Call ID: LC-SC3-NZE-5-2019-2020

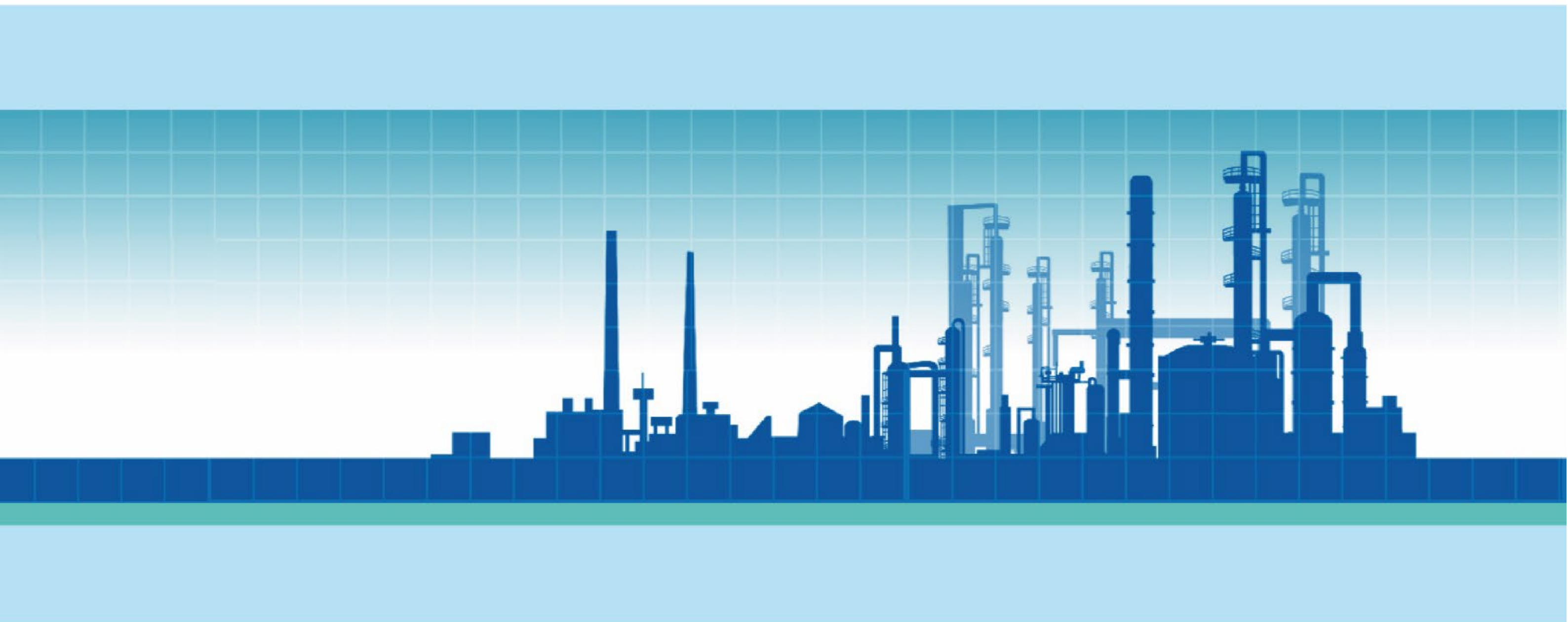
REALISE CCUS

Demonstrating a Refinery-adapted cluster-integrated strategy
to enable full-chain CCUS implementation - REALISE

D4.6 Synthesis Report on Societal Readiness

Niall Dunphy, Breffní Lennon

University College Cork – National University of Ireland, Cork



2023-10-18

Dissemination Level (Public)

@realise-ccus | www.realiseccus.eu

Document History

Revision History

This document has been through the following revisions:

Version No.	Revision Date	Brief Summary of Changes	Name
1.0	19-Oct-2023	Draft	N. P. Dunphy

Authorisation

This document requires the following approvals:

AUTHORISATION	Name	Signature	Date
WP4 Leader	Dr Niall Dunphy	Niall Dunphy	19-Oct-2023
Project Coordinator	Dr Inna Kim	Inna Kim	20-Oct-2023

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 884266

Disclaimer

Executive Summary

This report brings together the developed knowledge and outcomes from work carried out for Work Package 4 into a synthesis, drawing broad-based conclusions as to the societal readiness of the REALISE approach. The key objective of this work package has been to develop an in-depth understanding of the societal, socio-political, and commercial contexts of CCS deployment.

Accordingly, the work package has the following aims:

- To critically review and characterise best practice in education and public engagement as relevant to energy and related infrastructure.
- To work with stakeholders to co-develop and trial an education and public engagement programme to promote societal acceptability and social acceptance of CCS projects.
- To examine the socio-political context of CCS internationally, identifying key risks, evaluating risk mitigation and exploring financing implications of such risks.
- To engage with relevant industrial stakeholders to develop an understanding of the industrial and commercial context of CCS.
- To synthesise this newly developed knowledge into an overview of societal readiness – characterising the societal, political, and socio-economic barriers to CCS and proposing appropriate policy recommendations to address such barriers.

This draws on deliverables 4.1, 4.2, 4.3, and 4.5, and provides a synthesis of the key lessons learned from each report.

Table of Contents

Executive Summary 4
1 Introduction 7
1.1 Background 7
1.2 Context 7
1.3 Structure 8
2 Critical review of EPE initiatives 9
3 Developing and trialling EPE in Cork context 15
4 Socio-political considerations 24
5 Industrial networking activities 32
6 Public outreach activities 34
7 Barriers and recommendations 40
7.1 Societal, Political, and Socioeconomic Barriers 40
7.2 Policy and Regulatory Recommendations 42
8 Bibliography 45

Glossary

CCS	Carbon capture and storage
CCUS	Carbon capture, use, and storage
CfD	Contract for Difference
CO_2	Carbon dioxide
EIA	Environmental impact assessment
EOR	Enhanced oil recovery
EPE	Education and public engagement
GDPR	General data protection regulation
LL	Lifelong learning
NGO	Non-governmental organisation
OA	Outreach activities
PFI	Public Finance Initiative
PPP	Public Private Partnership
RAB	Regulated Asset Base
SA	Social assessment
WP	Work package

1 Introduction

1.1 Background

REALISE is an EU Horizon 2020 funded research and innovation project, exploring ways to develop and demonstrate an integrated strategy for carbon capture, (use) and storage (CCS/CCUS) for the refining industry. The REALISE project demonstrates a novel multi-absorber concept, which will enable the inclusion of small variable concentration sources. In turn, it is working towards to potential to capture up to 90% of CO_2 emissions from operating refineries, at a substantially reduced cost when compared to existing capture methods. The consortium is mindful that both the technical and social aspects must be considered when deploying CCS (*e.g*., see Bradbury *et al*. 2009; Markusson *et al*. 2012). Consequently, REALISE not only evaluates the entire CCS chain from emitter to storage it also considers the wider societal, socio-political, and commercial aspects that inform novel technology deployment. The work presented in this report brings together key learning outputs from a package of work examining these socially orientated aspects of deploying CCS technology, Work Package 4. More specifically, this report presents a synthesis of those outcomes and concludes by drawing broad-based assessment as to the societal readiness of the REALISE approach.

1.2 Context

Carbon capture and storage (CCS)[1] involves a set of existing and emerging technologies that potentially enable the mitigation of largescale carbon dioxide (CO_2) emissions from power generating plants, fossil fuel refineries, and other industrial sites. It also involves the removal of existing CO_2 from the atmosphere. Achieving these cuts in energy-related CO_2 emissions is vital if the goal of 1.5 degree Celsius (°C) rise in global temperatures – above preindustrial levels – by 2050 is to be realised and CCS can potentially contribute to the suite of social and technological tools needed to do so. This will involve a combination of (1) a phasing-out of CO_2 generation over time (by both reducing fossil-fuel use and upscaling low-carbon energy sources) and (2) the necessary upscaling of industrial-scale CO_2 sequestration by restoring natural carbon sinks supported by carbon capture and geological storage technologies (Rogelj *et al.* 2016). The consequences of failing to do so will lead to irreversible and lasting social and environmental damage to people and ecosystems (Pörtner *et al.,* 2022). Therefore, the scale of the challenge the climate crisis presents requires deep systemic changes to industrial activities so as to limit the production of CO_2, and other greenhouse gases, and CCS will need to become a significant part in achieving the necessary emissions reductions. In Europe, CCS/CCUS is increasingly recognised as a potentially key technology breakthrough in the move towards a circular economy (Dunphy *et al*., 2022). As such, it is designated as a priority area for the development of commercial applications under the European Green Deal (European Commission 2019).

Having said that, social opposition to large scale infrastructure continues to be a potential risk. Effective communication between prospective host communities and proposed projects is therefore of therefore of utmost importance. For example, strong public opposition remains a notable challenge in the siting of renewable energy developments, despite wider popular support for renewable energy technologies.

[1] See also carbon capture, usage and storage (CCUS).

So much so that it threatens to significantly slow Europe's transition to more sustainable modes of energy production (*e.g*., see Cohen *et al*., 2014; Enevoldsen & Sovacool, 2016). Notably, the prioritising of engaging the public on infrastructural development has been highlighted by the EU Energy Roadmap 2050, which stated '*(t)he current trend, in which nearly every energy technology is disputed, and its use or deployment delayed, raises serious problems for investors and puts energy system changes at risk'* (Dunphy *et al*., 2021, p6).

Energy systems can no longer be just considered a wholly techno-economic domain. They are better understood as socio-technical arrangements that as '*are both socially constructed and society shaping'* (Hughes 1987:51). Indeed, social processes have a significant influence in shaping the trajectory of technological development, just as much as the influence technological artifacts have in changing social and cultural practices (Rip and Kemp 1998). Understood in this way, we can begin to see how the socio-technical [energy] system is in fact a configuration of interconnecting technological and social elements comprising institutions, (legal) regulations, social practices, cultural values, beliefs, and expectations (Einsiedel et al. 2013). Therefore, understanding the social characteristics of a potential host site and developing appropriate education and public engagement (EPE) strategies[2] are important factors that will ultimately impact the success or failure of a project (Ashworth *et al.* 2009; Breukers *et al.* 2008; Reiner *et al.* 2006).

This deliverable was produced as part of work package 4 of the REALISE project, specifically from work carried out under Task 4.6 '*Synthesis report on societal readiness*' of work package 4 which seeks to develop an in-depth understanding of the societal, socio-political and commercial context of CCS deployment. It is the outcome of a synthesis of the five relevant deliverables reporting on the work for tasks: T4.1 *Education and public engagement best practice*, T4.2 *Social acceptability, societal impact*, T4.3 *Socio-political context analysis*, T4.4 *Industrial context analysis* and T4.5 *Public outreach activities and life-long learning*. Conventional research synthesis would involve analysis and synthesis of a large amount of often disparate research through one of several qualitative synthesis methods (Barnett-Page & Thomas, 2009). The task reported here was more straightforward involving the summarising of the research from three broad areas: education & public engagement practice, socio-political context and industrial and societal outreach.

1.3 Structure

Besides this introductory section, the document comprises a section summarising each of the five reports produced in this work package detailing the background, methodology and key outcomes. The final section then seeks to draw the research together, identify key societal, political, and socio-economic barriers to CCS, and finally offer policy and regulatory recommendations on how these barriers might be overcome.

[2] It may involve more than one strategy, or the redrafting of an existing one, as the societal dynamics change the course of the development.

2 Critical review of EPE initiatives

Dunphy, Niall; Lennon, Breffní; Quinlivan, Lauren; Velasco-Herrejón, Paola; & Curran, Róisín. (2021). *Critical review of EPE initiatives*. A research outputs of the REALISE H2020 project (grant agreement no. 884266). https://doi.org/10.5281/zenodo.7029984

Extract from project 'Description of Action'

'This first task will work towards develop a framework for social acceptance of deploying CCS at an industrial site. To this end, a critical review will be conducted by UCC of education and public engagement (EPE) associated with large energy and related infrastructure. Key examples of EPE will be identified through a literature search and via the partners' networks using a snowballing approach. These case studies will be characterised through a comprehensive desk study coupled with use of targeted informants. Parallel to this review, existing EPE practices in the Cork case study will be documented and evaluated by Ervia assisted by UCC. The resultant report will detail the case studies, outlining methods adopted, exploring key challenges, and presenting best practices.'

Abstract

While once considered a wholly techno-economic domain, energy systems may be better understood as a socio-technical system, which 'are both socially constructed and society shaping' (Hughes, 1987, p. 51). As Rip and Kemp (1998) observe, social processes may shape technology development, just as technological artifacts can influence changes in social and cultural practices. In this light, the energy socio-technical system can be conceptualised as a configuration of interconnecting technological and social elements including institutions, regulations, social practices, cultural values, beliefs and expectations (Einsiedel *et al.*, 2013). This deliverable was produced as part of work package 4 of the REALISE project, specifically with Task 4.1 'Education and public engagement best practice'. REALISE WP4 seeks to develop and in-depth understanding of the societal, socio-political and commercial contexts of CCS deployment.

Whilst the primarily focus of the planning and implementation phases of a CCS project might be on the technical and geological aspects – understanding the social characteristics of a potential host site and developing an appropriate education and public engagement (EPE) strategy can be an important factor influencing its successful rollout (Ashworth *et al.*, 2009; Breukers *et al.*, 2008; Reiner *et al.*, 2006). Understanding this importance, this deliverable is the outcome of a review of EPE around large infrastructure projects. This task is a preparatory exercise, which will directly inform the development of an EPE engagement programme (with associated performance indicators) within a subsequent related task, namely: T4.2. 'Social acceptability, societal impact.'

Methodology

This study aimed to develop an understanding of education and public engagement (good) practices and to identify and drawn lessons from prominent examples of EPE related to large-scale infrastructure projects, which would face comparable issues to a proposed CCS deployment.

As an initial step, a scoping exercise was conducted to select the case studies to be used in the study. Prospective candidates were identified through recommendations from REALISE consortium members and through a preliminary literature search. The inclusion criteria for the case studies were selected based on: (i) scale of proposed project; (ii) relevance to off-shore CCS deployment; (iii) diversity of experiences; (vi) diversity in outcomes; (vii) availability of literature; and (vii) availability of potential informants. This research was conducted through a literature review of relevant topics and (video-chat) interviews with key informants, with thematic analysis of interview notes, as outlined in the following sections.

Literature Review

The bibliography databases used for the literature search were a combination of commercial services available through university subscriptions and those that were freely accessible – these included Science Direct[3], JSTOR[4], and Google Scholar[5,6]. Database searches were created using keyword search constructions comprising words, phrases, and basic Boolean operators[7]. Such Boolean search combinations are quite flexible, and they act to make searches more precise. A 'backward' and 'forward' snowballing strategy was used to complement the aforementioned database searches. 'Backward snowballing' involved identifying literature contained in bibliographies of those papers already found; 'forward snowballing' involved identifying literature that cited papers already found[8].

Semi-structured interviews

The restrictions associated with the COVID-19 pandemic meant that all interviews had to be held remotely. While this did reduce the effectiveness of the interviews somewhat, there were also advantages to such engagement. Potential respondents had increased availability14, and because of this, geographical location was no longer a limiting factor, allowing us to spread our geographical spread. A total of nine semi-structured interviews were conducted with key informants who have specialist knowledge and experience of public engagement. Seven of these interviewees were associated with the selected case studies, while a further two are linked to EPE activities within the Cork area[9]. The nine interviewees came from Australia, Europe, North America, and South America, and were engaged using a range of teleconferencing technologies including Microsoft Teams and Zoom (depending on the interviewees' preferences).

