Public perception of CCS:

A Review of Public Engagement for CCS Projects

2nd Report of the Thematic Working Group on:

Policy, regulation and public perception

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About the CCUS Projects Network

The CCUS Projects Network comprises and supports major industrial projects underway across Europe in the field of carbon capture and storage (CCS) and carbon capture and utilisation (CCU). Our Network aims to speed up delivery of these technologies, which the European Commission recognises as crucial to achieving 2050 climate targets. By sharing knowledge and learning from each other, our project members will drive forward the delivery and deployment of CCS and CCU, enabling Europe's member states to reduce emissions from industry, electricity, transport and heat.

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Executive summary

There is an increasing awareness amongst governments around the world in the light of the widely accepted 'climate emergency', that carbon dioxide capture and storage (CCS) and carbon dioxide capture and utilisation (CCU) will be necessary to enable the deep carbon dioxide emission reductions needed to reach carbon neutrality by 2050. This needs to sit alongside a just transition for regions reliant on fossil fuels and carbon-intensive industry, and avoid a decline in employment and economic activity.

However, there is a lack of awareness of CCS as a climate mitigation technology amongst the general public and key stakeholders, and acceptance is hampered by some propagation of misleading beliefs, such as 'the technology does not work'. Some of the identified issues include a lack of trust of the businesses leading the project, and/or of the decision-makers such as regional or national government; fear of the risks associated with transport and storage and of environmental damage caused by the project; impact on local livelihoods; lack of belief in climate change and/or objections to the use of public money for CCS.

This report reviews the ways that CCS pilot and demonstration projects have addressed these issues and worked with key stakeholders to achieve project acceptance, including learning from two example projects: the Illinois Basin - Decatur Project in the USA and the Shell Quest Project in Canada. A compendium of materials used on projects and publicly available for teaching and public engagement is included at the end of the report.

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1 Introduction

There is an increasing awareness amongst governments around the world in the light of the widely accepted 'climate emergency', that carbon capture and storage (CCS) and some forms of carbon dioxide capture and utilisation (CCU) will be necessary to enable the deep carbon dioxide (CO_2) emission reductions needed to reach climate neutrality by 2050. This has to sit alongside a just transition for regions reliant on fossil-fuels and carbon-intensive industry, and avoid a decline in employment and economic activity. There is a lack of awareness of CCS as a climate mitigation technology amongst the general public and key stakeholders, and some propagation of misleading beliefs, such as 'the technology does not work'. As stated by David Cameron, then Prime Minister of the UK, to parliament after the cancellation of the DECC £1BN competition "In government you have to make tough choices. You have to make decisions about technology that works and technology that is not working [and] we made the right choice." (Carrington, 2015)

There have been failures to deliver CCS projects due to lack of public acceptance, notably Barendrecht, Netherlands (Limousin, 2010; Shell, 2014) amongst others. The Barendrecht project planned to store CO_2 from Shell's Pernis oil refinery, in a depleted gas field under the town of Barendrecht. The inhabitants were worried about damage to their homes and subsequent drops in property value and the project was cancelled. The reasons for this failure are explored further in Section 2.1. The learning from all large infrastructure projects, including wind turbines and railway lines, is that it is important to get public engagement right, from an early stage in the project development.

"*Effective stakeholder engagement and communication is fundamental to the success of any project – it helps ensure appropriate positioning of the project, management of emerging issues or risks, and also helps ensure that mitigation, management and enhancement measures are identified and developed in a way that reflects concerns and aspirations expressed by key stakeholders." (Shell, 2016)*

1.1 Objective and scope

The CCUS Projects Network provides a forum for EU CCUS projects to discuss issues, share knowledge and identify barriers and risks to the deployment of CCUS. Regular Knowledge Sharing meetings are held for the Network members and the subjects for the Themed Reports delivered by the Network Secretariat and Network members are proposed and discussed at these meetings. This report reviews the ways in which CCS pilot and demonstration projects have addressed public perception issues and worked with key stakeholders to achieve project acceptance, including the experiences of two example projects: the Illinois Basin - Decatur Project in the USA, and the Shell Quest project in Canada. A compendium of materials used on projects and publicly available for teaching and public engagement is included at the end of the report.

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1.2 Structure of this report

This report consists of five main sections. Firstly, an introduction, followed by the second section which provides an overview of CCS public acceptance. The third section presents the learning from the Illinois Basin - Decatur Project in the USA, and the Shell Quest project in Canada providing an insight into how these two projects handled public acceptance and provide lessons learnt for other projects. Some conclusions drawn from the analysis are presented in the final section. A compendium of materials used on projects and publicly available for teaching and public engagement, is included at the end of the report.

