Asian	Asian other	Other Black	Other, self-identi-fied
National average	80.5%	4.4%	0.8%	0.5%	2.5%	1.5%	0.6%	1.5%	0.5%	
Our sample	49.1%	19.6%	0.9%	1.8%	1.8%	0.9%	0.9%	8.9%	8.0%	8.0%

Table 12 - Age

Age	18-29	30-44	45-59	60-74	75+
National average	20.6%	26.1%	24.6%	18.7%	9.9%
Our sample	29.5%	26. 8%	21.4%	15.2%	6.3%

Table 13 - Gender

	Male	Female
National average	49%	51%
Our sample	52.2%	47.8%

Attitudes

During recruitment, we measured participants' concern about climate change and knowledge of CCUS, using questions that are also used in the BEIS Public Attitudes Tracker survey.[40] While quotas were not set, recruitment was monitored to ensure there were a broad range of views. This helped us to ensure that participants' views coming into the dialogue were broadly consistent with the UK population as a whole. The questions we asked are detailed in the tables below.

Overall, our participants were slightly more likely to have heard about carbon capture and storage compared to the baseline in the Public Attitudes Tracker, but no more likely to know a little or a lot about it.

Table 14 – Knowledge of carbon capture and storage

Q: How much, if anything, do you know about carbon capture and storage?

	BEIS Tracker (%) March 2020	Dialogue average	Difference	Aberdeen	Liverpool	Teesside	Nottingham	Port Talbot
Know a	4%	6%	2%	4%	0%	13%	10%	5%

40 BEIS Public Attitudes Tracker: Wave 33 (www.gov.uk/government/statistics/beis-public-attitudes-tracker-wave-33)

lot about it								
Know a little about it	19%	23%	*4%*	29%	30%	22%	19%	14%
Aware of it but don't really know what it is	23%	35%	*12%*	42%	39%	30%	19%	43%
Never heard of it	54%	36%	*-18%*	25%	30%	35%	52%	38%
Total Number		112	*n/a*	24	23	23	21	21

Among participants who knew at least a little about carbon capture and storage, levels of support were lower than found in the Tracker, due to a higher proportion of 'don't knows.' Levels of opposition were similarly low.

Table 15 – Support for carbon capture and storage in the UK (based on all who know at least a little about carbon capture and storage)

Q: From what you know, or have heard about using carbon capture and storage in the UK, do you support or oppose its use?

	BEIS Tracker (%) March 2020	**Dialogue average**	***Difference***	**Aberdeen**	**Liverpool**	**Teesside**	**Nottingham**	**Port Talbot**
Strongly support	18%	9%	-9%	-	-	13%	17%	-
Support	44%	24%	-20%	-	43%	25%	50%	-
Neither support nor oppose	31%	33%	2%	-	43%	63%	33%	25%
Oppose	4%	6%	2%	13%	14%	-	-	-
Strongly oppose	2%	-	-2%	-	-	-	-	25%
Don't know	1%	27%	26%	88%	-	-	-	50%
Total Number		33	*n/a*	8	7	8	6	4

NB: Base is those who know a little or a lot about carbon capture and storage, consistent with the Public Attitudes Tracker methodology

Dialogue participants were no more concerned about climate change than the general public. However, when thinking about the causes of climate change, our participants were slightly more likely to think that climate change is mainly caused by human activity as opposed to natural processes.

Table 16 – Concern about climate change

Q: How concerned, if at all, are you about current climate change, sometimes referred to as 'global warming'?

	BEIS Tracker (%) September 2020	Dialogue average	*Difference*	Aberdeen	Liverpool	Teesside	Nottingham	Port Talbot
Very concerned	38%	48%	*10%*	46%	57%	26%	62%	52%
Fairly concerned	44%	45%	*1%*	54%	43%	61%	29%	33%
Not very concerned	12%	4%	*-8%*	-	-	9%	5%	5%
Not at all concerned	4%	2%	*-2%*	-	-	4%	-	5%
Don't know	3%	2%	*-1%*	-	-	-	5%	5%
Total Number		112	*n/a*	24	23	23	21	21

Table 17 – Views on causes of climate change

Q: Thinking about the causes of climate change, which, if any, of the following best describes your opinion?