The semi-structured interviews were carried out using pre-formed, concise, easily understood, open-ended questions – the informants were invited to talk about the particular case study (or EPE activities), with which they were familiar. Prompts were used to guide the conversation including e.g., operational queries around the approach taken to public engagement, how they built relationships with local stakeholders, how the engagements were actually structured (whether they were formal, informal, or a combination of the two), what were the main concerns of local people and how were those issues addressed, what types of information were shared with local stakeholders, did consultation fatigue set in and how did the process leader address this, and given their experiences on the project what would

[3] www.sciencedirect.com
[4] www.jstor.org
[5] scholar.google.com
[6] The use of Google Scholar was notwithstanding some legitimate criticisms (see *e.g.*, Jacsó, 2010) not least because of the power of its search algorithms, however it was used in full knowledge of its shortcomings and with the combination of other academic databases.
[7] The three basic Boolean operators ['and', 'or', 'not'] connect words together to narrow or broaden results.
[8] Bibliographic databases provide such information to assist users.
[9] As the Cork Harbour area in Ireland is due to be the focus for the development of the EPE programme in T4.2

they change or do differently. Extensive notes were taken during the interviews (including non- verbal communication as appropriate [10]) – calls were recorded where technically possible (and when permission was given) and these recordings were used to supplement and enhance the notes – the interview notes were analysed as described below.

Data analysis and interpretation

This involved working iteratively back and forth between data and ideas using analytical categories are used to describe, characterise, and explain social phenomena (Pope *et al.*, 2000). It is a recursive, laborious, and frequently time-consuming process that can result in quite rich understandings. In this study, the data analysis of each interview began with a read-through of the extensive notes taken during the discussion; this was repeated several times until the material became familiar to the analyst[11]. Following this initial stage, the text was analysed line-by-line to capture key information about their projects and to identify themes relevant to public engagement activities. The first part of this exercise involved cross-referencing information with that from academic literature and publicly available documentation, filling gaps in knowledge, resolving inconsistencies, and as required identifying additional information needs. The second part involved using standard thematic analysis procedures to systematically order, categorise and label text through a process known as coding – with identifying codes applied to the relevant proportions of text. In such analyses, it is common for qualitative data analysis software (such as NVivo) to be used to facilitate coding, organising, linking and cross-referencing of material, however the size and complexity of the study facilitated coding by hand. It also greatly abbreviated the iterative analysis and interpretation process. In each case the researcher who interviewed the respondent also analysed the notes. The researchers involved, coordinated their activities and jointly reviewed their work.

Key Results

Public engagement with CCS is important for a range of reasons. From one point of view, it may serve to mitigate public opposition to developments – for example, those seen in the case study of Barendrecht. However, there are also reasons of democratic governance and decision quality that argue in favour of public views being considered (more fully) in CCS decision-making (Xenias & Whitmarsh, 2018). Public engagement and participation on decisions relating to the environment, or similarly, large energy infrastructure projects helps decision-makers to understand, identify and address public interest concerns, thus taking environmental and social considerations into account as part of the decision-making process (Richardson & Razzaque, 2006).

Recent research has shown that a number of different, yet related factors influence whether the public will show support or acceptance for a technology such as CCS. These can be summarised as:

- how information about CCS is framed.

[10] While not as effective as face-to-face interviewing – the ability to video chat with people (who in a pre-Covid context would likely not be amenable to such a mode of communication) did enable the capturing of non-verbal communication such as gestures, facial expressions, etc. which did differentiate the interview from traditional telephone interviews for example.

[11] In each case the researcher who interviewed the respondent was also analysed the notes.

- trust in the actors promoting CCS.
- level of the participation in the engagement process.

CCS framing and interest aligning

Framing and interest aligning can be key factors that shape publics perceptions about CCS. Because CCS is a technology that is relatively unfamiliar to the public, perceptions of CCS can be heavily influenced by the information and framing provided by those deploying CCS projects (Whitmarsh *et al.*, 2011). Therefore, it is worthwhile to tailor education and public engagement strategies for CCS if a higher social acceptance is required.

Early research into CCS found that public concern about climate change and the perception of CCS as part of a broader solution to climate change were key elements influencing public acceptance of the technology (Sharp *et al.*, 2009), with the success of a CCS project often linked to the views held by the public of its capability to decrease carbon emissions at an industrial scale (IEA, 2013; IPCC, 2014). For instance, Boyd *et al.* (2017) found that belief in climate change (*i.e.*, that climate change is occurring) was a factor correlating with support for CCS, with those holding the belief that climate change is a problem caused mostly by humans more likely to support the technology.

However, support for a technology at the abstract level does not automatically mean support for an individual project, where local concerns will come to the fore (Mullally *et al.*, 2018). This would indicate that care should be taken to adequately understand local perspective and address local concerns.

Conversely, concerns have also been raised that CCS is not environmentally sustainable, does not tackle the root of the problem and can be viewed as simply "sweeping the issue under the rug" all the while reducing investments in renewable energy technologies (L'Orange Seigo *et al.*, 2014). Research has shown that framing CCS as a bridging technology that will not reduce investments in renewable technologies can address these concerns and can have a positive effect on people's attitude towards the technology. Wallquist *et al.* (2011) quantified the effects of framing CCS as a bridging technology, measuring the effects on risk and benefit perceptions in study participants. The study found that the participants benefit-perceptions increased, and risk-perceptions decreased after they were provided with a paragraph to read on how CCS is only part of the solution to climate change and should be embedded in a range of other low-carbon technologies.

This knowledge suggests that consideration must be given to the public's perceptions of environmental problems when communicating issues regarding technologies such as CCS (Corner *et al.*, 2014; Nisbet, 2009). Providing the public with evidence that the technology can be an effective instrument for achieving significant cuts in carbon emissions, as a transition technology to offer time for the further development of renewable energy technologies, could play a crucial role in promoting public acceptance of CCS (Paluszny *et al.*, 2020). In such a discourse, it is important that a government is not perceived as having a special interest in a particular energy strategy bias, *e.g.,* promoting CCS over renewable energy technologies, and that the public will be involved in the debate on the technologies to be implemented (Oltra *et al.*, 2010).

Trust in actors promoting CCS

Trust in the actors promoting CCS is a crucial factor determining local stakeholder's inclination to protest, risk and benefit perception (Brulle *et al.*, 2012; Earle & Siegrist, 2008; Midden & Huijts, 2009; Terwel *et* *al.*, 2011; Terwel & Daamen, 2012; Yang *et al.*, 2016), and has therefore been recognised as a key influencing factor in the success or failure of CCS, or indeed, any energy infrastructure project.

For instance, people's evaluations of the value of the information provided depends to a considerable extent on the trust towards who provides the relevant information (Ter Mors *et al.*, 2010). Perdan *et al.* (2017) showed that universities and research institutions are the most trusted sources of information about CCS while energy companies and social media are the least trusted. Trust in non- governmental organisations (NGOs) is also high, meaning that local people tend to prefer to engage with them in the decision-making process than with industry and the government (Eurobarometer, 2011; Terwel *et al.*, 2011). Local research projects tend to face the least opposition from local stakeholders and are thus more likely to be successfully implemented than projects run by foreign energy companies, which commonly face strong opposition and cancellation (Oltra *et al.*, 2012). Nonetheless, when trust in industry and government is high in a particular context, attitudes towards CCS appear to be more positive (Oltra *et al.*, 2010).

Contrasting visons of CCS EPE programmes

Approaches to Education and Public Engagement (EPE) can profoundly influence community perceptions of CCS (Brunsting *et al.*, 2013; Buhr & Wibeck, 2014; Dütschke, 2011; Oltra *et al.*, 2012).

(i) Top-down, focus on information provision

Outcomes of one-way assessments and planning usually define community benefit packages that provide payments to compensate local communities affected by CCS (Bonham *et al.*, 2014). The assumption by policymakers is that the provision of community benefits based on financial incentives will aid in promoting social acceptance for CCS (Cowell, 2010; Cowell *et al.*, 2012). However, Bell *et al.* (2005) explain that the financial incentive strategy can result in the alienation of people if they feel that they have not been offered what they consider to be fair. Moreover, Wolsink (1994) describes this strategy as dangerous since payments can be seen as a bribe, especially when offered at a stage when there are already disagreements between developers and communities. This can be particularly problematic if incentives are targeted to 'economically vulnerable and politically weak communities' (Luloff, Albrecht & Bourke, 1998: 864). Thus, it is unclear whether financial incentives are an effective way to increase local support in settings in which bribery and corruption are prominent practices. This suggests that local communities' acceptance is more effectively secured through 'procedural fairness, as opposed to material (or outcome) fairness' (Walker *et al.*, 2017). As seen in the previous section, often the public does not trust politicians, developers or experts (Breukers & Wolsink, 2003; Healey, 1996), and as such, information is frequently seen as 'suspect' in a climate of mistrust. Meaningful participatory processes have thus become a means of building trust for greater community engagement and acceptance.

(ii) Participative approach

Participation as a right and an approach for community development can be further applied as a form of awareness-raising, consultation and/or empowerment (Arnstein, 1969). Raising awareness, although it can help improve understanding on particular issues, can also be a minimal form of community engagement when conducted on its own. Accordingly, consultation requires a two-way flow of information as it encourages the public to voice their views and interests to inform decisions. Yet, it does not necessarily address the public's concerns in practice nor in planning strategies (Bell *et al.*, 2005;

INVOLVE, 2004). Thus, it is widely recognised that consultation works best when it presupposes meaningful interactions, and participants' perspectives are included in planning and operation decisions (Aitken *et al.*, 2016). In contrast, empowerment, involves power and benefit-sharing among all stakeholders and the wider society. This approach can take the form of community-led engagement where community members determine objectives, define processes (Rowe & Frewer, 2005; Wilcox, 1994), or chose partnership approaches (INVOLVE, 2004).

However, is important to note that well-crafted participatory processes do not necessarily lead to greater rates of public acceptance and engagement. There is evidence that two-way community engagement can reduce social opposition, yet it cannot be seen as a way to secure project approval and execution (Aitken *et al.*, 2016). Participation is not enough to fully address the political implications, power inequalities between groups, and heterogeneity of stakeholders – i.e., who speaks for the public and how? (Fournis & Fortin, 2017; Haggett, 2010). Moreover, participation power is rarely completely devolved onto the 'community'; nor do 'communities' always want it (Cornwall & Jewkes, 1995).

In this report a number of examples of Education and Public Engagement from around the world were identified through a literature search combined with recommendations from the consortium members and their networks. The case studies were characterised through a desk study supplemented and complemented by interviews with key informants using video chat technology. The methods used for EPE in each of the cases was identified, key challenges faced by such programmes identified. Finally, examples of best practice from the case studies were identified. Based on the lessons learned from the case studies, and EPE experiences reported in the literature a number of recommendations for CCS developers have been forwarded, these include:

- Engage with communities early to open channels of communication and build trust.
- Hire liaison staff who either already have good relations with local communities, or who have the skills to develop trusting relationships with communities.
- Complement official formal communication with informal, indirect communications to ensure effective outreach and build a 'chain of trust' with communities.
- Build trust through early, open, and responsive communication with communities.
- Supply the public with high quality information, tailored to their specificities.
- Frame CCS within a larger climate change mitigation context.
- Ensure discussions remain respectful, especially when opposition arises.
- Enable social stakeholders to contribute (in a meaningful manner) to decision-making process.
- Be open and honest about motivations for CCS project.
- Don't reply on previous experience of communities; remember past performance is no guarantee of future results.

3 Developing and trialling EPE in Cork context

Dunphy, Niall P., Velasco-Herrejón, Paola & Lennon, Breffní (2022). *Social Acceptability Framework. Report on development and trialling of EPE Programme* (D4.2). A research output of the REALISE H2020 project (grant agreement no. 884266). https://doi.org/10.5281/zenodo.10022012

Extract from project 'Description of Action'

'Building on the developed knowledge from the previous task in consultation with community stakeholders in the Cork case study an EPE programme will be designed – by UCC, Ervia and UEDIN. This programme will be informed by just transition concepts and leverage the experiences of the case studies in the critical review. The approach will take an intersectional approach, considering the socio-demographic specificities of the relevant communities, including for example: gender; economic privilege; and life stage. During the design of the programme, key elements will be trialled in local communities by Ervia and UCC to evaluate effectiveness, to identify areas of potential improvement, and to ascertain transferability of the programme. As a means of measuring the programme's success, key performance indicators (KPIs) will be developed for each of three dimensions of justice, namely: distributive, procedural, and recognition justice.'

Abstract

This deliverable builds upon work undertaken from D4.1. Critical review of EPE initiatives as well as other research projects to develop and trial a framework for developing an Education and Public Engagement programme for carbon capture and storage in the context of the Cork case study area. A methodological approach is detailed for the creation of EPE programmes informed by just transition illustrating a variety of EPE activities that are typically employed as part of consultative, collaborative and co-creative public engagement processes. Examples of good EPE practice of Irish organisations are explored. Informed by this review a framework for EPE was developed for the Cork case study area – including the creation and curation of content meeting the needs of the target audience. Key elements of this framework were trialled in local communities to evaluate its effectiveness, identify areas of potential improvement and ascertain its transferability. Finally, to aid in the measurement of such a programme's success, key performance indicators (KPIs) are presented for each of the three dimensions of justice – distributive, procedural, and recognition justice.

Methodology

As the objective of this deliverable is to create an Education and Public Engagement Programme (EPE), which will be constituted by a generalised structure that delineates the primary components that should be considered in constructing the final product, the data which was gathered and analysed was the bodies of literature which could inform the selection of these primary components as well as the input of community members of the Cork Case Study. Therefore, this deliverable was composed by a mixed methods approach that combined a literature review and semi-structured interviews.

The approach undertaken for the literature review was adopted from the work of Smith *et al.* (2021) in which we undertook a comparable study on key concepts of EPE programmes associated with wave energy. The method of gathering and analysing the secondary data is best described as an integrative literature review. This "is a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on a topic are generated" (Torraco 2005:356).

Literature review

This search was both systematic and dynamic. Systematically, the approach was to use similar search expressions in multiple databases available such as Elsevier Scopus, Google Scholar and UCC library OneSearch and set the search parameters to relevancy, citations, and date in that order (Table 1). Dynamically, both a forward and reverse snowballing approach was used for references found in the bibliographies of multiple publications, examining both original sources and linked articles to.

Table 1 Search term examples and databases

Examples of search terms used	Databases searched
Education AND public sphere Conceptions of publics The public of public pedagogy Typologies of public engagement Social movement AND public pedagogy Importance of place in social representations Learning out of school Deliberative democracy AND engagement Ethics of social intervention Rationality and emotion in public engagement	Web of Science Science Direct Safe Journal JSTORS ProQuest Cambridge core Wiley online Library Taylor & Francis eBooks and eJournals Scopus SocINDEX OneSearch (university search energy for books and journal articles

Semi-structured interviews

To complement the literature review and enable an in-depth investigation into attitudes towards CCS and perspectives on EPE programmes in the Cork Case Study, key informants were engaged through semi-structured interviews. The aim of semi-structured interviews is to gain an appreciation of the perspective of interviewees about a focal matter. Dunphy *et al.*, (2021) note the importance of allowing sufficient time and scope in the engagement such the interviewees to give their point of view and to tell 'their story'. The semi-structured interviews were carried out using pre-formed, concise, easily understood, open-ended questions – the informants were invited to talk about their own community, the way they acquire trusted information, their knowledge of climate change, experience of consultation and public engagement programmes, and perceptions of CCS. Prompts were used to guide the conversation. The interviews were held in person and were recorded with the permission of the participants. To encourage interviewees to respond openly and freely, participant anonymity and confidentiality were guaranteed, and all responses were anonymised during the coding process.

