Carbon Capture and Storage (CCS) experts' attitudes to and experience with public engagement

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Abstract

Carbon capture and storage (CCS) is widely seen as a key technology for mitigating climate change. Public engagement with CCS is important for a range of reasons, but previous work has not explored the perceived rationales for, or benefits of, public engagement amongst CCS experts (including those who engage the public themselves). Here, we present mixed-methods research (comprising expert interviews and an online survey) to elucidate these rationales, and expose CCS expert views of public engagement. Our findings indicate some differences in perceptions of public engagement with CCS (and of the risks and benefits of CCS) between those who engage directly with the public and those who do not: the former tend to have a more nuanced view of engagement, and are also more enthusiastic about the benefits of CCS, than the latter. Overall, CCS experts recognise the importance of public engagement for the roll-out of CCS for both substantive and instrumental rationales, and are largely aware of the range of factors (knowledge, values, trust, etc.) influencing public engagement. Nevertheless, the relatively low salience of early and substantive engagement amongst CCS experts suggests there is room for improving the flow of learning from the public engagement research literature to those charged with delivering it.

Keywords

Carbon capture and storage; expert perceptions; public engagement; mixed-methods

Acknowledgements

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1   Introduction

Carbon capture and storage (CCS) is widely seen as a key technology for mitigating climate change (IPCC, 2014; IEA, 2013). Along with energy efficiency and certain other mitigation options, it is a cost-effective measure for reducing carbon dioxide (CO_2) emissions that cause climate change (Praetorius & Schumacher, 2009). While it likely offers environmental and economic benefits, it remains controversial (van Egmond & Hekkert, 2012; Polson et al., 2012) and there has been high-profile public opposition to particular CCS developments. For example, public opposition to the CCS project in Barendrecht, near Rotterdam, where 10 million tons of CO_2 were to be stored in a depleted gas field under a residential area, ultimately led to the project being cancelled (Bellona, 2010). In part, this outcome can be seen as a 'public engagement failure' (Brunsting et al., 2011; Terwel et al., 2012), which others are keen to avoid; thus, it is increasingly acknowledged that public acceptance of CCS is a vital precondition for its rollout (RCUK, 2010; Wennersten et al., 2015; van Alphen et al., 2007). For example, the coalition UK Government in 2012 concluded that '*CCS projects need to learn from experience to date which suggests that community engagement begins early and goes beyond the requirements under the regulatory regime*' (DECC, 2012).

How much of this rhetoric around the importance of public engagement with CCS is being assimilated into the CCS research community? And to what extent are efforts to engage the public with CCS grounded in the social scientific evidence of what is most effective? While much is known about public perceptions of CCS, much less is known about expert[1] experiences of or attitudes to public engagement with CCS. This paper presents a mixed-methods study which aims to address this knowledge deficit, with a view to improving engagement efforts and grounding them in the public engagement evidence base.

2   Background

2.1   Why engage the public?

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 Barendrecht. However, there are also reasons of democratic governance and decision quality that argue in favour of public views being considered in CCS decision-making. Fiorino (1990) distinguished three main rationales for public engagement: normative, substantive, and instrumental. That is, public engagement should involve those individuals who have a stake in the decision (e.g., communities affected by siting

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[1] Our definition of 'experts' was primarily functional, i.e. whether the respondent worked in the CCS industry, policy or research; sample is detailed in sections 3.1.1 and 4.1.2.

decisions; voters in the case of public funded projects); it can improve the quality of decision-making by drawing on diverse knowledge and values; or it may be used with a specific goal to raise public awareness, increase risk or product acceptance, or foster trust in experts, developers or government (Whitmarsh et al., 2009). As Stirling (2005, p.220) summarises: '*Under a normative view, participation is just the right thing to do. From an instrumental perspective, it is a better way to achieve particular ends. In substantive terms, it leads to better ends*'.