	BEIS Tracker (%) March 2020	Dialogue average	Difference	Aberdeen	Liverpool	Teesside	Nottingham	Port Talbot
Climate change is entirely caused by human activity	17%	6%	-11%	21%	-	4%	5%	-
Climate change is mainly caused by human activity	30%	46%	16%	33%	30%	48%	57%	62%
Climate change is partly caused by natural processes and partly caused by human activity	39%	39%	0%	46%	39%	43%	33%	33%
Climate change is mainly caused by natural processes	6%	8%	2%	-	30%	4%	5%	-
Climate change is entirely caused by natural processes	2%	-	-2%	-	-	-	-	-
I don't think there is such a thing as climate change	2%	-	-2%	-	-	-	-	-
Don't know/no opinion	-	1%	1%	-	-	-	-	5%
Total Number		112	n/a	24	23	23	21	21

Recruitment

Participants were recruited by a professional recruitment agency that

used a mix of on-street and digital recruitment methods. As recruitment for this dialogue began before COVID-19 restrictions came into place, some participants were recruited face-to-face, whilst others were recruited through databases and networks. When trying to recruit in Teesside, recruiters could not fulfil the quotas without extending the search areas and so when this report refers to Teesside, it also includes the surrounding areas. Participants were recruited with clear and accessible information about the process, but not the topic, so that people with more interest in CCUS were not more likely to attend. This ensured a broad range of views.

Participation was incentivised, with participants receiving a maximum of £320 for attending all workshops and completing all activities. Incentives were weighted to encourage participation in all sessions, including the video calls and online platform activities. Workshops were incentivised at £25 per session, including a £50 bonus for attending every session. Participants who completed all homework activities received an additional £75, whilst those who did not complete all activities but who completed at least one received £37.50.

Digital inclusion

While many participants found the online process convenient and accessible, we also identified a risk that some people could be excluded because of a lack of access, skill or confidence using digital tools. To minimise digital exclusion and dropout rates, every participant was contacted prior to the dialogue and given the opportunity to explain any additional needs and ask for support. We also hosted a 'tech check' prior to the process which enabled participants to get familiar with the technology and request and receive any additional support they may have needed. Participants received £20 for attending this. Participants were also supported with any technical issues throughout the process by members of the team, with a dedicated tech support present at each online workshop.

Attendance

The effectiveness of the digital support provided is demonstrated in the participant attendance statistics, which show that 83% of participants attended every workshop and 78% of participants completed all activities on the online platform. Participants who had initial tech support and one to one phone calls from our team took part at similar levels to others, and requests for support reduced

dramatically throughout the process. Reasons for missing sessions included health problems, technical issues and personal emergencies such as a burglary.

Appendix F: Dialogue process and activities

Development of dialogue activities

Prior to developing the process and materials for the dialogue, we conducted a rapid evidence review. This enabled us to ensure that information provided to participants was accurate and objective. Using a mix of desk research and interviews with stakeholders with a diverse range of views on CCUS, the review explored factors to consider in designing the dialogue. Following the rapid evidence review, we took an iterative approach to designing the process and materials, including a review by the Oversight Group and three face-to-face pilot sessions with members of the public.

Across the seven weeks of the dialogue, we engaged participants in four weekly cycles of events and activities. These are referred to as Weeks 1, 2, 3 and 4. The structure of the dialogue was based on the research questions (as listed in Appendix A).

Each week explored CCUS through a different lens or framing. This allowed us to introduce information at a measured pace and to explore how participant views changed depending on the context in which CCUS was discussed.

The table below shows the key workshop content in each week.

Table 18 - Workshop content

Week	Content	Key question/framing
1	**Climate change and net zero**: introducing participants to the concept of net zero and of negative emissions, intro to the concept of CCUS.	What are participants' initial reactions to CCUS, in the context of climate change and net zero?
2	**CCUS technology and applications**: exploring the different stages of CCUS (capture, transport, usage and storage) and the different applications (industry, power generation, Bioenergy with Carbon Capture and Storage (BECCS), Direct Air Carbon Capture and Storage (DACCS) and hydrogen production).	What are participants' attitudes to the different applications and stages of CCUS?
3	**CCUS projects**: introducing case studies for each of the four local areas (Nottingham had no local	How do participants view CCUS in the context of an

	case study so participants reviewed a case study in another area).	infrastructure project in their area?
4	**CCUS policy**: exploring different views on the path to net zero, each with a different role for CCUS.	In what policy context do participants see a role for CCUS?

In Weeks 1, 2 and 3, participants met on a Tuesday and Thursday evening, for 90 minute sessions with around half of that time in discussion groups of six to eight, and the remainder in plenary. In the final week (Week 4) only one session took place, on a Tuesday.

We ran two sessions per evening and 13 sessions in total. Participants from Liverpool, Port Talbot and Nottingham took part in one session and participants from Aberdeen and Teesside in the other.