Table 2 Interview participants

Code	Position/Profession
A1	Employee of a local business <50 years old (female)
A2	Employee of a local business <50 years old (female)
A3	Homemaker <50 years old (female)
A4	Retiree >50 years old (female)
A5	Social worker >50 years old (male)
A6	Beekeeper >50 years old (male)
A7	Academic researcher <50 years old (male)

Data analysis and interpretation

All interviews were manually transcribed. Following this initial stage, the text was carefully analysed to capture key information to identify themes according to the dimensions proposed for the EPE programme. Emerging information was cross-referenced and linked to that from the literature review, and in so doing resolving inconsistencies filling some knowledge gaps and identifying others. The relatively small dataset made it possible to code the text by hand and significantly reduced the iterative analysis and interpretation process. In each case, the researcher who interviewed the respondent also analysed the notes.

Key elements of the developed education and public engagement were trialled to evaluate effectiveness, to identify areas of potential improvement, and to ascertain transferability of the programme. As outlined in the deliverable, the trials in both local communities and amongst practitioners took the form of face-to-face interviews, outreach event, world café, lecture & discussion, conference engagement.

Key Results

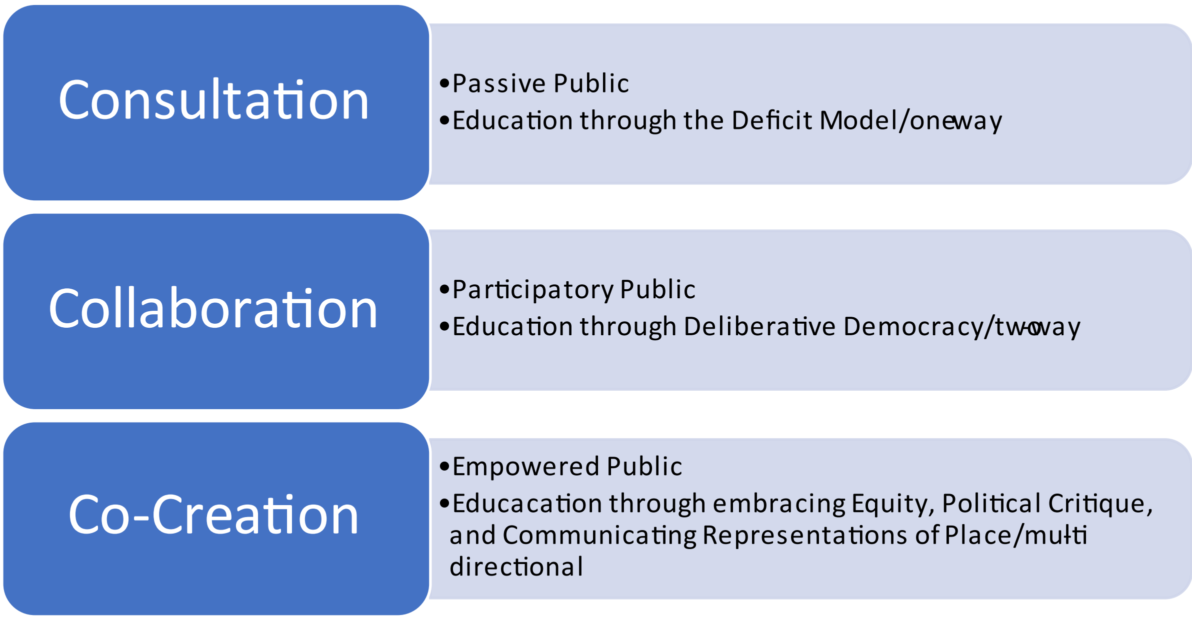


Figure 1 The EPE framework conceptualised (After Smith)

In previous work, we described three broad types of public engagement – consultation, collaboration and co-creation illustrated in Figure 1 below (Smith *et al.,* 2021) – that parallel Sherry Arnstein's famous ladder of participation (1969). However, we do not assume a hierarchical structure to these levels of participation. Rather than labelling consultation as inferior and co-creation as 'the best', it could be argued that different levels and types of public participation are appropriate for different situations and publics. In the following sections, we consider each of these three EPE framework types and describes examples of activities typically utilised for each.

Consultation

Of the three types, consultation represents the least active form of engagement; despite this fact, participation still takes place, though it remains a top-down process, usually operating as a vehicle for information distribution. Other times the consultation process may offer opportunities for public contributions on the stipulations necessary to gain public support for the project or intervention (Haggett, 2011). In consultative engagement, the public is frequently offered a single choice i.e., to get with the programme (*e.g.*, accepting a project if that is what is proposed). The consultation tier frequently carries negative connotations, though this is not always justified. Not every project or activity must be debated endlessly before every citizen; at the same time, the public must be provided with information on current topics of important (e.g., the recent vaccination roll-out for COVID-19 is a good example). Even when considering from an equity and justice stance, there are many instances where this top-down, (mostly) one-way communication may be all that is required (Reed *et al*., 2018).

Collaboration

Collaboration activities represent an increase in public participation, whereby the flow of information shifts from unidirectional (from organisers to participants, as typified in consultation activities) towards a more collaborative process which incorporates the values, concerns, and knowledge of the public into a consensus-building, decision-making process (Harris, 2002). A more limited view of collaboration involves the unidirectional flow of information from the public to organisers; despite the lack of two-way dialogue, this scenario still allows for the incorporation of the public's views into the decision-making process. The activities discussed below begin with examples of this more minimal type of collaboration, and end with activities which centre around a dialogue and exchange of ideas. This type of engagement is symbolic of the public pedagogical theme of deliberative democracy, in which decision-making revolves around reasoned debate, rather than just voting (Chambers, 2003).

Co-Creation

Change is the central focus of co-creative engagement, which seeks to bring about progress and change through a partnership between government/academic/corporate representatives and the public. The process remains deliberative, though the public – through representatives within the organisations voicing their interests – hold greater influence over the direction of the intervention and decision-making process (MacKenzie & Warren, 2012). This type of engagement "*constructively advances an argument that has been building in the participation literature amongst practitioners for some time about the need for governing institutions to more carefully listen to and be responsive to public voices rather than ritualistically carrying out invited public engagement processes as an end in themselves*" (Pallett *et al*., 2019, p. 609). As Engels *et al.* (2019) describe "*test beds and living labs represent an experimental, co-creative approach to innovation policy that aims to test, demonstrate and advance new sociotechnical arrangements and associated modes of governance in a model environment under real-world conditions*". Co-creation activities whereby members of the public are trained to take on leadership roles within their community as part of the proposed policy or project represent the height of public participation within EPE programme activities involving an initiating organisation.

Engagement methods

The authors offer a range of methods for education and public engagement in the deliverable. These are described in Table 3 below, outlining the characteristics for each method. Each method is also given a short summary with appropriate references to direct the reader to further reading on each.

Table 3 Characteristics of engagement methods (adopted from O'Connor et al., 2016 and Rowe & Frewer 2005)

Method	Depth of participation	Inclusivity	Cost	Demand on participants
Brainstorming session	Consultation Collaboration Co-creation	Limited	Minimal	Low
Citizen panels	Consultation	Low	Low	Significant
Citizens Jury	Collaboration	Moderate	Moderate-Significant	Significant
Consensus conference	Consultation Collaboration	Moderate	Moderate	Significant
Design Charrette	Collaboration Co-creation	Variable	Moderate	Significant
Design games	Collaboration Co-creation	High	Low	Moderate
E-panel	Consultation	Variable	Moderate-Significant	Low
Focus group	Collaboration Co-creation	Variable	Low	Moderate
Hackathon	Collaboration Co-creation	Limited	Moderate	Moderate-Significant
Interviews	Consultation	Limited	Moderate-Significant	Low-Moderate
Online forum	Consultation Collaboration	Moderate	Low	Minimal
Open day	Consultation	High	Moderate-Significant	Low
Opinion poll	Consultation	High		Minimal
Participant observation	Consultation	Limited	Moderate-Significant	Moderate
Public meeting	Consultation	High	Minimal	Low
Public talks / Public lecture	Consultation	High	Low-moderate	Low-moderate
Social media	Consultation Collaboration	High	Minimal	Minimal
Surveys	Consultation	high	Low-Moderate	Minimal
Visioning exercises	Collaborative	High	Low	Low
Website	Consultation	High	Low	Low
Workshop	Collaboration Co-creation	Variable	Low	Moderate

REALISE EPE Programme

The public has often been cited as a “barrier” to Carbon Capture and Storage (CCS) deployment, because decisions on whether projects move forward often depend on the local community’s acceptance (or at least their passive acquiescence). In July 2008, the G8 set a goal of launching 20 CCS demonstration projects globally by 2010, with wide-scale deployment in 2020 (WRI 2010). Nonetheless, this goal has not been met mainly due to local opposition, which has often been cited as one of the reasons for project delays and cancellations (Slavin & Jha 2009). Deliverable 4.1 showed that CCS will not be widely deployed at the pace needed without local community support. Not all proposed CCS projects will move forward, and many will be opposed by local communities for different valid reasons. Thus, realising the public-good potential of CCS-generated climate mitigation will require establishing trusting, respectful, and stable relationships among project developers, regulators, and local communities.

Community engagement can be defined as the process through which a project developer or/and a regulator builds and maintains constructive relationships with communities, involving them in a timely and transparent way over the life of a project (Herbertson *et al*. 2009). This process is often initiated by either the developers and/or regulators. Although it is possible for communities to take the initiative to host CCS projects and contact developers, project developers have been, in most cases, the ones that lead the characterisation of potential sites, selecting project locations and determining which communities are eventually engaged.

EPE Stakeholder Identification and Analysis

Once the main stakeholders have been identified, following the guideline of section 4.1.3 of the deliverable, stakeholders were placed according to how much influence and interest they have in the project (Figure 2). This map assisted in identifying the greatest and least efforts that are likely to be required for the communication strategy. Stakeholders in the greatest effort group who might have little or no interest in the CCS project but that can have a large potential to influence a CCS project such as local businesses, the community centre, inhabitants of the Cork Harbour Area and the town councils, will require a proactive engagement plan. Education will be the key strategy for this group and communication activities will need to be focused on the technology and the benefits of the project. By informing these groups with effective and credible information early in the process, the project developers can start building trust and relationships with their members.

In the highest commitment group are stakeholders that have an important influence in the community and that also could have a potential interest in the development of a CCS project. Examples of these are citizen groups that have an environmental commitment such as Tidy Towns and Cobh Zero Waste. These stakeholders would require a less proactive engagement that the former quadrant but still can be used as a resource for the communication activities that will take place with other stakeholders.

Stakeholders that fall into the category of the least effort are actors that do not have as much influence in the CCS project and also might have low interest in it. These can include potential opponents to the project that do not live in the Cork Harbour Area. It might be difficult to shift strong views and therefore communication with these groups will be monitored but not proactive. Stakeholders are to be actively engaged only if misinformation is being disseminated.

In the last quadrant are stakeholders that could have a potential influence in the CCS project but that do not have a high influence in its development. Groups can include the Cork Country Council, Sport

Clubs, the Education Sector, the Church and neighbouring communities in Cork County. Stakeholders in this group generally need to be kept informed but are least likely to be interested in being engaged. However, it's important to note that stakeholders can change quickly and therefore need to be monitored to make sure that these groups do not require a more active engagement.

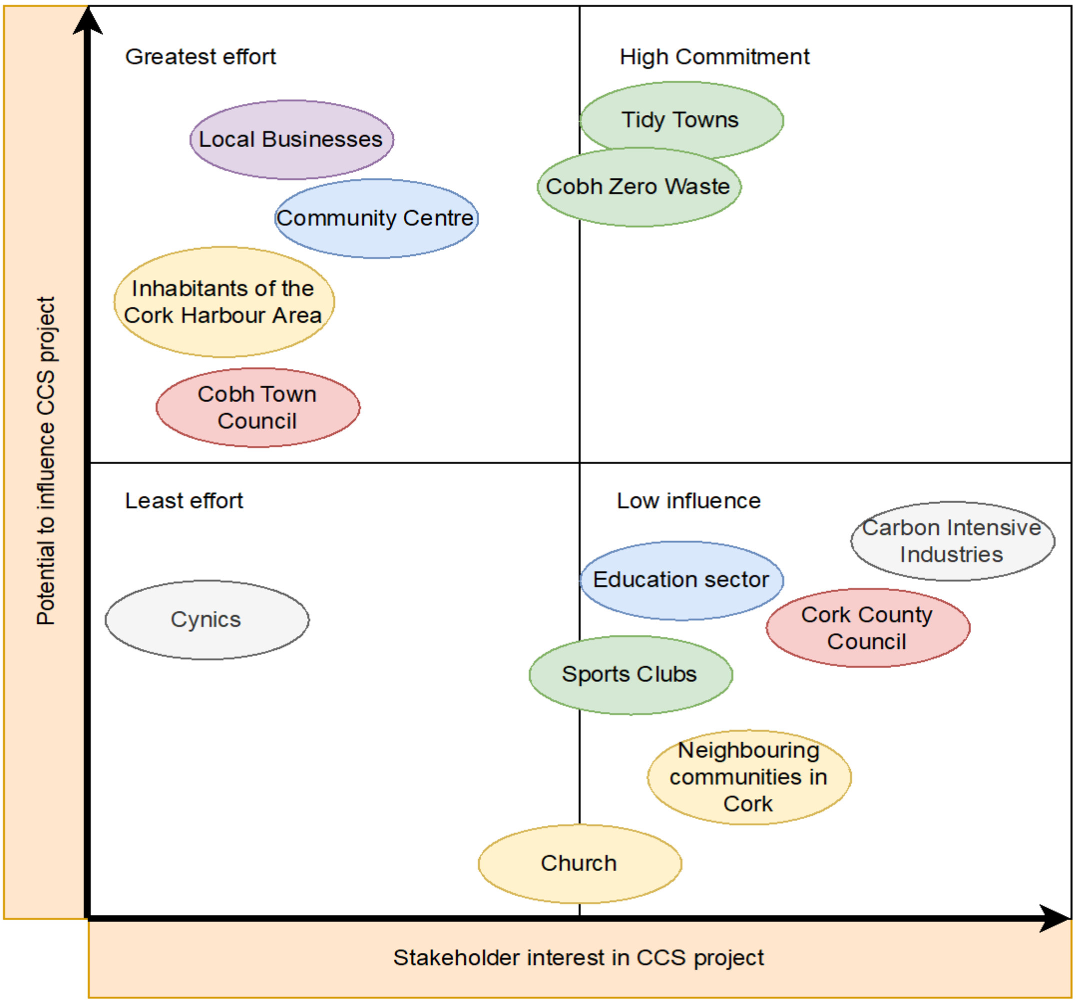


Figure 2 Stakeholder map for the Cork Harbour Area

Justice Key Performance Indicators (KPIs)

The mass deployment of strategic infrastructure associated with decarbonisation, including carbon capture and storage, is dependent on substantial societal buy-in. There needs to be acceptance at different levels – the general public needs to be supportive of, or at least neutral towards, the technologies involved, while prospective host communities need to accept the specific proposals for deployment of these technologies in their midst (Dunphy *et al.*, 2022). However, such buy-in has not always been evident, as evidenced by the public opposition to many projects, which is seen as an impediment to the ongoing transition (Enevoldsen & Sovacool, 2016). Feelings of unfairness are often key to understanding opposition to the development of infrastructure and the deployment of often novel technologies. Indeed, fairness can almost be said to be a prerequisite for a successful decarbonisation (Dunphy *et al.*, 2023).

Drawing from the just transition (see *e.g.*, Newell & Mulvaney 2013) and energy justice literature (see *e.g.*, McCauley & Heffron 2017), fairness or justice in this respect can be seen as having three principal dimensions. The first, recognition justice is concerned with the appropriate identification and acknowledgement of stakeholders, ensuring social groups do not feel marginalised (see McCauley *et al.* 2013); the second, procedural justice is focused on decision making, ensuring inclusive, fair and transparent decision-making processes (see *e.g.*, Sovacool & Dworkin 2015); while the third, distributive justice: considers the fairness of how benefits and ills arising from projects are allocated (see *e.g.,* Lee & Byrne 2019). For some communities impacted by existing or previous projects, restorative justice is also important in attempting to address past and ongoing harm caused by past decisions (see *e.g.*, Heffron & McCauley 2017).