2 Overview of CCS public acceptance

2.1 Lessons learnt from the past

The learning from failed and successful infrastructure projects is unanimous:

"*The most important lesson learned from the Barendrecht project is that it is important to create mutual trust between stakeholders and commitment to each other and to the project. This can be done by including all stakeholders in the project process at an early stage and communicating about the project and its process to the community*." (Brunsting, Best-Waldhober, Feenstra, & Mikunda, 2011)

The Barendrecht project intended to inject about 10 $MtCO_2$ from Shell's Pernis oil refinery over a 25 year period in a depleted gas field under the town of Barendrecht, The Netherlands. Initial criticism and public opposition to the project developed into a disagreement between local and national government and the project was ultimately cancelled. There was a strong feeling from local stakeholders that they had not been included in the decision-making process (Brunsting et al., 2011) and that the risks associated with the project were high: they were worried about damage to their homes and subsequent drops in property value.

It is often assumed that there is widespread lack of knowledge and understanding of CCS amongst the general public, and that non-technical people are more often opposed to CCS projects than those with a greater technical understanding. However, there is also evidence that a greater awareness and understanding of CCS does not necessarily result in a more positive attitude towards CCS. Trust in the organisations providing the information has a strong influence on how the information is received by stakeholders; and is perceived as being more balanced and neutral if provided by independent bodies or researchers, and when supported by multiple information sources (Brunsting et al., 2011; Mabon, Shackley, Blackford, Stahl, & Miller, 2015). A lack of awareness of CCS does not mean that people cannot quickly gain some understanding and ask complex questions. Dr Sallie Greenberg of the IBDP states that scientists and the community are often asking and trying to answer the same questions (Greenberg, 2019). Some of the historical issues and barriers to public understanding and perception of CCS are discussed further in the following sections.

2.1.1 Trust

Trust is difficult to build but can be earned by open and honest communication about risks, and risk mitigation and management. It is also the case that companies and businesses that have long been

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operating in the area may already be perceived as trusted bodies, and can build on this track record with local communities. Involving multiple agencies in communication with communities can be helpful, but may have to be carefully managed to avoid confusion over responsibilities or messages. A barrier to trust occurs when a party is perceived to have a commercial interest (Terwel, ter Mors, & Daamen, 2012), especially where public funding contributes to the project.

Measurement and monitoring regimes are key, to provide evidence to stakeholders that their concerns are being taken seriously. So, it is often the case that projects go above and beyond what is needed initially to ensure public acceptance. Interesting new developments include public participation in these measurement and monitoring campaigns (SECURe, 2018).

In Weyburn, Canada, there were widespread reports of high CO_2 concentrations in soils and related groundwater pollution, due to nearby injection and storage of CO_2. This was ultimately proven to be due predominantly to existing biogenic sources through a measurement technique called noble gas finger-printing (Gilfillan, Sherk, Poreda, & Haszeldine, 2017) but had already received a lot of public attention and these narratives persist.

Other onshore storage projects such as the Illinois Basin - Decatur Project (IBDP) (MGSC, 2005) and Quest (Shell, 2015), incorporated well and water table testing into their measurement and monitoring regimes to provide comfort and security to local landowners and inhabitants as required by regulation.

Researchers from the QICS project, a controlled seabed release of CO_2 off the west coast of Scotland, UK (QICS, 2017), worked closely with local communities from the very start of the project. One key learning from the QICS project was that publics do not want to be told by researchers or developers that storage sites are completely secure and will never leak; they want to know that monitoring processes will be in place and mitigation strategies prepared, especially to deal with 'worst case' scenarios (Mabon et al., 2015).

2.1.2 Place

Geography and place also play a significant role in public acceptance: local or regional employment in the oil and gas sector, or chemical industry, provides a public with an aligned knowledge base, used to working with the technologies and risks and able to understand the processes. Whereas, different employment sectors and regional areas in proximity to the storage site can have strongly differing views, or need different narratives and detail to explain CCS technology, the project and the impact on their lives.