It should be noted that for the first three weeks, participants interacted with the same group of people from their own location in break-out discussion groups. There were two subgroups per location. In the final workshop, in Week 4, participants were put in groups with participants from the other locations, which gave them an opportunity to hear other perspectives.

Over the course of the dialogue, participants used Recollective to complete individual activities and feedback tasks relevant to the discussions in each week. The Recollective platform was a useful tool, and 86% of participants completed all activities. Take-up was not, however, universally and two participants, despite receiving contact and tech support, did not engage at all with the online activities.

Breakdown of the dialogue activities

Week 1:

- **Synchronous Zoom Session 1: CCUS in the context of net zero**
    - **Objective** - To introduce participants to the carbon cycle, climate change including historical emissions, the concept of net zero, and the principle of carbon capture and storage.
- **Synchronous Zoom Session 2: CCUS in the context of net zero**
    - **Objective** - To understand participants attitudes and preferences towards net zero technologies and their relative importance.
- **Recollective platform questions (repeated measures are marked *)**

- **My Net Zero Pathway***
  - Participants were asked to use a slider task to indicate how much of a role they think each of these solutions should have in helping the UK reach net zero by 2050.
- **Acceptability of CCUS in the UK and locally***
  - Participants were asked 'How do you feel about CCUS being deployed in the UK?
- **Understanding of CCUS***
  - Participants were asked 'Based on what you know at this moment in time, how would you rate your understanding of CCUS?

Week 2

- **Synchronous Zoom Session 1: CCUS technology**
  - **Objective** - To enable participants to learn about and discuss CCUS technology. Information provided on each stage: capture, transport, usage and storage; and different applications: industry and power generation.
- **Synchronous Zoom Session 2: CCUS technology**
  - **Objective** - To enable participants to learn and discuss hydrogen production and negative emissions technology. To begin the development of CCUS project criteria.
- **Recollective platform questions (repeated measures are marked *)**
  - Pros and cons of CCUS
  - Participant questions
  - Criteria for deploying CCUS
  - My net zero pathway*
  - Reflections and whether views have changed

Week 3

- **Synchronous Zoom Session 1: CCUS projects**
  - **Objective** - To enable participants to learn about specific CCUS project proposals. To understand participants' views on CCUS projects in their local area. Case studies for each

of four locations.

- **Synchronous Zoom Session 2: CCUS projects**
    - **Objective** - To enable participants to learn and discuss CCUS planning and project development. To understand if and how participants' needs, and expectations, change over the course of the development of a CCUS project. To encourage participants to see the project development from different perspectives.
- **Recollective platform questions (repeated measures are marked *)**
    - Pros and cons of each case study (Liverpool, Aberdeen, Teesside, Port Talbot)
    - My Net Zero Pathway*
    - Acceptability of CCUS in the UK and locally*
    - Understanding of CCUS*
    - What 3 words would you use to describe your views on CCUS?*

Week 4

- **Workshop 1: CCUS policy**
    - **Objective** - To understand participant views on CCUS policy and governance, including if and how CCUS technology fits in the UK policy pathways to net zero.
- **Recollective platform questions (repeated measures are marked *)**
    - What 3 words would you use to describe your views on CCUS?*

Appendix G: Analysis

What data was collected?

In order to analyse participant views in depth we collected three main types of data during the project:

- Individual participant generated data, collected using tasks and activities uploaded to the Recollective platform.
- Group generated data from transcripts of Zoom workshops.
- Facilitator notes and observations.

Qualitative data

We coded all of the qualitative data collected from verbatim transcripts of workshops, facilitator observations and individual Recollective responses using our bespoke analysis tool – Magpie. We considered both stated attitudes and how participants express their views, informed by discourse analysis. We coded data at sentence level using a code frame, adding subcategories where necessary.

Four overarching themes were identified – feasibility, safety, deployment and the role of CCUS on the pathway to net zero. These themes were used to structure our analysis and the writing of this report and are reflected in the headings of chapters 4-7.

Verbatim quotes have been selected to demonstrate the type of language participants used and how views were expressed.

Quantitative data

All quantitative data was collated from closed questions that were individually answered by participants on the online Recollective platform. Not all participants answered all questions, so the sample size varies. The quantitative data has been used primarily to assess any changes over time, particularly where participants were asked to rate how they feel about CCUS technology. We used this data alongside qualitative data to triangulate the results. The quantitative data complement the findings of the discussions and are supplemented by the comments that participants added on Recollective to explain their selection.

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