Recognition justice: Discussions of social justice tend to focus on two primary dimensions, namely: who wins and who loses (distributive justice) and claims of unfairness in the process (procedural justice). However, perhaps a more fundamental element of justice is recognition, which can be expressed as cultural domination, non-recognition, disrespect. Velasco-Herrejón *et al.* (2022, p. 25) for instance note that "while theories of distributive justice offer models and procedures by which distribution may be improved, these do not examine the social, cultural, symbolic and institutional conditions underlying unfair distributions and processes in the first place". In the context of implementing an education and public engagement programme (around CCS and related projects), the following key performance indicators are suggested.

1. Comprehensive: There is general agreement that stakeholders have been identified. There are no legitimate complaints regarding exclusion and there is no social mobilisation around access to EPE process).
2. Recognition: An appropriate process (*e.g.,* social survey) is undertaken at the commencement of the EPE programmes to develop an understanding of socio-cultural specificities of the community. Reports on stakeholder recognition to be made public within one week.
3. Inclusive: All stakeholders identified in #2 above, who wish to be involved, are engaged through the EPE programme.

Procedural justice: People's perceptions of fairness are strongly shaped by which decisions are made, who is involved and who has influence (Walker, 2012). Unjust procedures and structures can lead to the dominance of one group resulting in (perceived) injustice. Power dynamics are central to understanding the process of side-lining and exclusion. It is important that an EPE programme is itself implemented fairly but also that it supports procedural justice in the proposed developmental project. In the context, the following key performance indicators are suggested.

1. Responsive: 95% of complaints about EPE process addressed within two weeks, 100% within one month; Complaints process available to all stakeholders.
2. Ethical: 100% of engagements to reflect informed consent processes.
3. Transparent: Report on 90% of engagements published within two weeks, 100% with one month. Reports on stakeholder feedback on decision-making process prepared for developers to be made public within one week.

Distributional justice: The fundamental division with a lot of infrastructure projects, is that while developers and other economic stakeholders will likely gain substantially, there is often little if any net gain for local communities (notwithstanding so-called community benefit schemes). Perceived fairness in the allocation of benefits and ills associated with a project is an important component in its acceptability to local populations. In the context of an EPE programme the following KPIs are suggested.

1. Receptive: Mechanism for community stakeholders to provide feedback on distributional justice aspects of proposed project to be put in place within first two weeks of EPE programme.
2. Transparent: Reports on stakeholder feedback on distributional justice process prepared for developers to be made public within two weeks.

Restorative justice: Healy *et al.* (2019) note that this dimension of justice concerns "… a process for resolving crime (or injustices) by focusing on redressing harm done to victims, holding offenders accountable, engaging communities in conflict resolution and reducing future harm through crime prevention." In the context of an education and public engagement programme, the focus is on ensuring that information on past (perceived) injustices in fed into the decision-making processes in a open and transparent manner.

1. Informed: Report on identification of historic decisions that impacted negatively on community to be completed within first month of EPE programme. Report to be made public within one week.
2. Transparent: Proposal for addressing any identified negatively impacting decisions to be made public within the second month of EPE programme.

The work reported in this deliverable built on the knowledge developed within Task 4.1 critical review of EPE initiatives; it outlines how one would develop an effective EPE programme that addresses the needs of multiple stakeholders with differing degrees of agency and connection to the a prospective development. In consultation with community stakeholders in the Cork case study, the work took an intersectional approach, considering the socio-demographic specificities of the relevant communities, including gender; economic privilege; and life stage.

The report first outlined a methodological approach for the creation of EPE programmes informed by just transition illustrating a variety of EPE activities that are typically employed as part of consultative, collaborative and co-creative public engagement processes. Then, education and public engagement processes frequently adopted by organisations in Ireland were explored in some detail, to finally propose an EPE for REALISE. Key elements of this framework were trialled in local communities to evaluate its effectiveness, identify areas of potential improvement and ascertain its transferability. Finally, to aid in the measurement of such a programme's success, key performance indicators (KPIs) were presented for each of the three dimensions of justice (distributive, procedural, and recognition justice).

4 Socio-political considerations

Loughrey, Matthew; Gillespie, Angus; Havercroft, Ian; Pinto, Errol; Raji, Nabeela; Consoli, Chris; & Rassool, Dominic (2022). *Analysis of socio-political considerations of CCS* (D4.3). A research output of the REALISE H2020 project (grant agreement no. 884266).

Extract from project 'Description of Action'

'This task will use the social science expertise of UCC and the CCS expertise of SINTEF and TNO to explore the socio-political lessons learned from global CCS projects, the conditions and policies that have enabled successful deployment and their implications for CCS at EU refineries such as the Whitegate refinery in Ireland. Utilising the consortium's extensive contacts in the CCS domain and global reach, refinery projects/facilities from around the world will be engaged to identify international best practices. This will comprise identifying and analysing the socio-political lessons from failed CCS projects internationally; characterising key enablers of operational CCS facilities worldwide; and identifying prerequisites for successful deployment. Key to realising this understanding is addressing socio-political risks associated. An international stakeholder workshop will be held focusing on the identification of key socio-political project risk, evaluation of risk mitigation strategies and exploring the financing implications of these risks. An extensive review of policy and regulatory framework will be undertaken at the EU and member state level exploring e.g., current EU provisions; recommendations for capture of CO2 at refineries (including financial support mechanisms, regulation); Wider transport and storage policy considerations (including access to infrastructure; London Protocol; storage liability etc.). For each case study, the CCS readiness index (CCS-RI) will be determined. The CCS-RI is defined by GCCSI and monitors the progress of CCS development on a country level. The index of studied countries is part of the CO2RE database, developed and maintained by GCCSI. The methodology will be adapted in REALISE for determining the index each CCUS business case. REALISE will clearly indicate policy, law and regulation, and storage resource development barriers, and propose ways how to address those.'

Abstract

As part of the REALISE project, this section examines how socio-political risks have been managed, successfully or otherwise, in previous CCS projects. The learnings from this review will be used as an important input to producing a practical risk assessment framework for socio-political issues in CCS projects. Socio-political risks are considered at the broadest level, covering the three dimensions of the "triangle of social acceptance" – society in general, the market and the local community. The CCS industry is relatively small, but there are already several examples of socio-political risks having caused problems during development. Over the past ten years, there have been at least 87 recorded cases of CCS projects that were abandoned at some point between their design and construction phases. Socio-political risks played at least a contributory role in around 5% of those abandonment decisions. Potential stakeholder management learnings and best practices were reviewed in case studies of five CCS projects. These projects' experiences were explored through a brief summary of the project details and main learnings as well as common graphics to illustrate the impact of socio-political events and decisions on the project's prospects.

Socio-political risk management can be viewed as a deliverable or as a process. Rather than simply make a binary choice between the two, socio-political issues should be managed with the same respect as technical and operational CCS project risks. The growing range and richness of templates and checklists available to guide stakeholder management in CCS projects should be treated as prompts for best

practices and not to short-circuit efforts. The more applied the risk identification work, the easier it should be to develop mitigation efforts. Over-reliance on checklists can encourage simple mechanical assessments.

Methodology

The key objective of this deliverable is to examine how socio-political risks have been managed, successfully or otherwise, in previous CCS projects. The learnings from this review will be used as an important input to producing a practical risk assessment framework for socio-political issues in CCS projects. The work is based on an initial literature review to produce a practical understanding and definition of socio-political risks. With that guidance on scope, the relevant issues are considered for CCS projects, firstly based on general principles and then, with the help of several project case studies, using common applied themes and insights. The report concludes with a discussion of the main learnings and recommendations for managing socio-political risks for future CCS projects.

The Global CCS Institute offers a unique insight into how socio-political risks have been managed in both failed and successful CCS projects over the past ten years and draws from the Global CCS Institute publication by Ashworth *et al.*, (2011) designed to help CCS project managers in effectively deal with such issues. Five CCS projects were used as case studies for this report, each with different perspectives on managing socio-political risks that ultimately caused the cancellation of three of them. These are:

- Barendrect, The Netherlands – cancelled in 2010.
- White Rose and Peterhead, UK – cancelled in 2015.
- Zerogen, Australia – cancelled in 2010.
- Tomakomai, Japan – successfully completed in 2019.

Key Results

The report develops an indicator of the readiness of refineries for the application of CCS and applies it across European refineries.

Management of Socio-Political Risk

The CCS industry is relatively small, but several examples of socio-political risks have already caused problems during development. Over the past ten years, at least 87 recorded cases of CCS projects were abandoned at some point between their design and construction phases. Socio-political risks played at least a contributory role in around 5% of those abandonment decisions. A clear lesson from previous experience is that socio-political risks should be managed with the same rigour as all other significant risks and this management should commence at the conception of the project. This will involve including socio-political risks in the project's risk management framework and the availability of deep community engagement, social science, and external engagement expertise. Failure to do so is a failure to manage a risk that can, and has, caused the complete failure of projects, even where they were sound from a commercial or engineering perspective.

Policy & Regulatory Frameworks

The successful deployment of CCS at refineries is contingent upon the presence of enabling policies that are designed to overcome broader CCS market failures. These market failures are not specific to CCS within any particular industry or sector, including refineries, so it follows that enabling policies will support refineries by default. Importantly, however, policies must place a sufficient value on CO_2 captured to ensure there is a business case for investing in CCS at refineries. From the point of view of CCS investments, enabling policies must deliver the following:

- Place a sufficient value on captured CO_2 to overcome revenue risk. Applying CCS to any industrial facility incurs significant additional capital and operating costs. Unless there is a financial return from CCS to the project owner, the investment will not be made.
- Overcome the cross-chain risk. CCS projects that have a single source connected to a single storage facility pose an important risk to investors because the unavailability of either component can cripple the entire value chain. This can lead to significant loss of revenue, making investment in such projects high-risk.
- Manage long-term storage liability. While the risk of leakage during the operation or post-closure phase of a CCS facility is diminishingly small, it is not zero. Although a private investor may manage this risk while a CCS facility is operating, it will be impossible for businesses to bear this risk for an indefinite period beyond post-closure.
- There are well-established policies and mechanisms that have been implemented that have enabled investment in commercial CCS projects. They include carbon pricing, or payment for each tonne of CO_2 stored, capital grants or other forms of government support or risk sharing for essential CO_2 transport infrastructure, and legislated mechanisms for the transfer of some forms of liability for stored CO_2 from the operator to the state once certain criteria are met. These are all broadly applicable to CCS at refineries.

Law and regulation similarly play a crucial role in supporting the deployment of CCS projects. The development of CCS-specific legal and regulatory frameworks, as well as the removal of legal barriers to the technology, will be critical to ensuring more widespread deployment. CCS-specific regulatory frameworks will enable the development of CCS applications across a wider variety of technologies and locations, including projects linked to refineries.

Finance

The availability of affordable finance for CCS is critical. Debt financing from commercial banks for CCS is currently difficult due to the immaturity of the CCS industry compared to other industries for which banks have a long history of lending. There are a range of green bonds, sustainable bonds/social bonds that are a potential financing option for CCS at refineries, subject to an assessment, on a case-by-case basis, as to whether the CCS project complies with eligibility requirements of the particular bond. National import export credit agencies can also provide debt finance, loans, lines of credit or bonds as well as insurance and guarantees to support CCS projects, in support of national companies seeking to export goods or services.

Refinery Readiness Indicator

The suitability or readiness of a refinery to have CCS retrofitted to the plant depends on many factors. A Refinery Readiness Indicator was developed and applied to European refineries. It is a benchmarking tool that provides an indication of how close a refinery is to being "CCS Ready" compared to other refineries. The Indicator uses seven criteria, each with an appropriate weighting, to calculate the Refinery Readiness Indicator Score for each refinery.

1. Policy and Regulation.
2. CO_2 partial pressure and total CO_2 emissions.
3. Distance to geological storage resource and transport mode (ship and/or pipeline).
4. Regulations for transport of CO_2, both domestic and transboundary.
5. Potential to form a CCS hub, considering other nearby CO_2 sources.
6. Location Cost Factor.
7. Presence of other active CCS projects in the host country.

Overall, the highest-scoring refineries are large (>2Mtpa CO_2), adjacent to suitable storage and in a country with an enabling environment for CCS. The following high-level messages are clear:

- Strong policy and regulatory frameworks create an enabling environment for CCS deployment.
- The larger refineries (>2Mpta CO_2) are the highest-scoring, offering the lowest costs per tonne of CO_2.
- Access to adjacent and viable storage formations promotes the highest score; however, longer distances to better storage also improve the overall result.

The five highest scoring refineries were:

1. Shell Nederland, The Netherlands.
2. BP Scholven, Germany.
3. PCK Schwedt, Germany.
4. PKN Orlen, Poland.
5. ENI Taranto, Italy.

CO_2 Capture Technologies for Refineries

Refineries are complex industrial plants with small, lesser complex plants still having many varied CO_2 emission sources. There are three major sources of CO_2 in refineries; process heaters and boilers, FCCs and power generation (utilities). Although hydrogen production only accounts for approximately 2% of refinery emissions, the flue gas that is produced has a significantly higher CO_2 concentration than other sources in a refinery (15 – 99%).

There is a range of technologies available to capture CO_2 from these sources. Post-combustion carbon capture covers a range of specific technologies that fall into the category's liquid solvents, solid adsorbents and membranes. Pre-combustion carbon capture refers to removing CO_2 from hydrocarbon fuels before combustion, typically through the generation of hydrogen as the fuel for combustion. Oxy-fuel combustion is the third method for carbon capture. The nitrogen that is approximately 80% of the air commonly used for combustion serves to dilute flue gas CO_2 content to less than about 15% for process heaters, boilers and other thermal heat recovery systems. Post-combustion capture processes are designed to separate the relatively dilute CO2 from the bulk flue gas nitrogen. In oxy-combustion processes, the bulk nitrogen is removed from the air before combustion in an Air Separation Unit (ASU). The fuel is burned with a mixture of oxygen (from the ASU) and recycled flue gas to control the combustion temperature in the absence of nitrogen. The resulting combustion products will have CO_2 content of about 90% or greater.

The selection of appropriate technologies for a given application should consider the typical partial pressure of CO_2 in a point source, the volume (tonnage) of CO_2 from that point source, and the relative availability and cost of energy sources (heat and electrical). Within a refinery environment, it is essential that planning for staged deployment of capture projects is undertaken. Refineries have a range of point sources with varying costs and scales, and it is likely that these would be deployed in separate stages rather than as a single, integrated project. Given the economics in most plants, it is likely that larger-scale capture projects would be deployed on the SMR and/or FCC units in stage one, then progressively working up the marginal abatement cost curve as resources are available.

CO_2 Transport and Storage

CO_2 can be transported through a combination of four modes. Listed alphabetically, they are pipelines, rail, road, and waterways. Of these modes of transportation, pipelines are the most versatile, used extensively worldwide to distribute and transport oil and gas. Using roads or rail to transport CO_2 requires additional capacity planning and potential debottlenecking since these modes are also used to transport people, freight, and other types of cargo. The transport of CO_2 through waterways, especially international waterways, has unique requirements. Planning for staged deployment of capture projects at a refinery is essential, and transport design should be considered in unison to ensure the most suitable transport design and method selected. It is likely in Europe that a combination of transport methods will be applied for refinery, and other CO_2 sources, to transport CO_2 to a suitable storage location.