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For example, the areas around the Total Lacq CCS project in France had long experience of oil and gas production and the chemical industry, in fact chemical waste was already injected into a local geological formation; there was a wide network of pipelines, including in close proximity to the city of Pau; and the extracted gas was dangerous with a high concentration of SO_x so the community had a strong awareness of safety and geological risk (Ha-Duong, Gaultier, & deGuillebon, 2011). The more rural areas around Jurançon were less receptive and the newly elected mayor was against the project. However, as the mayor learned more he became more positive and ultimately supportive as Total agreed to give €1.5M for projects on environmental protection, renewables and energy efficiency alongside other themes such as social, education, culture and sport.

The place and its culture should also influence the types of materials that are prepared to use as communication tools. For example, the Tomakomai CCS Demonstration Project in Japan produced a range of manga-like cartoon books to explain CCS and its role in climate mitigation (Tomakomai, 2016).

2.1.3 Global versus local

CCS is viewed by its proponents as one technology in the suite of solutions that are needed to combat global warming and climate change. The narrative has been based around the following points:

- CCS can sustain the modern lifestyle and is compatible with current social structure
- CCS provides a bridge to a sustainable energy system in the transition from fossil fuels
- CCS is about solidarity with the developing world, enabling developing countries to rise to the same levels of consumption as developed countries (Markusson, 2012)

In some regions, currently, and more widely in the past, there was a lack of belief in climate change, such as the Greenville project in the USA (Malone, Bradbury, & Dooley, 2009) and hence CCS was criticised as a waste of public money. This can be the case even with a general acceptance that climate change is happening, as there may be a preference for public funding to be used for renewables (Oltra et al., 2012). It can be difficult to value a solution to a global problem locally, where there are local impacts such as environmental pollution, or the perception that the project would lead to drop in house prices, such as in Barendrecht (Terwel et al., 2012). In Ayr, Scotland, a proposed coal power plant with carbon capture and storage was strongly opposed by local communities because of fears of the environmental impact of coal power and the plant construction phase (BBC, 2012); the advantages of CCS climate mitigation were lost in fears around local pollution.

2.1.4 Offshore versus onshore

Many previous projects were associated with onshore CO_2 storage, predominantly in the USA where this is still the case, whereas the majority of current European projects are focussed on offshore storage (Equinor, 2020; Ervia, 2020; PBDE, 2020) but it should not be assumed from a public acceptance perspective that offshore storage will be easier than onshore storage. A key outcome of the QICS (Quantifying and Monitoring Potential Ecosystem Impacts of Geological Carbon Storage) project was to explore these attitudes:

"*The marine environment can be a major source of employment and income for coastal communities like those in Argyll, so anything perceived as affecting this marine environment may be viewed as*

exposing coastal communities to risk - albeit risk to livelihood and valued biological diversity instead of the techno-scientific risk usually associated with onshore storage. Furthermore, a number of participants in this study used their knowledge of physical processes on land to envision what the risks of offshore storage might be, and did not always see physical distance as insulating them from problems like ground-water contamination or induced seismicity." (Mabon et al., 2015)

The importance of place and concern over how decisions are made extends to include the seabed, so it is likely that the issues of public and stakeholder perception are as relevant to offshore storage as to onshore. However, it may be that for projects where CO_2 storage will be offshore the siting of onshore pipelines and associated risk may become a comparable or bigger issue (Shackley et al., 2009).

2.1.5 NGOs and champions

However strongly environmental NGOs (ENGOs) may desire action on climate change, they are often suspicious of the fossil fuel industry actors who historically have been the most likely to undertake CCS. CCS is a complex case: they are attracted by the potential large-scale emission reductions, but wary of end-of-pipe solutions (Reiner, 2011).

CCS projects in Norway have the strong support of the NGO Bellona who see CCS not just as an option but as a necessity; whereas in the Netherlands there has been much opposition from Greenpeace who see CCS as unproven, risky and expensive, and locking-in society to fossil fuel use. However, it may be said that with the current worldwide recognition of the climate emergency many ENGOs are reviewing or shifting their stance. For example, WWF have recently published views that include CCS on biogenic sources in their climate mitigation analysis following an understanding of the problem that faces society and the economy, and the need for negative emissions (WWF, 2019) to balance activities that cannot be completely decarbonised, such as agriculture. Also, there have been helpful comments from some members of Greenpeace about the need to employ CCS in industries such as cement (Greenpeace, 2019).

Shell has been aware of the need to work with independent, trusted agencies, such as the Pembina Institute in Canada on the Quest project and Scottish Carbon Capture & Storage (CCS academic consortium) in Scotland, UK on the Peterhead Project; to provide technical CCS information and act as pro-CCS, project-agnostic experts.