Understanding these rationales is important because, as Devine-Wright (2011, p.20) argues '*the same engagement initiative may be instigated or supported by organizations holding quite different rationales which, left implicit, can create tensions and difficulties*'. More critically, the format and outcomes of public engagement undertaken for these different reasons are likely to be quite different: if engagement is instrumental whereby the end goal is predefined (e.g., to persuade a local community to accept a CCS pipeline), methods may comprise one-way information provision (e.g., marketing campaign) which avoids opening up debate about alternatives; substantive or normative engagement tends to seek more two-way, dialogic and participatory methods without predefined outcomes, other than improved decisions and relationships (Dietz & Stern, 2008).

Considerable work shows that the dominant rationale for undertaking public engagement exercises in relation to risk and technical issues is instrumental (Stirling, 2005; Devine-Wright, 2011). For example, those promoting public engagement and dialogue on nanotechnology often refer to the public as 'laypeople' or 'consumers', both of which imply instrumental rationales (Wickson et al., 2014). The aim of engagement here is pre-defined: to accept technical information, trust experts and adopt products. Less often, the public is viewed as 'stakeholders' whose involvement in decision-making is seen as leading to better outcomes, whatever these may be (Wickson et al., 2014). Other work similarly shows that the way the public is 'constructed' by experts and the media can act as a barrier to engagement. Höppner (2010), for example, showed media representation of public opinion on climate change to be apathetic and hypocritical, which served to reinforce roles and political preferences. Technology roadmaps and scenarios similarly often perceive of the public as a 'barrier' to the successful roll-out of innovations, rather than a valued resource or partner in constructing a particular socio-technical future (e.g., Whitmarsh & Wietschel, 2008). Similarly, for cases where particular communities may be affected by siting or development decisions (e.g., renewable energy schemes), there appears to be little evidence of community engagement for substantive or normative rationales (e.g., building communities, improving decision quality); rather, engagement is typically undertaken '*to secure public acceptance of developer-led projects*' (Devine-Wright, 2011, p.21). This perspective lends itself to seeing public engagement in an instrumental light, rather than seeing the public engagement in substantive or normative lights.

Underlying instrumental rationales is a 'deficit model' of the public as lacking in requisite technical information to make 'correct' decisions; and (usually) an assumption that 'the public' is homogenous. In contrast to this, research shows that public views and contexts are highly varied and that knowledge about technical issues is a poor predictor of attitudes, risk perceptions or behaviour (e.g., Burgess et al., 1998). Indeed, knowledge can often increase opposition as well as support for research or policy, since individuals become more discriminating of evidence and risk regulation arrangements (e.g., Evans & Durant, 1995; Kahan et al., 2012). Critiques of the deficit model have led to development of more 'upstream' and two-way forms of public engagement, adopted for substantive and normative rationales, as well as a recognition of the emergent and diverse contexts for public engagement (Chilvers & Kearnes, 2016). Engaging the public early can avoid attitudes becoming polarized, and can ensure public concerns and values are fed into decision-making in a genuine way – rather than after options have been closed down (Rogers-Hayden & Pidgeon, 2007). Indeed, more participatory and democratic forms of public engagement, if organized appropriately, can lead to more sustainable outcomes as well as improved relationships (Dietz & Stern, 2008; Niemeyer, 2013).

Evidence of the lay-expert divide in risk perception is also pertinent to the reasons for engagement. Slovic (2000) showed that across a range of risks, experts and non-experts often ranked them in very different ways. Weber (2010) argues this disparity is due to different information processing styles, with experts tending to use more deliberative and analytic ('slow') processing, whereas the public rely more on direct experience and heuristic ('fast') processing. Other work highlights more social and cultural explanations for lay-expert divergence in risk perception (Pidgeon et al., 2003; Kahan et al., 2010), for example that expert samples have a distinct composition (e.g., male, white) that does not reflect the broader the public, many of whom (e.g., women, ethnic minorities) may be more exposed to different risks. This so-called 'white male' effect helps explain why risks may be defined differently by expert and non-expert groups (Flynn et al., 1994). Together, the risk perception literature draws attention to lay-expert divergence, which is often not only due to differences in amount or type of knowledge but also to different decision-making contexts, epistemologies, values and resources (e.g., Wynne, 1991; Irwin et al., 1999). This lends support to undertaking public engagement for substantive reasons: since experts' perceptions may be partial, a fuller and more robust analysis of risk issues and identification of solutions is more likely with broader representation of views and values.