The provisions of the London Protocol could influence projects where transporting CO_2 through waterways is a requirement. Only eight countries (Contracting Parties) have ratified the agreement. However, a provisional application of the amendment to Article 6 of the London Protocol was agreed to in 2019 at the 14th Meeting of the Contracting Parties. Countries with plans to transport CO_2 internationally can proceed but have additional requirements to liaise with the International Maritime Organization. There are several business models relevant to the transport and storage of CO_2. Government policy has a significant role in enabling the development of the necessary infrastructure, just as it did in other industries such as electricity and telecommunications, water distribution, renewable energy, road and rail. Examples of policies or business models applicable to CO_2 transport and storage include the following:

1. Regulated Asset Base (RAB): In this model while the asset is owned by the State, private companies manage and operate the infrastructure. However, investment decisions are managed by a regulatory body. The private company receives payments for services provided to customers while also receiving incentives (subsidies, tax benefits) from the government to ensure the continuity of operations.
2. Public Private Partnership (PPP) or Private Finance Initiative (PFI): The government invites tenders for infrastructure projects. A consortium between a public-sector entity and private companies is set up as a separate company. This company carries out all stages of the project, from initiation, selection, and design, to execution and operation. Through a contract, it receives revenues for services provided to customers or receives performance-based payments from the public-sector entity for managing the infrastructure.
3. Contract for Difference (CfD): Used in the power and utility sector, this structure is a financial contract awarded through an auction. The energy generator that wins the contract is guaranteed a revenue stream for the contract's duration by providing a difference payment and

providing long-term revenue certainty (Low Carbon Contracts Company, 2022) (Low Carbon Contracts Company, 2022) (Low Carbon Contracts Company, 2022). This guaranteed revenue stream can provide a basis for financing capital-intensive projects like CO_2 transport and storage.

4. Cost Plus: These financial contracts are used for capital-intensive projects. In this financial arrangement, project developers are paid for project expenses in addition to an additional payment for executing the contract (or a profit margin).
5. Waste sector type contract: These contracts are like other contracts common in the waste management sector. Project developers are paid for the units of CO_2 they can inject and store, or CO_2 sold for EOR.
6. Hybrid models/contracts: The models and contracts described above can be used in combination depending on the complexity of the project.

For ease of reference, the applied learnings on socio-political risk management are presented below as a list of technical barriers, these are shown chronologically rather than necessarily in order of importance.

1. Treat socio-political issues as would other risk elements: Full integration with prevailing systems to manage operational and commercial risks could be the simplest way to encourage thoroughness. That could help address the choice of "process vs. deliverable" as stakeholder management would follow common practices. Leading practice risk management systems will use some form of rating and subsequent Risk Assessment Matrix (RAM) to allocate accountability for prioritising and managing individual socio-political risks.

1. If proven, use internal risk processes or those of main contractors: Similar to the previous point, adoption of stakeholder management will be helped when it is based on familiar existing company systems and processes. Again, integration and normalisation of socio-political risk management is the objective. If the organisation commissioning the CCS owner is inexperienced in major capital projects, it can instead consider using the risk management processes of the main Engineering, Procurement and Construction (EPC) contractor.

2. Review best practices and use associated templates: It is becoming easier, because of both project numbers and open-sharing, to access key learnings from preceding CCS project developments. Stakeholder management is a separate component of those reviews. Several CCS organisations and previous best practice reports exist to facilitate valuable reviews and suggest replicable check-lists and templates. This report could be useful in that respect.

3. Communicate importance of stakeholder management, externally and internally: Emphasising the role of managing socio-political risks signals its importance to both internal teams, managing the process, and external stakeholders, with whom a productive dialogue is needed. Integration with prevailing corporate processes reinforce the same message internally. More orthodox forms of communication might be merited to reach and assure external stakeholders.

4. Follow a circular process of "analyse – diagnose – feedback – monitor": The best risk management processes are based on iterative cycles; the same can be done for socio-political issues. Approaching the task in this way encourages more pragmatism in describing and actioning risks from its beginning. It also tends to help consider stakeholder management as on ongoing project process and not a one-off, more static report.

5. Always plan social analysis at or before the project start: Regardless of whether stakeholder management is approached as a process or deliverable, the value of a robust baseline analysis of the project's key groups and socio-political issues is indisputable. That focused investigation could avert potentially disruptive blindsides. Also, more practically, it enhances the quality of monitoring work to detect and diagnose changes during the project's development phases.

6. Engage broadly during risk identification stage: Some leading examples of socio-political risk management have emerged from challenging corporate norms and beliefs at the earliest stages. In turn, that has been helped by actively including diverse interests to identify risks. Besides the final CCS operator, standard identification workshops and processes could extend to contractors, local authorities, previous CCS project developers, CCS organisations and academic experts. For a relatively small investment in diversity, unexpected insights (that can still be later discarded if not validated) could prove valuable in the ongoing stakeholder management process.

7. Consider internalising key stakeholders: At least for the identified most critical external bodies, or people, including them in some form of supervisory board – with a genuine opportunity to influence the project's direction, if not choices – could help build stronger working relationships.

8. Describe pre-mitigation and residual risk status: Reflecting the best practice "bow tie" general risk management model that addresses both pre-event mitigation and post-event recovery, taking time to describe (and quantify) residual risks enhances the speed and effectiveness of recovery if the underlying event does occur. Describing residual risks also promotes a deeper, more practical understanding of issues.

9. Formulate mitigation options in an operationally-friendly form: The main purpose of this is to ease the possible conversion to action and so make feedback loops more effective. Witnessing their concerns being addressed is the best route to building stakeholder trust and support. Another benefit is that producing an actionable mitigation narrative encourages internal consultation with operational teams and so a more robust outcome.

10. Identify and contribute to contiguous socio-political risk management: The trend towards fragmentation of the CCS supply chain and emergence of separate, but interdependent, operators of CO2 capture and CO2 infrastructure could lead to the neglect of some cross-chain socio-political risks. A refinery CCS project could, for example, be threatened by stakeholder concerns with its CO2 storage issues, that are managed by a separate hub and cluster operator. While professional stakeholder management should encourage inclusivity (see 7 above), CCS developers should actively promote a more fully integrated supply-chain approach to socio-political risk management.

11. Consider sharing practices and findings with ESG community: New and strengthening sources of scrutiny of stakeholder management could come from the ESG sector. Evidence of best practices and/or achieving breakthrough solutions with stakeholders could be powerful testimonies for ESG investors. Proof of project actions to substantiate ESG-related targets is always sought by ESG advisors. Their inclusion in, for example, the narrative of a project sponsor's Sustainability Report is a valuable validation of an organisation's strategy.

As part of the REALISE project, this report has reviewed and provided key insights in the following :

- the management of socio-political risks in carbon capture and storage (CCS) projects

- policy and regulatory frameworks that enable or incentivise investment in CCS
- financing options for CCS projects
- CO_2 capture technologies specifically relevant to refineries
- barriers and policy considerations relevant to the transport and storage of CO_2.

The application of CCS to European refineries can reduce annual emissions of CO_2 by many millions of tonnes. The successful execution of a CCS project requires a robust and effective risk management process that includes socio-political risk. Some early CCS projects failed as a direct consequence of ineffective management of socio-political risk. Incorporating lessons learnt from previous experience coupled with robust risk management processes is critical to ensuring projects proceed successfully.

CCS is an immature industry that can materially contribute to a significant public good – a stable climate. Government has a critical role in establishing the policies and regulations to create a business case for private sector investment in this critical technology. There are several examples of policies and regulations that have successfully supported CCS investments around the world that are applicable to European refineries. There are no fundamental technical barriers to the retrofit of CCS to refineries. A range of CO_2 capture technologies to suit the variety of gas streams created by refineries is commercially available. Large gas streams with higher concentrations of CO_2, such as from hydrogen production, are lower cost and should be the first to benefit from CCS. Also, the transboundary movement of CO_2 by ship must comply with the specific requirements of the London Protocol. Parties to the protocol wishing to import or export CO_2 must advise the International Maritime Organisation that they will comply with those requirements. CO_2 transport also requires infrastructure such as pipelines and port facilities. Government has a role in supporting the development of this infrastructure which is essential to meeting ambitious climate targets.

5 Industrial networking activities

Viguier, Romain F.H (2023). *Reports on Industrial networking activities* (D4.4). A research output of the REALISE H2020 project (grant agreement no. 884266).

Extract from project 'Description of Action'

'A transnational Industry Club will be established as a means to develop an understanding of the industrial and commercial context of CCS. It will act as a forum to give voice to key actors interested in carbon capture and storage. The Industry Club will be an external body to the project and will acts as a forum which will provide expert knowledge, and economic insight to the project, while also serving as a means of disseminating information to these key players. This Industry Club, animated by UEDIN, and contributed to, and facilitated by, all partners, will comprise members from oil and gas, energy infrastructure, petrochemicals, and all companies and contractors active throughout the value chain (fuel, plastic, products, etc.) The Industry Club will:

- *contribute to plan the commercial deployment of capture technologies in refineries.*
- *ensure the technology is acceptable for the industry and is technologically & economically viable.*
- *contribute to the elaboration of a shared vision of CCS development in relevant regions.*
- *support the elaboration of a Business Model for carbon capture in refineries.*
- *attend regional stakeholder engagement events.*
- *facilitate dissemination amongst industrial sector and advise on exploitation of project's outputs, hence maximising the project's impact.'*

Abstract

A transnational industry club was established to develop an understanding of the industrial and commercial context of CCS in the refinery sector. This club served as a forum, giving a voice to key actors involved in the refinery sector or operating in industry clusters associated to refinery plants.

The Industry Club provided expert knowledge and economic insights to the project, along with a platform for knowledge sharing, dissemination, and dialogue. It consisted of members from various industries focused on innovative solutions to reduce emissions.

This Industry Club, an external body to the project, not only provided expert knowledge and economic insights but also served as a means of disseminating information to target stakeholders. UEDIN animated the Industry Club, and it interacted with all project partners. The club comprised members from the Oil and Gas, energy infrastructure, petrochemicals, and other companies, contractors, or trade associations active throughout the value chain (fuel, plastics, products, *etc*.).

The Industry Club had the following roles:

- Contribution to planning the commercial deployment of Capture technologies in refineries.
- Ensure the technology's acceptability for the industry and its technological and economic viability.
- Contribute to the elaboration of a shared vision of CCS development in relevant regions.
- Support the development of a Business Model for Carbon Capture in Refineries.
- Attend stakeholder engagement events.

• Facilitate dissemination within the industrial sector and advised on the exploitation of the project's output, thus maximizing the project's impact.

As the project comes to an end, members of the industry club are expected to contribute to further develop CCS technologies in refineries at a commercial level and actively work toward establishing an economic model for carbon capture in the industry.

Methodology

Members of the Industry Club were consulted throughout the project, on innovation development, business cases development and environmental policy. Industry Club members contributed to the project understanding of the industrial context of CCUS development.

Key Results

The economic context of developing CCUS technologies in the refinery sector is characterized by a number of environmental, economic and market factors.

The most important factors are environmental regulations and emissions reduction targets. The project focussed on developing business cases for Industrial CCUS in three sites in Ireland, China and South Korea and this work illustrates that refineries are under increasing pressure in many regions of the world to comply with stringent environmental regulations and ambitious carbon reduction targets. CCUS technologies offers a mean to help refineries meet industry emission reduction targets and avoid increasingly costly penalties and taxes.

Public awareness and concern about climate change have grown significantly and stakeholders, including investors, but also customers, and local communities, are placing increasing pressure on refineries to reduce their environmental impact. The deployment of CCUS can help refineries demonstrate their commitment to environmental responsibility and sustainability, which is increasingly seen as a competitive advantage.

The introduction of carbon pricing mechanisms, such as carbon taxes and emission trading schemes, is making carbon emissions more costly. In parallel governments and organisations in various countries are offering economic incentives, subsidies, and funding to help the development and deployment of innovative technologies to reduce emissions from industries. The implementation of CCUS technologies will help refineries reduce their carbon liabilities and manage operating costs more effectively.

It's important to note that the deployment of CCUS technologies in the refinery sector requires a significant investment of capital, technology integration, and expertise. Refineries need to weigh the economic benefits against the costs, as well as consider the long-term viability and sustainability of CCUS solutions. The specific industrial situation can vary by region and the prevailing regulatory and market conditions. Given the increasing emphasis on carbon reduction and sustainability, the deployment of CCUS technologies in the refinery sector is likely to be driven by a combination of regulatory mandates, economic incentives, technological advancements, and a desire to meet stakeholder expectations.

In summary, the economic context for developing CCUS technologies in the refinery sector is shaped by regulatory, environmental, and market pressures, as well as opportunities for revenue generation, cost reduction, and improved sustainability. As technology advances and the global focus on carbon reduction intensifies, these economic drivers are likely to become even more significant.

6 Public outreach activities

Nakao, Andressa; Knuutila, Hanna; & Dunphy, Niall. (2023). *Public Outreach activities and life-long learning* (D4.5). A research output of the REALISE H2020 project (grant agreement no. 884266).

Extract from project 'Description of Action'

'REALISE will not only analyse the societal effect but actively contribute to increase societal readiness index estimated in Task 4.4 before and after the project end and to improve public acceptance by offering and performing outreach activities (led by NTNU but with the participation of all partners):

• Information disclosure on demonstration activities, safety, risks and outcome through mini seminars (in conjunction with the project meetings) for local municipalities, employees at refineries and other local industry;
• Dissemination to Young Generation, e.g., mini seminars for students, guest lectures, participation in Summer Schools;
• Research based learning activities in all partner universities: The project will provide research challenges to different courses and will educate masters level students at all partner universities. As a concrete example, REALISE will contribute to an innovative course (Experts in Teamwork at NTNU) where interdisciplinary teams of students work on real-life challenges.'

Abstract

Outreach activities (OA) are designed to help or encourage members of a specific community to better understand the benefits of the research results and development to engage with different sociality important topics. It is designed for a large audience and provides expertise and knowledge about a specific topic to the public (European Commission, undated). Further, outreach activities imply an interaction between researchers and the public with a commitment and a two-way communication (European Commission, undated). Examples of outreach activities used in REALISE are school presentations, workshops, public talks and lab visits.

An outreach activity and communication are related but do not mean the same thing. The main difference between communication and outreach activity is the interaction between sender and receiver. Communication only goes in one direction. It does not require the feedback pathway.

According to the European Commission (2001), life-long learning (LL) is defined as "all learning activity undertaken throughout life, to improve knowledge, skills and competences within a personal, civic, social and/or employment-related perspective". It is the process of learning in different contexts, which is not limited to childhood or a classroom but can take place in various situations. It involves life experiences as the learner seeks to gain knowledge for professional or personal reasons. This concept has gained greater importance with the development of new technologies that change how we receive and delivery information, share knowledge and communicate.

A simple model for the development and implementation of OA and LL is shown in Figure 1 below. Using Karikari and Yawson's (2017) model, the five steps are outlined as such: (i) initiation, (ii) development, (iii) implementation, (iv) evaluation, and (v) sharing.

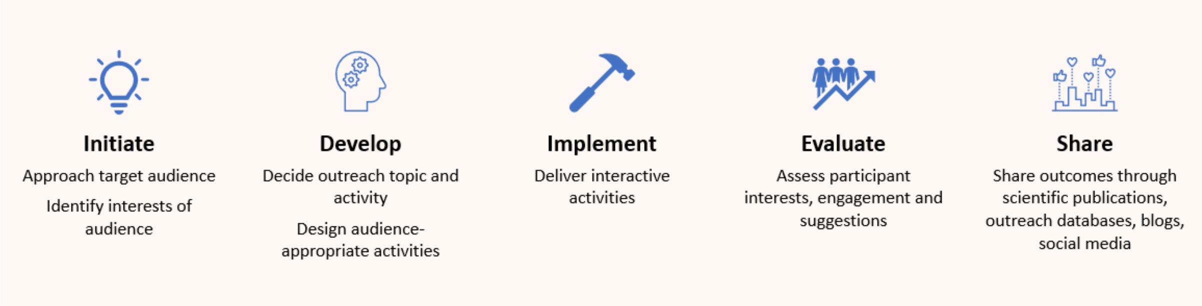


Figure 3 Simple model for OA and LL implementation (Karikari and Yawson, 2017)

This report outlines the REALISE work performed for Task 4.5, which relates to public outreach and life-long learning activities. Task 4.5 focused on actively contributing to improving public acceptance by offering and performing a range of outreach activities, including:

- Organising mini-seminars for local municipalities, employees at refineries and other local industries related to REALISE demonstration campaigns,
- Disseminating to the young generation by organising mini-seminars for students, giving guest participating in summer schools, and
- Offering research-based learning activities in all partner universities.