Other important potential champions include politicians, media experts / journalists, academics / researchers and respected members of local communities.

2.1.6 Stakeholders

The advice gained from the experiences of multiple projects is the need to map out the range of stakeholders who will be involved in or impacted by the project – "*individuals, groups, agencies and authorities at local, national and international level"*, and to build relationships and work with these stakeholders; designing this stakeholder engagement into the project development plan from the very beginning of the project. It is imperative that this engagement is two-way – "*actively listening, seeking feedback and responding to feedback*" (Shell, 2016).

These stakeholders may be influenced by previous unconnected projects in the area, such as removal of obsolete plant that has not been undertaken, or water contamination, not necessarily

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anything to do with the CCS project itself. In some situations, remediation of these problems can lead to greater trust and acceptance of the new project.

The Shell Peterhead project in the UK engaged with these stakeholders in a range of ways, including formally as required by local planning regulations, but also through events for supply chain, and with local communities in community centres and schools in towns and villages in the area around the project. As mentioned in Annex A they developed a one-day event including a 2.5 km walk around the site to engage with the local community (Shell, 2016).

2.1.7 Examples of common questions about and arguments against CCS

This section identifies some of the commonly asked questions and explores possible responses. However, each project should consider what their response should be in the context of region, the type of stakeholder and the type of project and may wish to seek the advice of independent advisors, academics and NGOs before formulating their responses.

Large-scale CO_2 storage will cause seismic events – unfortunately there is an inclination to link CO_2 storage with fracking, probably because that is another sub-surface activity that is highly visible in the news. Pressure control is key in both technologies, but for CO_2 storage the operator intent is to avoid fracturing of rocks and to control the CO_2 injection so that there is no risk of leakage. Again, this is where a project can provide comfort through well-designed measurement, monitoring and verification plans and delivery.

The technology doesn't work – capture technologies across the world have been in use since the 1970's; hundreds of kilometers of pipeline have been transporting CO_2 in the USA for decades (Dakota, 2000); injection of CO_2 into offshore storage sites has been operating successfully for more than two decades (Equinor, 1996); full chain projects on coal power plant and oil-refining have injected millions of tonnes of CO_2 and safely and securely stored it, in the USA and Canada (SaskPower, 2014; Shell, 2015).

CCS just locks us in to the continued use of fossil-fuels; public money should be invested in renewable energies – not all CO_2 emissions are due to fossil fuel use in energy production: 6-8% of global emissions are from steel production, predominantly the direct outputs of the processes involved in steel production, and 6% similarly from cement production (IEA, 2019). We need these products to construct renewables, buildings, roads bridges, etc. There are also additional connotations here, it may part of the response to explain that renewables are not 'zero carbon' energy sources because of the emissions from production, transport, commissioning and operation.

The technology is too costly for governments or developers to deploy – Though it is true that costs are high, as for any large infrastructure project, evidence from other sectors shows costs reduce as deployment rolls out, the costs of onshore and offshore wind have decreased substantially over time due to learning from deployment and both the Quest and Boundary Dam projects have already indicated that next build plant would have costs reduced by 25-30% (Lavery, 2018). It is likely that CCS will require government subsidy as have energy efficiency, low carbon heat and renewables to support their development. Project costs can also be reduced by the reuse of existing infrastructure, such as pipelines originally purposed for O&G transport.

It's too late for CCS to contribute to climate action; fossil fuel use is being phased out – urgent climate action is needed and CCS is part of the portfolio of solutions that should be deployed to decarbonise heat, transport, industry and power, particularly as it is capable of large volume CO_2

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emission reduction and especially in light of new Net Zero targets around the world. Also, see above for the comments on non-power-related emissions.

Projects will encounter many other frequently-asked questions themselves and may find it useful to compile their own list of questions and appropriate responses.

3 Learning from project experience

The notes below are based on face-to-face meetings at the project sites and record key points in the narrative as presented by the project public engagement experts (site visits were funded by the SECURe project under the European Union's Horizon 2020 research and innovation programme Grant Agreement No 764531, and are reported in more detail in that project's deliverables (SECURe, 2018)).