Methodology

Using Karikari and Yawson's (2017) model, described above, task leaders implemented a phased-based approach to the work. Firstly, target audiences were selected during the initiation stage, and their interests identified. At this stage, social expertise often approaches the potential audience to understand their social characteristics better and elaborate an appropriate EPE strategy. All outreach and life-long learning activities in REALISE have a specific target audience. People in a target audience typically share demographic similarities, location, or educational status. Another term often used is stakeholders, and there may be overlap in some instances between target stakeholders and target audience, but there are significant differences. Generally, a stakeholder is someone with an interest or concern in something, especially a business. Target audiences are people most likely to be interested in a product or service.

In the next step, the outreach activity development starts. The selection of which key message, summarising the main points of information the target audience should hear, understand, and remember, are defined and disseminated to the selected audience. Consequently, the expected impact is discussed. The key messages support the REALISE project's communication goals and are based on the main outcomes. At this stage, the dissemination methods and tools available and the resources needed for the activity are considered in order to optimise the design of activities.

Then, OA and LL were implemented, followed by an in-depth activity evaluation. The evaluation can be based on different methods, but typically, feedback from the audience is collected to give a starting point for the assessment. At this stage, there was also an opportunity to evaluate the audience's reception and suggestions, and to discuss the expected impacts. The expected impacts are the effects (positives) that the REALISE project can promote about the results and outcomes that are exploited in industry and society over the long term. These effects can be technological, social, environmental, and economical. The final step was to share the outcomes of the activity through publications, social media, and outreach databases.

Key Results

In the REALISE project, several target audiences have been identified as listed in the application. An overview of these is given in Table 3. REALISE's key messages, shown in Table 4, were adapted to each target audience based on our vision and objectives. The selected key messages were refined and updated throughout the project. The first column gives the tag for each key message, the second column has the main message for the selected target audiences. Table 5 presents the expected impacts of the OA and LL implementation. The first column gives the tag for each impact, and the second column has the desired impact. The tags are used in chapter 4 of the deliverable. Finally, Table 6 shows the connections between the different target audiences, expected impacts and key messages.

Table 4 Target Audience from the REALISE CCUS project

TAG	Target Audience
A01	REALISE Consortium: - Research and Development (R&D) of CO_2 capture technology based on chemical absorption SINTEF, TNO, NTNU, THU, POLIMI), - engineering companies (Pentair, Biobe), - a SME (Cybernetica), - Industry (Equinor, Ervia, Irving Oil with 2 power generation stations at Cork cluster, SDSTC in China, SKI in South Korea, - communication of the technical and societal aspects, risks, and developments in the field of CCUS to broad public (UCC, SCCS, and Global CCS Institute).
A02	Decision and Policy Makers: As develop recommendations for policy and regulatory changes to overcome societal, political, and socio-economic barriers is part of our vision, one of our target audiences are the decision and policy makers. In this audience our focus are the regulatory bodies, European platforms, Environmental agencies, Trade Associations, taxpayers, and NGOs
A03	Scientific Audience outside consortium and Academic Community: One of the main objectives of REALISE is provide a safe space where topics related to our outcomes can be utilised in the field of education, in labs and lesson courses. The Scientific audience and the academic community can indirectly raise awareness and promote new interdisciplinary opportunities. This audience includes Universities, Research Centres, Research Institutes, and Scientists.
A04	Technology providers: This audience includes engineering companies, CCUS operators, Refinery plant builders, R&D and innovation, and Other CCUS projects
A05	Refineries and other industries: This audience includes refineries and other CO_2 emitters on chemical industry, advanced plastic materials and utilities, transport & storage operators.
A06	General public: This term will be used to include the audience that does not belong to the previous target audiences described. Or to refer to the people in a society without defining a specific category.

Table 5 Key Messages from the REALISE CCUS project

Tag	Key message
KM01	*Programme for education and public engagement*
KM02	*Adapted models and modelling approaches to be used in education*
KM03	*Extended CCS readiness index (CCS-RI)*
KM04	*Successful demonstration of free-to-operate CO_2 capture technology ready for upscaling (TRL6-7)*
KM05	*Dedicated software for advanced control system*
KM06	*Successful use of solvent management technologies DORA and IRIS demonstrated in operational environment (TRL7)*
KM07	*Open-access simulation tool for assessing CO_2 capture strategy at refineries*
KM08	*Roadmap for full chain CCUS based on results from techno-economic evaluation of full-scale capture, transport, utilisation and storage/EOR*
KM09	*Recommendations on CO_2 utilisation routes*
KM10	*CO_2 quality information*
KM11	*Most suitable plastic materials and application*
KM12	*Dedicated software for advanced control system, with a flexible design, allowing for application in any absorption-based CO_2 capture plant*

Table 6 Expected Impact for the OA an LL

TAG	Expected Impact
EI01	Awareness of project vision and results
EI02	Creating new scientific knowledge and challenges
EI03	Increased interest and, ultimately, private investment, in novel CO_2 capture and conversion technologies to save emission credit costs and obtain profitable by-products.
EI04	Accelerate the market-uptake of the results
EI05	Enhance project results among the community
EI06	Enhance cooperation and cross-fertilisation among the community
EI07	Prove that solvent based absorption can be a cost-effective alternative

Table 7 Summary of REALISE key message, target audience and expected impact and their correlations

Key message	Target Audience	Expected Impact
Programme for education and public engagement	REALISE consortium Academic community Decision and policy makers	Awareness of project vision and results among students and general public
Adapted models and modelling approaches to be used in education		
Extended CCS readiness index (CCS-RI)		
Successful demonstration of free-to-operate CO_2 capture technology ready for upscaling (TRL6-7)	Scientific audience	*Awareness of project vision and results among researchers* *Creating new scientific knowledge and challenges.*
Dedicated software for advanced control system		
Successful use of solvent management technologies DORA and IRIS demonstrated in operational environment (TRL7)		
Open-access simulation tool for assessing CO_2 capture strategy at refineries		
Roadmap for full chain CCUS based on results from techno-economic evaluation of full-scale capture, transport, utilisation and storage/EOR		
Open-access simulation tool for assessing CO_2 capture strategy at refineries	CO_2 emitters Chemical industry Advanced plastic materials Utilities, transport & storage operators	*Increased interest and, ultimately, private investment, in novel CO_2 capture and conversion technologies to save emission credit costs and obtain profitable by-products.*
Roadmap for full chain CCUS based on results from techno-economic evaluation of full-scale capture, transport and storage/EOR		
Recommendations on CO_2 utilisation routes		
CO_2 quality information		
Most suitable plastic materials and application		
Dedicated software for advanced control system, with a flexible design, allowing for application in any absorption-based CO_2 capture plant	Technology providers	Accelerate the market-uptake of the results. Enhance project results among the community. Enhance cooperation and cross-fertilisation among the community. Prove that solvent based absorption can be a cost-effective alternative.
Successful demonstration of free-to-operate CO_2 capture technology based on 2^{nd} generation low-energy solvent (HS-3) ready for upscaling (TRL6-7)		
Successful use of solvent management technologies DORA and IRIS demonstrated in operational environment (TRL7)		

A key focus of this work was to provide a suite of external outreach and life-long learning activities, supplemented by confidential deliverables that helped improve capacity across consortium partners. A good example of this effort is the project website – https://realiseccus.eu – which provides an easily accessible location to share project information and demonstrate the benefits of CCUS. It was designed with the target audiences listed in Table 2 in mind and contains project news and events, partner details as well as project objective and work package descriptions. It also contains information on CCUS and its applicability to the refineries sector and climate targets. It also provides a public platform for the project research outputs and results, with public deliverables available to download from the project website.

To reach a general audience, including young people, three types of activities were performed:

- mini seminars,
- guest lectures and participation in summer schools, and
- research-based learning activities in partner universities.

With these activities, it was possible to perform three different approaches for disseminating our key messages to three different spheres where young people participate.

The mini seminars were carried out as webinars. A webinar instigates a much broader audience, it makes sharing knowledge more accessible for people who are in different locations, and it spreads knowledge faster. We used experts from different fields around Europe. In the mini seminars, we presented to students around the world the fundamental concepts of REALISE. The mini seminars were organised to appeal to a general audience, but also to university students and young professionals. Details about these can be found in Table 6. The first mini seminar started with a presentation on climate change, what it means and how it can affect the future. The first presentation started with a wider scenario with the conventional options for CO_2 capture technologies, narrowing down to the absorption process. Highlighting REALISE project relevant topics, *e.g.*, the importance of having an optimised solvent in the process. At the end of the first mini-seminar, technology development from low TRL to high TRL was discussed. The main idea was to inform the students about CO_2 capture, the REALISE project, and to encourage them to ask questions and participate.

The second mini seminar, as a sequence, presented other parts of the REALISE project. The starting presentation gave an overview of the CO_2 capture from industrial clusters, current approaches, and challenges. The subsequent presentation introduced the concept of heat recovery, which is fundamental for chemical engineering students and showed the multi-disciplinarity of the REALISE team, as our project goals require collaboration between multiple disciplines. The final presentation presented one of the REALISE outcomes, the OCTOPUS tool. It was essential to show the students that our goals are feasible, and that joint work can achieve good results. Again, the main idea was to help students understand the topic's importance and ask questions. Reaching many students with mini seminars requires targeted marketing and the use of platforms like LinkedIn. The main challenge of digital mini seminars was how to achieve an active participation of the students. In the time available, it was at times difficult to foster the students' trust so that they became more active listeners.

The guest lectures and participation in summer schools also allowed us to reach a more specific group of students who already have a certain level of knowledge, educational background (for example, chemical engineering) and degree-level experience. Despite the outreach being narrower (only those who participated in the summer school could join), summer schools and guest lectures open up opportunities for more activity-based learning, increasing the communication between the participants and presenter. A detailed overview of the guest lectures and summer school presentations is provided for it the deliverable.

Our outreach activities and lifelong learning to our target audience have been diverse, and various relevant channels have been used for dissemination. Our experts disseminated the results through presentations, videos and posters addressing the young generation, in addition to scientific audiences, policymakers, and other stakeholders covering the key messages in the project.

7 Barriers and recommendations

7.1 Societal, Political, and Socioeconomic Barriers

Drawing from research undertaken for tasks 4.1, 4.2, 4.3 and informed by the stakeholder feedback obtained during tasks 4.4, and 4.5, the following societal, political, and socio-economic barriers to CCS have been identified.

Societal:	– *Public scepticism*: societal distrust towards the science of carbon capture and storage, and public suspicions about proposed business models, have and continue to negatively impact the scaling up of this technology. – *Negative perceptions*: the public's association of carbon capture and storage with 'dirty' fossil fuels has affected the image of the industry, which has in turn impacted potential investments (carbon divestment) and affected the discourse around required policy innovations. – *Community hostility*: opposition to specific deployments by prospective host communities have and continue to negatively impact the scaling up of this technology. – *Technical expertise shortage*: at present there is a shortage of specific technical expertise due to industries (both upstream and downstream of this technology) requiring niche skills that are immediately compatible with CCS/CCUS deployment.

Political:	– *Policy lacunae*: there is a lack of the necessary legal and regulatory frameworks at both national and international levels to support the development of CCS projects. – *Regulations and infrastructure*: current regulations – which in most cases are designed for other purposes – can have a detrimental impact on the timeframes to design, construct, and operate these facilities. This increases the costs and risks associated with these projects. – *Socio-political risk*: the level investment required for the largescale deployment of this technology requires stable, supportive environments. The possibility of changing governments, following each election cycle, makes political contexts inherently unreliable, impacting business planning and investment. – *Transboundary requirements*: the transboundary shipment of CO_2, particularly using international waterways are complex. The non-ratification of the amendment to the London Protocol to allow for cross border transport of CO_2 serves to inhibit CCS deployment.

Socio-Economic:	– *OPEX uncertainty*: since operating expenditures rely on commodity prices, notably the price of oil, there is uncertainty about the reliability of cash flows after facilities start operating. – *CAPEX uncertainty*: capital expenditures are related to site specificity and to distinct policy requirements in different jurisdictions. The resulting cost estimates are also unique to each facility. It is another source of uncertainty since it offers little replicability for future projects. – *Lack of revenue model*: CO_2 prices are set through a patchwork of international compliance and voluntary markets each driven by their own jurisdictional policy, legislative, and regulatory requirements. The prices are low, and projects also require support through tax assistance. – *Uncertainty in demand*: Due to significant capital expenditure requirements, large industrial entities are usually the only viable project developers. Additionally, a seamless value chain for the utilization of CO_2 in most commercial and industrial products is lacking. – *Technology performance uncertainty*: while several CCS technologies are being developed and have been tested in pilot facilities, many have not been tested at scale. This leads to uncertainties about the technology's performance for large applications. – *Resource usage at scale*: if CCS is to be used at scale, it would require considerable supporting resources in addition to transportation networks. For example, scaling up CCS would also require scaling up electricity capacity. – *Risk perception*: the timelines for developing CCS projects are long and could take between seven to ten years for projects to come online after being initiated. The associated hurdle rates for CCS projects are higher because of the higher risk associated with future cash flows. Hence, CCS projects require a higher return. – *Regulations and infrastructure*: current regulations – which in most cases are designed for other purposes – can have a detrimental impact on the timeframes to design, construct, and operate these facilities. This increases the costs and risks associated with these projects. – *Socio-political risk*: the level investment required for the largescale deployment of this technology requires stable, supportive environments. The possibility of changing governments, following each election cycle, makes political contexts inherently unreliable, impacting business planning and investment. – *Transboundary requirements*: the transboundary shipment of CO_2, particularly using international waterways are complex. The non-ratification of the amendment to the London Protocol to allow for cross border transport of CO_2 serves to inhibit CCS deployment.

7.2 Policy and Regulatory Recommendations

At present, most CCU technologies are yet to be commercialised fully and the large-scale expansion of CCS/CCUS will involve significant expansions of cheap renewable energy and low-carbon hydrogen. In synthesising these outputs, the barriers to ramping up CCS/CCUS deployment can be seen as an intersection of social, political, and socioeconomic bottlenecks that will need to be addressed. A majority of CCS projects remain impeded by gaps in the business case, lengthy and/or complex implementation, and the uncertain levels of public acceptance and support. Therefore, recommendations for policy and regulatory changes to address the various identified barriers include:

Societal Policy Recommendations

<u>Societal:</u>	*Public scepticism*: 1. national governments to provide access to useful, trustworthy, and verifiable information on CCS. 2. national governments to implement public information campaigns on CCS's potential contribution to climate change mitigation. 3. additional transparency measures to be implemented for all decision making around CCS. *Negative perceptions:* 1. national governments to develop a detailed roadmap for decarbonisation that includes an explanation of the role of CCS and details the plans for phasing out of fossil fuels. *Community hostility*: 1. national governments to treat citizens (and collectively, communities) as legitimate stakeholders in decision-making on the deployment of CCS. 2. CCS developers to be mandated to meet specified good practice in implementing education and public engagement programme. *Technical expertise shortage*: 1. partner internationally (through the EU or with like-minded countries) to work with the sector to identify skills shortages. 2. partner internationally to develop multi-disciplinary education and training programmes to address the identified skills gaps.