3.1 Illinois Basin - Decatur Project

In 2003 the Department of Energy (DOE) in the USA set up the Regional Carbon Sequestration Partnerships Initiative in order to develop CCS technologies as part of the national strategy to reduce greenhouse gas emissions and mitigate climate change that was current at that time. Seven regional partnerships were created under this initiative, one of which was the Midwest Geological Sequestration Consortium (MGSC). Each region collected and analysed data on potential storage sites. The project selected in the MGSC region for development and funding from the DOE was the IBDP which to date has stored 1 $MtCO_2$ (Survey, 2012). Dr Sallie Greenberg is the current lead on this project and some of her experience and advice on engaging with stakeholders is captured below.

General

- Public acceptance is not well-defined; it may actually be possible that the public would be happy to accept CCS but there is little public awareness of what it means.
- Stakeholder engagement to-date has been conducted primarily on a project-by-project basis. This is not a viable engagement mechanism to bring broad-scale attention and understanding to CCS.
- Many of the questions asked by the public are the same as the questions scientists and engineers ask themselves.
- Sometimes there are existing problems that people are worried about that influence their acceptance of a CCS project e.g. old plant blocking a view, waiting on decommissioning and the new (CCS) project is perceived to be linked with these issues.

Approach taken by the project

- Regional and state-wide stakeholder engagement commenced in 2004; specific IBDP project stakeholder public engagement started in earnest in Decatur in 2006-7. The IBDP wells were drilled in 2009-2010.
- The project used a roadshow with briefings, presentations at public events and science meetings; and engaged with local media early on. They partnered with a media champion who was active and supportive of the project.

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- A second project in the immediate vicinity of IBDP, the Illinois Industrial Sources CCS project, included the local college, Richland Community College, where courses based on addressing climate change include modules and material on CCS, and there is an outreach centre with information on CCS and carbon emissions across the USA and the world.

Recommendations

- When communicating with the public be open about the risks, and the benefits.
- Engagement is not about convincing people of your perspective – stakeholder engagement is about establishing a two-way conversation – be respectful.
- Unbiased experts are needed to talk with stakeholders and provide factual information.
- Place is important - meet people at community centres, their homes, coffee shops.
- Timing is important – be aware of restrictions on their time e.g. farmers are busy April to October so don't try to set up meetings within that time frame.
- Tools can be useful when engaging with stakeholders, i.e. using voting in discussions to understand people's views, such as phone apps; and hands on activities such as communication tool kits (see Compendium below).
- Local issues – be aware of what people care about locally e.g. ground water has to be protected.
- Be proactive, when regulatory requirements include public hearings organise these well in advance of the legal requirement to do so; initiate public engagement before the permit process is initiated.

Figure 1: Some of the Teaching Tools created by the IBDP (copyright P. Parmiter, SCCS).

3.2 Quest

Quest is a fully-integrated, full-chain project developed by Shell in Alberta, Canada which was funded by both the governments of Alberta and Canada. It was designed to store a million tonnes of CO_2 per year, and to date has stored more than 4 $MtCO_2$ (Shell, 2020).

General

- The site is based in sparsely populated farmland (like Decatur), with not much industry in the area and the community was new to Shell. CO_2 pipelines were viewed as an unknown entity.

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The county was a new location for the regional waste dump – this backdrop didn't help, as there was a perception that CO_2 waste was also being dumped.

- There was little awareness of CO_2 and its role as a greenhouse gas. In fact, some people did not know that know that humans produce CO_2 themselves when breathing out.
- CCS was unknown to the community and their objections centred around the application of government funding that could have been used for other activities that would benefit the community. There were many non-believers in climate change.

Approach taken by the project

- Shell worked with a local NGO (Pembina Institute) to provide independent technical knowledge and information.
- Engaged with the community – offered coffee in local coffee shops.
- Set up a Community Advisory Panel to raise issues and present responses when drilling started, interest reduced as the project was shown to work.
- Started public engagement two years before drilling started in 2010; the project opened in 2015.
- Media work was undertaken at the launch, at the start of injection and at the point where 1Mt had been stored. When they reached > 4Mt CO_2 for the first time there was more positive than negative traffic on social media; the conversation had moved on over the years, plus the memory of government funding had receded.
- Monitoring once the project in place – 2 years of sampling the groundwater of each landowner every quarter (eventually this became an annoyance to the landowners and they stopped answering phone calls).

Recommendations

- The project used local Shell experts, to engage with the community, dressed casually, no suits, and identified people who can communicate and listen.
- A learning from this experience was that for future projects they would advise spending less money on consultants and more on sending experts into the community. Public acceptance was won by building relationships and trust; not by providing technical info or trying to win people round to the purpose of the project.
- Measurement, monitoring and verification needs to be site specific, do not replicate blindly between projects.