Economic	*Policy lacunae*: 1. national governments to undertake a regulatory audit to identify and characterise shortcomings in legal and regulatory frameworks necessary for CCS. 2. (EU to develop a framework for member state cooperation in the field of carbon capture and storage. *Regulations and infrastructure*: 3. national governments to undertake a regulatory audit to identify and characterise regulations that are impeding CCS deployment. 4. national governments to cooperate with EU and other member states to create the structures enabling the required investment in CCS-related infrastructure. *Socio-political risk*: 1. national governments to work towards developing a political consensus on policies relating to CCS deployment. 2. the socio-political risk caused by the change of government should be characterised and reflected in contractual arrangements. *Transboundary requirements*: 1. national governments to work towards ratifying the 2009 amendment to the London Protocol to allow for cross border transport of CO_2 for geological storage.

Socio-Economic:	*OPEX and CAPEX uncertainty*: 5. business models for public-private partnerships around CCS to be developed to provide long-term certainty for investments including, *e.g.*, cost-plus or hybrid contracts. *Lack of revenue model*: 1. national governments to work collectively to establish appropriate minimum 'gate fees' for CO_2 which will meet the costs involved. 2. transportation of CO_2 for CCS to be subsidised from national carbon taxes. [note: these two recommendations will also contribute to addressing the *Risk perception*]. – *Uncertainty in demand*: 1. national governments and the EU to work collaboratively to ensure the true cost of carbon emissions are internalised by emitters. – *Technology performance uncertainty*: 1. implement incentivised business models, coupled with contract for difference auctioning, to attract risk capital. 2. develop insurance products and/or markets that (partially) offset the risks involved. *Resource usage at scale*: 1. national governments to carry out a review of infrastructure needs for CCS to enable informed decision making.

8 Bibliography

Agostino, D. & Arnaboldi, M. (2016). A Measurement Framework for Assessing the Contribution of Social Media to Public Engagement: An empirical analysis on Facebook. Public Management Review, 18(9): 1289–1307. https://doi.org/10.1080/14719037.2015.1100320

Aitken, M., Haggett, C. & Rudolph, D. (2016). Practices and rationales of community engagement with wind farms: awareness raising, consultation, empowerment. Planning Theory & Practice, 17(4): 557–576. https://doi.org/10.1080/14649357.2016.1218919

Arnstein, S. R. (1969). A Ladder Of Citizen Participation. *Journal of the American Planning Association*, 35(4): 216–224. https://doi.org/10.1080/01944366908977225

Ashworth, P., Boughen, N., Mayhew, M. & Millar, F. (2009). An Integrated Roadmap of Communication Activities around Carbon Capture and Storage in Australia and Beyond. *Energy Procedia,* 1(1): 4749–56. https://doi.org/10.1016/j.egypro.2009.02.300

Ashworth, P., Bradbury, J., Feenstra, C. F. J., Greenberg, S., Hund, G., Mikunda, T., Wade, S. & Shaw, H. (2011). *Communication and Engagement Toolkit for CCS Projects.* Canberra: Commonwealth Scientific and Industrial Research Organisation (CIRSO).

Bachen, C., Raphael, C., Lynn, K.-M., McKee, K. & Philippi, J. (2008). Civic Engagement, Pedagogy, and Information Technology on Web Sites for Youth. *Political Communication*, 25(3): 290–310. https://doi.org/10.1080/10584600802197525

Barnett-Page, E. & Thomas, J. (2009). Methods for the synthesis of qualitative research: a critical review. BMC Medical Research Methodology, 9(1): 59. https://doi.org/10.1186/1471-2288-9-59

Bell, D., Gray, T., & Haggett, C. (2005). Policy, Participation and The'Social Gap'In Wind Farm Siting Decisions. *Environmental Politics*, 14(4): 460–477. http://dx.doi.org/10.1080/09644010500175833

Bittle, S., Haller, C., & Kadlec, A. (2009). Promising Practices in Online Engagement. Public Agenda: Center for Advances in Public Engagement (CAPE). New York.

Bonham, S., Chrysostomidis, I., Crombie, M., Burt, D., van Greco, C. & Lee, A. (2014). Local Community Benefit Sharing Mechanisms for CCS Projects. *Energy Procedia*, 63: 8177–8184. https://doi.org/10.1016/j.egypro.2016.03.002

Boyd, A. D., Hmielowski, J. D. & David, P. (2017). Public Perceptions of Carbon Capture and Storage in Canada: Results of a National Survey. *International Journal of Greenhouse Gas Control* 67: 1–9. https://doi.org/10.1016/j.ijggc.2017.10.010

Bradbury, J., Ray, I., Peterson, T., Wade, S., Wong-Parodi, G., & Feldpausch, A. (2009). The Role of Social Factors in Shaping Public Perceptions of CCS: Results of Multi-State Focus Group Interviews in the U.S. *Energy Procedia* 1(1): 4665–72. https://doi.org/10.1016/j.egypro.2009.02.289

Breukers, S., & Wolsink, M. (2003). Institutional capacity in policy processes for wind energy in the Netherlands. ECPR Conference, Marburg, 20.

Breukers, S., Pol, M., Upham, P., Lis, A., Desbarats, J., Roberts, T., Duetschke, E., Oltra, C., Brunsting, S., de Best-Waldhober, M., Reiner, D. & Riesch, H. (2008). *Engagement and Communication Strategies for CCS Projects : Gaps between Current and Desired Practices and Exemplary Strategies*. (D3.1). A research output of the FP7 project NEARCO2 (grant agreement # 226352).

Brulle, R. J., Carmichael, J. & Jenkins, J. C. (2012). Shifting public opinion on climate change: An empirical assessment of factors influencing concern over climate change in the U.S., 2002- 2010. *Climatic Change*, 114(2): 169–188. https://doi.org/10.1007/s10584-012-0403-y

Brunsting, S., de Best-Waldhober, M. & Terwel. B. W. (2013). 'I Reject Your Reality and Substitute My Own!' Why More Knowledge about CO_2 Storage Hardly Improves Public Attitudes. *Energy Procedia* 37: 7419–27. https://doi.org/10.1016/j.egypro.2013.06.684

Buhr, K. & Wibeck, V. (2014). Communication approaches for carbon capture and storage: Underlying assumptions of limited versus extensive public engagement. *Energy Research & Social Science*, 3: 5–12. https://doi.org/10.1016/j.erss.2014.05.004

Chambers, S. (2003). Deliberative Democratic Theory. *Annual Review of Political Science*, 6(1): 307–326. https://doi.org/10.1146/annurev.polisci.6.121901.085538

Cheeseman, A. & Wright, T. (2019). Examining environmental learning experiences at an earth education summer camp. *Environmental Education Research*, 25(30): 375–387. https://doi.org/10.1080/13504622.2018.1509301

Chun, S. A., Shulman, S., Sandoval, R, & Hovy, E. (2010). Government 2.0: Making connections between citizens, data and government. *Information Polity*, 15(1-2): 1–9. https://doi.org/10.3233/IP-2010-0205

Cohen, J. J., Reichl, J. & Schmidthaler, M. (2014). Re-focussing research efforts on the public acceptance of energy infrastructure: A critical review. *Energy*, 76: 4–9. https://doi.org/10.1016/j.energy.2013.12.056

Cohen, M. F. & Nagle, E. (1934). *An Introduction to Logic and Scientific Method*. New York & Burlingame: Harcourt, Brace & World, Inc.

Corner, A., & Clarke, J. (2017). A Fresh Approach to Public Engagement. In Talking Climate (*pp.* 1-13). Cham: Palgrave Macmillan. https://doi.org/10.1007/978-3-319-46744-3_1

Corner, A., Markowitz, E. & Pidgeon, N. (2014). Public engagement with climate change: The role of human values. *Wiley Interdisciplinary Reviews: Climate Change*, 5(3): 411–422. https://doi.org/10.1002/wcc.269

Cornwall, A. & Jewkes, R. (1995). What is participatory research? *Social Science & Medicine*, 41(12): 1667–1676. https://doi.org/10.1016/0277-9536(95)00127-s

Cotterill, S., John, P., Liu, H. & Nomura, H. (2009). Mobilizing citizen effort to enhance environmental outcomes: A randomized controlled trial of a door-to-door recycling campaign. *Journal of Environmental Management*, 91(2): 403–410. https://doi.org/10.1016/j.jenvman.2009.09.010

Cotton, M. & Devine-Wright, P. (2012). Making electricity networks "visible": Industry actor representations of "publics" and public engagement in infrastructure planning. *Public Understanding of Science*, 21(1): 17–35. https://doi.org/10.1177/0963662510362658

Cowell, R. (2010). Wind power, landscape and strategic, spatial planning—the construction of 'acceptable locations' in Wales. *Land Use Policy*, 27(2): 222–232. https://doi.org/10.1016/j.landusepol.2009.01.006

Cowell, R., Bristow, G. & Munday, M. (2012). *Wind energy and justice for disadvantaged communities.* York: Joseph Rowntree Foundation.

de Lima, D. P. R., Gerosa, M. A., Conte, T. U. & de M. Netto, J. F. (2019). What to expect, and how to improve online discussion forums: the instructors' perspective. *Journal of Internet Services and Applications,* 10(1): 22. https://doi.org/10.1186/s13174-019-0120-0

Devaney, T. A. (2001). Statistical Significance, Effect Size, and Replication: What Do the Journals Say? *The Journal of Experimental Education*, 69(3): 310–320. https://doi.org/10.1080/00220970109599490

Dunphy, N. P., Lennon, B., Quinlivan, L., Velasco-Herrejón, P. & Curran, R. (2021). *Critical Review of EPE Initiatives* (D4.1). A research output of the REALISE Horizon 2020 Project (grant Agreement no. 884266). https://doi.org/10.5281/zenodo.7029984

Dunphy, N. P., Revez, A., Lennon, B., & Brenner-Fließer, M. (2023). *Typology of Energy Citizenship(s).* A research outputs of the ENCLUDE H2020 project. https://doi.org/10.5281/zenodo.10005552

Dunphy, N. P., Velasco-Herrejón, P. & Lennon, B. (2022). *Social Acceptability Framework. Report on development and trialling of EPE Programme* (D4.2). A research outputs of the REALISE H2020 project (grant agreement no. 884266). https://doi.org/10.5281/zenodo.10022012

Dütschke, E. (2011). What drives local public acceptance - Comparing two cases from Germany. *Energy Procedia*, 4, 6234–6240. https://doi.org/10.1016/j.egypro.2011.02.636

Earle, T. & Siegrist, M. (2008). Trust, Confidence and Cooperation model: A framework for understanding the relation between trust and Risk Perception. *International Journal of Global Environmental Issues*, 8(1-2): 17–29. https://doi.org/10.1504/IJGENVI.2008.017257

Einsiedel, E. F., Boyd, A. D., Medlock, J. & Ashworth, P. (2013). Assessing Socio-Technical Mindsets: Public Deliberations on Carbon Capture and Storage in the Context of Energy Sources and Climate Change. *Energy Policy,* 53: 149–58. https://doi.org/10.1016/j.enpol.2012.10.042

Enevoldsen P. & Sovacool B. K. (2016) Examining the social acceptance of wind energy: practical guidelines for onshore wind project development in France. *Renewable and Sustainable Energy Reviews*. 53: 178–184. https://doi.org/10.1016/j.rser.2015.08.041

Engels, F., Wentland, A. & Pfotenhauer, S. M. (2019). Testing future societies? Developing a framework for test beds and living labs as instruments of innovation governance. *Research Policy*, 48(9): 103826–103837. https://doi.org/10.1016/j.respol.2019.103826

Eurobarometer (2011). Public Awareness and Acceptance of CO_2 capture and storage. https://europa.eu/eurobarometer/surveys/detail/848

European Commission (2001). COM(2001)678 Final. Making a European Area a Lifelong Learning a Reality. Communication from the Commission. Brussels

European Commission (2019). "OM/2019/640 Final. The European Green Deal. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Commission (undated). Guidelines for Outreach Activities in the MSCA Under Horizon 2020. Retrieved 08 March 2023 from https://ec.europa.eu/assets/eac/msca/documents/documentation/publications/outreach_activities_en.pdf

Fernandez Chozas, J., Stefanovich, M. A. & Sørensen, H. C. (2010, Oct 6). *Toward Best Practices for Public Acceptability in Wave Energy: Whom, When and How to Address*. 3rd International Conference on Ocean Energy, Bilbao, Spain.

Fernandez, C. S. P., Green, M. A., Noble, C. C., Brandert, K., Donnald, K., Walker, M. R., Henry, E., Rosenberg, A., Dave, G. & Corbie-Smith, G. (2021). Training "Pivots" from the Pandemic: Lessons Learned Transitioning from In-Person to Virtual Synchronous Training in the Clinical Scholars Leadership Program. *Journal of Healthcare Leadership*, 13: 63–75.

https://doi.org/10.2147/JHL.S282881

Fernández, J., Llopis, F., Gutiérrez, Y., Martínez-Barco, P. & Díez, Á. (2017). Opinion Mining in Social Networks versus Electoral Polls. *RANLP 2017 - Recent Advances in Natural Language Processing Meet Deep Learning,* 231–237. https://doi.org/10.26615/978-954-452-049-6_032

Firmstone, J. & Coleman, S. (2015). Public engagement in local government: the voice and influence of citizens in online communicative spaces. Information, *Communication & Society*, 18(6): 680–695. https://doi.org/10.1080/1369118X.2014.986180

Fournis, Y. & Fortin, M.-J. (2017). From social 'acceptance' to social 'acceptability' of wind energy projects: towards a territorial perspective. *Journal of Environmental Planning and Management,* 60(1): 1–21. https://doi.org/10.1080/09640568.2015.1133406

Frederiksen, N. (1984). The real test bias: Influences of testing on teaching and learning. *American Psychologist*, 39(3): 193–202. https://doi.org/10.1037/0003-066X.39.3.193

Freeman, M. (2006). *Truth Commissions and Procedural Fairness*. Cambridge: Cambridge University Press.

Garett R., Chiu, J., Zhang, L. & Young S. D. (2016). A Literature Review: Website Design and User Engagement. *Online Journal of Communication Media Technology*, 6(3): 1-14. PMID: 27499833; PMCID: PMC4974011.

Getrich, C. M., Sussman, A. L., Campbell-Voytal, K., Tsoh, J. Y., Williams, R. L., Brown, A. E., Potter, M. B., Spears, W., Weller, N., Pascoe, J., Schwartz, K. & Neale, A. V. (2013). Cultivating a Cycle of Trust with Diverse Communities in Practice-Based Research: A Report From PRIME Net. *The Annals of Family Medicine,* 11(6): 550–558. https://doi.org/10.1370/afm.1543

Gibbs, A. (1997) Focus Groups. Social Research Update, 19. https://sru.soc.surrey.ac.uk/SRU19.html

Ginosar, A. & Reich, Z. (2022). Obsessive–Activist Journalists: A New Model of Journalism? *Journalism Practice*, 16(4), 660–680. https://doi.org/10.1080/17512786.2020.1816488

Girling, C., Booth, K. S., Kellett, R. W., Mahyar, N., Burke, Kelly, L. & Krahn, A. (2017). Collaboration Tools to Support Informed Public Engagement. *Landscape Research Record* 6(6): 264–278.

Haggett, C. (2010). A Call for Clarity and a Review of the Empirical Evidence: Comment on Felman and Turner's 'Why not NIMBY?'. *Ethics, Place & Environment*, 13(3): 313-316. https://doi.org/10.1080/1366879X.2010.528625

Haggett, C., Aitken, M., Rudolph, D., van Veelen, B., Harnmejer, J., and Markantoni, M. (2014). Supporting community investment in commercial energy schemes., Summary report. ClimateXChange and the Scottish Government. https://www.climatexchange.org.uk/media/1550/supporting_community_investment_in_commerical_energy_schemes_-_summary.pdf

Harris, C. (2008). The Irish Taskforce on Active Citizenship – The CLEAR Analysis. *Representation*, 44(1), 15–26. https://doi.org/10.1080/00344890701869066

Harris, N. (2002). Collaborative planning: From theoretical foundations to practice forms. In P. Allmendinger & M. Tewdwr-Jones (eds.), *Planning Futures: New Directions for Planning Theory*, (*pp.* 21–43). London & New York: Routledge.