4 Summary and Conclusions

Although the number of real, full-chain CCS projects worldwide is relatively small, there is much experience and learning from projects that have failed or been withdrawn (for many reasons, including public opposition, funding withdrawn, company unable to make investment decisions, etc.) and from those that have been successful and have now stored many millions of tonnes of CO_2.

These projects are complex with many types of stakeholder and engagement activities and it is clear from the experience of these large infrastructure projects that public engagement and communication needs to be designed into the project development planning at an early stage. It is

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also clear that each project is different, with different geography of place, types of stakeholder and stakeholder groups, with different narratives and engagement techniques required. There is no one-size-fits-all and these plans need to be carefully designed to suit the individual project needs.

A summary of the key points concluded from the previous sections are listed below:

- **Start early** – initiate your public engagement at the beginning of the development of the project, avoid presenting the project as a *fait accompli* that the community have had no opportunity to influence
- **Map stakeholders** – understand your audience, local decision-making processes and key players
- **Transparency** – be open about risks and opportunities and discuss avoidance and mitigation
- **Meeting locations** – use places where the stakeholders feel comfortable, e.g. their own home, local coffee shop, community centre.
- **Timing of meetings** – be aware of the range of commitments of your audience, such as shift working or seasonal employment so that meetings are timed around their availability
- **Two-way conversation** – do not expect to convince people, open a dialogue, listen and be receptive
- **Respect** – the views of the community should be treated with respect, for example if there is a perceived risk, even if the project deems this risk to be low, the discussion should be conducted about what processes, equipment or monitoring should be put in place to provide comfort
- **Be proactive** – organise public meetings well in advance of the legal requirement to do so, avoid appearing to do the minimum that is required
- **Local issues** – there may be concerns that the local community have that are nothing to do with the project but may need to be dealt with in order to move forward
- **Communication tools** – use a wide range of communication tools and techniques, these will have different impacts with different audience types, such as hands-on demonstrations, site tours, videos, social media, face-to-face meetings, group meetings
- **Community group** – support the development of a local community advisory group to engage closely with the project developers and report back to the community
- **FAQ** – build up a record of the frequently-asked questions and develop meaningful and evidence-based responses
- **Advocates** – helpful if you can find a trusted/independent advocate, these may appear from the local community, and may be a local NGO, journalist, academic or local decision-maker
- **Trust** – it is helpful if the project lead business, or other partners are locally-trusted businesses/industry and have a positive history with the community
- **Continue** to engage throughout the project.

The summary above provides a starting point for the development of engagement plans. Annex A of this report provides a compendium of materials and tools that have been developed by various groups and businesses, and there are a number of additional reviews and best practise manuals that developers can consult for advice and strategies (Lockwood, 2017; NETL, 2019; Shell, 2016; WRI, 2010).

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6 Glossary of abbreviations and units

Abbreviation	Meaning
CCS	carbon capture and storage
CCU	carbon capture and utilisation
CCUS	carbon capture utilisation and storage
CO_2	carbon dioxide
DOE	Department of Energy (USA government department)
ENGO	environmental non-governmental organisation
EU	European Union
FAQ	Frequently asked questions
IBDP	Illinois Basin - Decatur Project
MGSC	Midwest Geological Sequestration Consortium
Mt	megatonne (10^6 tonnes, million tonnes)
$MtCO_2$	megatonne (10^6 tonnes, million tonnes) of carbon dioxide
Mt/yr	megatonne per year
NGO	Non-governmental organisation
SO_X	oxides of sulphur
USA	United States of America
WWF	World Wildlife Fund

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Annex A: Compendium of public engagement resources and materials

Videos

Table 0-1 Table of useful video resources

Title	Description	Source	Length (minutes)	Link
Storing CO_2 is a piece of cake	Time lapse video produced by SCCS, showing layers of cake and icing being built up and sandwiched together, with a fondant drilling rig on top, and liquid injected through a straw from the surface to one of the deep layers. Not intended to be an accurate or to-scale depiction, but rather to capture viewers' imagination in relation to the subsurface.	SCCS	1:19	https://www.youtube.com/watch?v=CXZJlPSnKEs
Storing CO_2 in the subsurface	Maxine Akhurst, British Geological Survey, describes the types of rocks in the subsurface, and demonstrates the porosity and permeability of sandstone, and the impermeability of shale rock.	SCCS	13:44	https://www.youtube.com/watch?v=IoEnksHn3L8
How do rocks store CO_2?	Shorter version of Storing CO_2 in the subsurface.	SCCS	2:53	https://www.youtube.com/watch?v=KvNqqgP6Xgc

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Title	Description	Source	Length (minutes)	Link
CO_2 Multistore	Animation summarising the findings of the 2015 CO_2 Multistore Joint Industry Project, led by SCCS. Give a good indication of the distances and depths involved in CO_2 transport and storage	CO_2 Multistore Joint Industry Project	2:30	https://www.sccs.org.uk/index.php?option=com_content&view=article&id=221&Itemid=408
Take a journey more than 2000 metre underground with Shell's Carbon Capture and Storage Project	Animation from Shell explaining CCS in the context of a project in Alberta, Canada.	Shell	4:00	https://www.youtube.com/watch?v=sqkXYKRFkFc
Capturing carbon to store it safely underground	Animation from Shell on how CCS works.	Shell	1:55	https://www.youtube.com/watch?v=f3T9B83rZss
How it works: Carbon Capture and Storage	Animation from Shell explaining full-chain CCS in the context of the Quest project.	Shell	1:30	https://www.youtube.com/watch?v=EyPI20h9kx0
Bellona's song about Norwegian CCS	Music video by Bellona calling for CCS on energy-from-waste plants in Norway.	Bellona	4:11	https://www.youtube.com/watch?v=QFZ2pPlADLU

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Title	Description	Source	Length (minutes)	Link
CCS: The Bridge to a Cleaner Future	Talking heads on the role of CCS and EOR in a just transition.	International Brotherhood of Boilermakers	15:52	https://boilermaker.ca/en/ccs-bridge-to-a-cleaner-energy-future/
Teesside, 2030	Talking heads and animation on the role of industrial CCS in Teesside and beyond.	Teesside Collective	4:15	https://www.youtube.com/watch?v=vQJHNRqqOjQ
Ervia – Gas Networks Ireland Vision 2050	Explanation of CCS in the context of Ireland's energy and climate targets	Ervia	2:30	https://youtu.be/e9xcaA4M2SM
Tomakomai CCS Demonstration Project	Various videos explaining CCS and the project	Japan CCS Co Ltd	Various	https://www.japanccs.com/en/library_category/movie/

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Hands-on activities

Audience-Pleasing Physical Models to Support CO_2 Outreach(Hovorka, Hotinski, & Friedmann, 2005)

Includes instructions for five demonstrations:

- *Chemistry of burning* – using styrofoam balls to make ball-and-stick molecular models to demonstrate the chemical reactions involved in burning methane.
- *Imagine you could see the carbon in CO_2* - using charcoal briquettes to illustrate the carbon produced by cars
- *What is the Greenhouse Effect?* – using pipe cleaners to represent light and heat energy wavelengths
- *CO_2 is a Gas* – experiments using CO_2 in the form of dry ice.
- *Reservoir in a jar*[1] – using marbles, water and coloured lamp oil to illustrate CO_2 trapping mechanisms in porous rock

https://repositories.lib.utexas.edu/bitstream/handle/2152/66005/GCCCDigPub05-04k.pdf?sequence=2&isAllowed=y

CO2degrees Challenge: Information for educators – Hands-on experiments

Instructions and videos for the following experiments:

- *What is CO_2? Making molecules* - This experiment uses balls and toothpicks to represent atoms and bonds.
- *What is CO_2? Make carbon dioxide - it's a blast!* - Mixing vinegar and bicarbonate of soda to see what happens. Note: safety warning
- *What is CO_2? Counting carbon* - This experiment uses peas to visualise 'parts per million'.
- *What is CO_2? The CO_2 lava lamp* - Developed with the support of Richland Community College, this experiment shows density of liquid and how CO_2 acts within those layers. Note: safety warning.
- *CO_2 and our environment* - Exploring global warming - Developed with the support of Richland Community College, this experiment uses jars and lamps to show the effect of heat from the sun. Note: safety warning.
- *CO_2 and our environment - Acidic oceans* - This experiment shows how dissolving CO_2 gas in water can make a weak acid.
- *CO_2 capture - Creating and capturing CO_2* - This experiment shows how CO_2 is created and captured when vinegar and bicarbonate soda are mixed. Note: Safety warning.
- *CO_2 capture - Capturing CO_2 from soda* - The experiment uses a balloon to capture CO_2 from a soda bottle.
- *CO_2 capture – Biofuels* - Developed with the support of Richland Community College, this experiment shows how to make ethanol - a replacement for gasoline - from yeast and corn syrup. CO_2 is also created during this process. Note: safety warning.
- *CO_2 transport activity* - This experiment uses air pressure to move CO_2 along a hose or pipe.