Healey, P. (1996). The communicative turn in planning theory and its implications for spatial strategy formation. *Environment and Planning B: Planning and Design*, 23(2): 217–234. https://doi.org/10.1068/b23021

Heierbacher, S. (2010). *Engagement streams framework.* National Coalition of Dialogue and Deliberation.

Hendriks, C. M. & Lees-Marshment, J. (2019). Political Leaders and Public Engagement: The Hidden World of Informal Elite–Citizen Interaction. *Political Studies*, 67(3): 597–617. https://doi.org/10.1177/0032321718791370

Holliman, R., Whitelegg, L., Scanlon, E., Smidt, S, & Thomas, J. (eds.) (2009). *Investigating science communication in the information age: Implications for public engagement and popular media.* Oxford: Oxford University Press.

Hughes, T. P. 1987. The Evolution of Technological Systems. in W. E. Bijker, T. P. Hughes, and T. J. Pinch (Eds.), *The Social Construction of Technological Systems. New Direction in the Sociology and History of Technology* (*pp*. 51–82) Cambridge: The MIT Press.

IEA. (2013). *Technology Roadmap: Carbon Capture and Storage*. Paris: International Energy Agency.

INVOLVE. (2004). INVOLVE conference report – People at the heart of research. National Institute for Health Research.

IPCC. (2014). *Climate Change 2014: Mitigation of Climate Change, Working Group III Contribution to the Fifth Assessment report of the Intergovernmental Panel on Climate Change*.

Karikari, T. K. & Yawson, N.A. (2017). A model approach to public engagement training for students in developing countries. *Journal of Microbiology & Biology Education*, 18 (1): 357–363. https://doi.org/10.1128/jmbe.v18i1.1244

Krueger, R. A. (1998). *Analyzing & Reporting Focus Group Results*. Thousand Oaks: Sage Publications, Inc. https://doi.org/10.4135/9781483328157

Krueger, R. A. & Casey, M. A. (2015). Focus Group Interviewing. In: K. E. Newcomer, H. P. Hatry, J. S. Wholey (Eds.), *Handbook of Practical Program Evaluation* (*pp.* 506–534). Hoboken: Wiley. https://doi.org/10.1002/9781119171386.ch20

L'Orange Seigo, S., Dohle, S. & Siegrist, M. (2014). Public perception of carbon capture and storage (CCS): A review. *Renewable and Sustainable Energy Reviews*, 38: 848–863. https://doi.org/10.1016/j.rser.2014.07.017

Laurian, L. (2007). Deliberative Planning through Citizen Advisory Boards. *Journal of Planning Education and Research*, 26(4): 415–434. https://doi.org/10.1177/0739456X06298819

Leslie, A. (2013). Collaborative Democracy. *Anthropology Now*, 5(1): 36–45, https://doi.org/10.1080/19492901.2013.11728385

Lindström, K. (2014). *Patchworking publics-in-the-making: design, media and public engagement.* (Doctoral thesis), Malmö University. Available from: https://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Amau%3Adiva-7401

Low Carbon Contracts Company. (2022). *Helping to Accelerate the Delivery of a Net Zero Future: Annual Report and Accounts 2021/22*. London. Available from: https://www.lowcarboncontracts.uk/resources/guidance-and-publications/low-carbon-contracts-company-lccc-annual-report-202122/

Lowitzsch, J., Hoicka, C. E. & van Tulder, F. J. (2020). Renewable energy communities under the 2019 European Clean Energy Package – Governance model for the energy clusters of the future? *Renewable and Sustainable Energy Reviews*, 122: 109489. https://doi.org/10.1016/j.rser.2019.109489

Lukaszewski, J. E. (2016). *The Manager's Guide to Handling the Media in Crisis: Saying & Doing the Right Thing When It Matters Most*. Brookfield: Rothstein Publishing.

Luloff, A. E., Albrecht, S. L. & Bourke, L. (1998). NIMBY and the hazardous and toxic waste siting dilemma: The need for concept clarification. *Society and Natural Resources 11(1): 81-89* https://doi.org/10.1080/08941929809381063

Mackenzie, M. K. & Warren, M. E. (2012). Two trust-based uses of minipublics in democratic systems. In J. Parkinson & J. Mansbridge (eds.), *Deliberative Systems* (pp. 95–124). Cambridge: Cambridge University Press.

Markusson, N., Kern, F., Watson, J., Arapostathis, S., Chalmers, H., Ghaleigh, N., Heptonstall, P., Pearson, P., Rossati, D. & Russell, S. (2012). A Socio-Technical Framework for Assessing the Viability of Carbon Capture and Storage Technology. *Technological Forecasting and Social Change,* 79(5): 903–18. https://doi.org./10.1016/j.techfore.2011.12.001

Masadeh, M.A. (2012). Focus Group: Reviews and Practices. *International Journal of Applied Science and Technology*, 2(10): 63–68.

Michael, M. (2009). Publics performing publics: of PiGs, PiPs and politics. *Public Understanding of Science*, 18(5): 617–631. https://doi.org/10.1177/0963662508098581

Midden, C. J. H. & Huijts, N. M. A. (2009). The role of trust in the affective evaluation of novel risks: The case of CO_2 storage. *Risk Analysis*, 29(5): 743–751. https://doi.org/10.1111/j.1539-6924.2009.01201.x

Morgan, D. L. (1996). Focus Groups. Annual Review of Sociology, 22(1): 129–152. https://doi.org/10.1146/annurev.soc.22.1.129

Mullally, G., Dunphy, N. & O'Connor, P. (2018). Participative environmental policy integration in the Irish energy sector. *Environmental Science & Policy*, 83: 71–78. https://doi.org/10.1016/j.envsci.2018.02.007

Nisbet, M. C. (2009). Communicating Climate Change: Why Frames Matter for Public Engagement. *Environment: Science and Policy for Sustainable Development*, 51(2): 12–23. https://doi.org/10.3200/ENVT.51.2.12-23

Nisbet, M. C. & Kotcher, J. E. (2009). A Two-Step Flow of Influence? *Science Communication*, 30(3), 328–354. https://doi.org/10.1177/1075547008328797

O'Neill, S. & Nicholson-Cole, S. (2009). "Fear Won't Do It": Promoting Positive Engagement with Climate Change through Visual and Iconic Representations. *Science Communication*, 30(3): 355–379. https://doi.org/10.1177/1075547008329201

Oltra, C., Sala, R., Solà, R., Di Masso, M. & Rowe, G. (2010). Lay perceptions of carbon capture and storage technology. *International Journal of Greenhouse Gas Control*, 4(4): 698–706. https://doi.org/10.1016/j.ijggc.2010.02.00174

Oltra, C., Upham, P., Riesch, H., Boso, A., Brunsting, S., Dutschke, E. & Lis, A. (2012). Public Responses To CO2 Storage Sites: Lessons From Five European Cases. *Energy & Environment*, 23(2): 227–248. https://doi.org/10.1260/0958-305X.23.2-3.227

Owens, S. & Driffill, L. (2008). How to change attitudes and behaviours in the context of energy. *Energy Policy*, 36(12): 4412–4418. https://doi.org/10.1016/j.enpol.2008.09.031

Pallett, H., Chilvers, J. & Hargreaves, T. (2019). Mapping participation: A systematic analysis of diverse public participation in the UK energy system. *Environment and Planning E: Nature and Space,* 2(3): 590–616. https://doi.org/10.1177/2514848619845595

Paluszny, A., Graham, C. C., Daniels, K. A., Tsaparli, V., Xenias, D., Salimzadeh, S., Whitmarsh, L., Harrington, J. F. & Zimmerman, R. W. (2020). Caprock integrity and public perception studies of carbon storage in depleted hydrocarbon reservoirs. *International Journal of Greenhouse Gas Control*, 98: 103057. https://doi.org/10.1016/j.ijggc.2020.103057

Patanakul, P. & Milosevic, D. (2009). The effectiveness in managing a group of multiple projects: Factors of influence and measurement criteria. *International Journal of Project Management,* 27(3): 216–233. https://doi.org/10.1016/j.ijproman.2008.03.001

Perdan, S., Jones, C. R., & Azapagic, A. (2017). Public awareness and acceptance of carbon capture and utilisation in the UK. *Sustainable Production and Consumption*, 10: 74–84. https://doi.org/10.1016/j.spc.2017.01.001

Purkus, A., Gawel, E., Deissenroth, M., Nienhaus, K., & Wassermann, S. (2015). Market integration of renewable energies through direct marketing - lessons learned from the German market premium scheme. *Energy, Sustainability and Society*, 5(1): 12. https://doi.org/10.1186/s13705-015-0040-1

Razzaque, J., & Richardson, Benjamin. J. (2006). Public Participation in Environmental Decision Making. *Environmental Law for Sustainability*, 9: 165–194. https://ssrn.com/abstract=1794203

Reed, M. S., Vella, S., Challies, E., de Vente, J., Frewer, L., Hohenwallner-Ries, D., Huber, T., Neumann, R. K., Oughton, E. A., Sidoli del Ceno, J., & van Delden, H. (2018). A theory of participation: what makes stakeholder and public engagement in environmental management work? *Restoration Ecology*, 26(S1): S7-S17 https://doi.org/10.1111/rec.12541

Reiner, D., Curry, T., De Figueiredo, M., Herzog, H., Ansolabehere, S., Akai, M., Johnsson, F. & Odenberger, M. (2006, Jun 19-22). An International Comparison of Public Attitudes towards Carbon Capture and Storage Technologies. Paper presented as the *8th International Conference on Greenhouse Gas Control Technologies*, Trondheim, Norway.

Revilla, M. & Ochoa, C. (2017). Ideal and Maximum Length for a Web Survey. *International Journal of Market Research*. 59(5): 557–565. https://doi.org/10.2501/IJMR-2017-039

Rheingold, H. (2008). Using participatory media and public voice to encourage civic engagement. In W. L. Bennett (Ed.), *Civic life online: Learning how digital media can engage youth* (pp. 97–118). Cambridge: MIT Press.

Rip, A. & Kemp, R. (1998). Technological Change. In: S. Rayner & E. L. Malone (Eds.) *Human choice and climate change. Vol. II, Resources and Technology* (*pp*. 327–99). Columbus: Battelle Press.

Rogelj, J., den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., Sha, F., Riahi, K. & Meinshausen, M. (2016). Paris Agreement Climate Proposals Need a Boost to Keep Warming Well below 2 °C. *Nature,* 534(7609): 631–39. https://doi.org/10.1038/nature18307.

Rowe, G. & Frewer, L. J. (2005). A typology of public engagement mechanisms. *Science Technology and Human Values*, 30(2): 251–290. https://doi.org/10.1177/0162243904271724

Santoro, J. D., Yedla, M., Lazzareschi, D. V, & Whitgob, E. E. (2017). Disability in US medical education: Disparities, programmes and future directions. *Health Education Journal*, 76(6): 753–759. https://doi.org/10.1177/0017896917712299

Sharp, J. D., Jaccard, M. K. & Keith, D. W. (2009). Anticipating public attitudes toward underground CO_2 storage. *International Journal of Greenhouse Gas Control*, 3(5), 641–651. https://doi.org/10.1016/j.ijggc.2009.04.001

Slattery, E. L., Voelker, C. C. J., Nussenbaum, B., Rich, J. T., Paniello, R. C. & Neely, J. G. (2011). A Practical Guide to Surveys and Questionnaires. *Otolaryngology–Head and Neck Surgery*, 144(6): 831–837. https://doi.org/10.1177/0194599811399724

Smith, A. L., Quinlivan, L. & Dunphy, N. P. (2021). *Education and Public Engagement Framework for Ocean Literacy* (D7.4). A research output of the SafeWAVE Project Co-Funded by the European Maritime and Fisheries Fund (EMFF) Program of the European Union. https://doi.org/10.13140/RG.2.2.35191.29600

Smith, L. H., & Renzulli, J. S. (1984). Learning style preferences: A practical approach for classroom teachers. *Theory Into Practice*, 23(1): 44–50. https://doi.org/10.1080/00405848409543088

Ter Mors, E., Weenig, M. W. H., Ellemers, N., & Daamen, D. D. L. (2010). Effective communication about complex environmental issues: Perceived quality of information about carbon dioxide capture and storage (CCS) depends on stakeholder collaboration. *Journal of Environmental Psychology*, 30(4): 347–357. https://doi.org/10.1016/j.jenvp.2010.06.001

Terwel, B. W. & Daamen, D. D. L. (2012). Initial public reactions to carbon capture and storage (CCS): Differentiating general and local views. *Climate Policy*, 12(3), 288–300. https://doi.org/10.1080/14693062.2011.637819

Terwel, B. W., Harinck, F., Ellemers, N. & Daamen, D. D. L. (2011). Going beyond the properties of CO2 capture and storage (CCS) technology: How trust in stakeholders affects public acceptance of CCS. *International Journal of Greenhouse Gas Control*, 5(2): 181–188. https://doi.org/10.1016/j.ijggc.2010.10.001

Thomas, J. & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, 8(1): 45. https://doi.org/10.1186/1471-2288-8-45

Toliver, S. R., Jones, S. P., Jiménez, L., Player, G., Rumenapp, J. C. & Munoz, J. (2019). 'This Meeting at This Tree': Reimagining the Town Hall Session. *Literacy Research: Theory, Method, and Practice,* 68(1): 45–63. https://doi.org/10.1177/2381336919869021

Torraco, R. J. (2005). Writing Integrative Literature Reviews: Guidelines and Examples. *Human Resource Development Review,* 4(3): 356–67. https://doi.org/10.1177/1534484305278283

Walker, B. J. A., Russel, D., & Kurz, T. (2017). Community Benefits or Community Bribes? An Experimental Analysis of Strategies for Managing Community Perceptions of Bribery Surrounding the Siting of Renewable Energy Projects. *Environment and Behavior*, 49(1): 59–83. https://doi.org/10.1177/0013916515605562

Wallquist, L., Visschers, V. H. M., Dohle, S., & Siegrist, M. (2011). Adapting communication to the public's intuitive understanding of CCS. *Greenhouse Gases: Science and Technology*, 1(1): 83– 91. https://doi.org/10.1002/ghg3.4

Wenzel, A. (2019). Public Media and Marginalized Publics. *Digital Journalism*, 7(1): 146–163. https://doi.org/10.1080/21670811.2017.1398594

Whitmarsh, L., Seyfang, G. & O'Neill, S. (2011). Public engagement with carbon and climate change: To what extent is the public "carbon capable"? *Global Environmental Change*, 21(1): 56–65. https://doi.org/10.1016/j.gloenvcha.2010.07.011

Wibeck, V. (2014). Enhancing learning, communication and public engagement about climate change – some lessons from recent literature. *Environmental Education Research*, 20(3): 387–411. https://doi.org/10.1080/13504622.2013.812720

Wilcox, D. (1994). *The Guide to Effective Participation*. London: The Joseph Rowntree Foundation.

Wolsink, M. (1994). Entanglement of interests and motives: assumptions behind the NIMBY-theory on facility siting. *Urban Studies*, 31(6): 851–866. http://www.jstor.org/stable/43196142

Xenias, D. & Whitmarsh, L. (2018). Carbon capture and storage (CCS) experts' attitudes to and experience with public engagement. *International Journal of Greenhouse Gas Control,* 78: 103–116. https://doi.org/10.1016/j.ijggc.2018.07.030

Yang, L., Zhang, X. & McAlinden, K. J. (2016). The effect of trust on people's acceptance of CCS (carbon capture and storage) technologies: Evidence from a survey in the People's Republic of China. *Energy*, 96(2016), 69–79. https://doi.org/10.1016/j.energy.2015.12.044