[1] NB Rowena Stead at BGRM has been refining the reservoir in a jar, so can advise on a more sophisticated version than given in this document.

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- *CO_2 storage - Storage and porosity* - This experiment uses water and small pebbles to show how CO_2 can be safely stored underground.
- *CO_2 storage - Chocolate CO_2 storage* - This experiment explores porosity and permeability of different types of chocolate bars.
- *CO_2 and enhanced oil recovery - Enhanced oil recovery (EOR)* - Developed with the support of Richland Community College, this experiment illustrates how CO_2 can be used to push more oil and gas out of reservoirs.
- *CO_2 and enhanced oil recovery - CO_2 injection and fluid displacement* - This experiment shows how CO_2 can displace fluids. Note: safety warning.

https://co2degrees.com/learn-more/educators2

Juice Carton Enhanced Oil Recovery

- The student drinks all but 1cm of the juice in the carton.
- They then blow gently into the straw to increase the pressure inside the carton.
- The pressure difference between the inside of the carton and the outside encourages the last of the liquid to travel up the straw and into their mouth.
- This is the exact principle used in EOR.

https://co2degrees.com/sites/default/files/geobus-module1-3_the-carbon-cycle.pdf

Paper Pipelines

Classroom exercise building pipelines out of paper that can transport a marble.

https://co2degrees.com/sites/default/files/geobus-module2-2_paper-pipelines.pdf

What Happens to CO_2 Stored Underground?

Chemistry experiment blowing CO_2 into calcium hydroxide

https://co2degrees.com/sites/default/files/geobus-module2-3_what-happens-to-co2-stored-underground.pdf

Teaching materials

What To Do with CO_2

CCS and CO_2 related teaching materials, aligned (at the time of publishing) with the Curriculum for Excellence (Scotland) and Key Stage 3 (England). Focused on power CCS. Resource pack developed in partnership with The Crown Estate and GeoBus (University of St Andrews), with support from The Global CCS Institute, Royal Dutch Shell and SCCS.

https://co2degrees.com/content/crown-estate-and-geobus-education-resources%20

[2] On the same page are games and teaching materials

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Introduction to carbon capture and storage

Global CCS Institute teaching resources as above:

https://co2degrees.com/

Other

Shell Carbon Capture & Storage VR Experience

When viewed through a virtual reality headset, takes the viewer from the atmosphere to the subsurface. Length: 2:40

https://www.youtube.com/watch?v=rMsaOjrknow

Figure 2: Using the Shell 3D visualisation headset at Dynamic Earth (copyright SCCS).

Peterhead 2.5km walk / Rock Doctors to the Rescue

SCCS/GCCSI/GeoBus worked with the Shell Peterhead project to develop a 2.5km walk to give the public a feel for how deep the CO_2 is stored; and exploring the geology that makes carbon capture and storage (CCS) possible. After the project cancellation this was developed into a guided 2.5km outdoor walk around Holyrood Park, Edinburgh, and used by SCCS at public science engagement events.

Figure 3: 2.5km walk for the local community at the Shell Peterhead project (copyright SCCS).

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Guides to public engagement

Best Practices: Public Outreach and Education for Geologic Storage Projects

Produced by the US National Energy Technology Laboratory, derived from experiences gained by Regional Carbon Sequestration Partnerships in the USA, including the IBDP.

https://www.netl.doe.gov/sites/default/files/2018-10/BPM_PublicOutreach.pdf

Produced by the World Resources Institute (WRI), a collective product of a carbon dioxide capture and storage stakeholder process convened by the World Resources Institute between April 2009 and October 2010, additional perspectives were added through the peer review: *CCS and Community Engagement: Guidelines for Community Engagement in Carbon Dioxide Capthre, Transport, and Storage Projects* (ISBN: 978-1-56973-756-9).

http://pdf.wri.org/ccs_and_community_engagement.pdf

Volume II, Chapter 4 of the reports produced by the National Petroleum Council who were requested by Secretary of Energy Rick Perry to provide advice on actions needed to deploy commercial carbon capture, use, and storage technologies at scale into the U.S. energy and industrial marketplace *Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage*

https://dualchallenge.npc.org/files/NPC%20CCUS%20Chapter%204-Dec12.pdf

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