2.2 Public engagement with CCS

A substantial body of knowledge has emerged in the last decade on public perceptions of CCS, comprising both qualitative and quantitative studies. These highlight very low public awareness of CCS (Demski et al., 2013; Curry et al., 2005; Yang et al., 2016). For the minority that has views, these are often mixed: concerns include the long-term viability ('temporizing') of CCS, its safety (e.g., risk of CO_2 leaks, explosion), its association with coal mining, cost, and the ability of institutions to

regulate/monitor storage sites (Demski et al., 2013; Palmgren, 2004; De Best-Waldhober et al., 2009). However, people are positive about the potential of CCS to reduce carbon emissions (e.g., Demski et al., 2013) and offer economic benefits (L'Orange Seigo et al., 2014; Yang et al., 2016). Both the way in which CCS information is framed (e.g., van Knippenberg & Daamen, 1996; Broecks et al., 2016; de Vries, 2016, 2017) and audience characteristics (e.g., knowledge, values) influence public views on the technology (Yang et al., 2016). For example, there is disparity in public perceptions according to whether attitudes are studied at the level of general public or specific communities likely to be affected by CCS (Midden & Huijts, 2009; Huijts et al., 2007). For the general public, factors such as values, beliefs, trust, and education are likely to predict CCS support. For proposed/actual communities affected by CCS, familiarity with the industry, operator trust, place identity, perceived costs and benefits (both direct – e.g., financial compensation or job creation – and indirect – e.g., climate change mitigation) are likely to be more important (Desbarats et al., 2010; L'Orange Seigo et al., 2014).

This work also highlights that the engagement process can profoundly influence community perceptions of CCS (Oltra et al., 2012; Dütschke, 2011; Buhr & Wibeck, 2014; Brunsting et al., 2015). In particular, there are clear benefits of early and substantive engagement (Coyle, 2016; Poumadere et al., 2011; Brunsting et al., 2011; Cheng et al., 2013; Chrysostomidis et al., 2013; Lofstedt, 2015), consistent with broader literatures on public participation (Chilvers & Kearnes, 2016; Rogers-Hayden & Pidgeon, 2007; Dietz & Stern, 2008). For example, the 'Big Sky' CCS demonstration project was initially opposed by local communities; but engagement activities which explored the value basis for opposition and then involved communities in decision-making about siting significantly improved support (NETL, 2013). Other small-scale community engagement has been shown to broaden debate to incorporate a wider range of issues and reveal unexpected viewpoints (Coyle, 2016). Yet, in as far as European CCS public engagement exercises (e.g., Vattenfall, Ketzin, Barendrecht; see Desbarats et al., 2010 for project details) have been assessed, they appear to have relied more on one-way information provision methods (e.g., letters, websites) than two-way dialogue; and often information was provided late or was poorly received due to lack of trust in the developer or the decision process (Desbarats et al., 2010; Ashworth et al., 2010; Terwel et al., 2010; de Vries et al., 2016). Indeed, trust in information sources and decision-makers is one of the most critical factors in effective engagement with CCS (Terwel et al, 2009a,b; Koot et al., 2016; Ter Mors et al., 2010). While this broadly suggests an instrumental rationale for public engagement, those involved in conducting engagement were not interviewed or surveyed to elicit their understanding of the purpose or benefits of public engagement.

While studies of public perceptions of CCS have mushroomed, the same cannot be said for studies of expert views on both CCS and public engagement with CCS. Work directly comparing expert stakeholders and public views on CCS tend to find more support amongst experts than the public (Huijts et al., 2007). One study (Shackley et al., 2007) explored views of European energy

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stakeholders (industry, government, environmental non-governmental organizations (NGOs), researchers and academicians and parliamentarians who all showed broad support for CCS and identified few risks (although NGOs were less supportive). Importantly, this work also elicited stakeholders' views about public opinion, and across all stakeholder groups, it was assumed that the public was overwhelmingly negative about CCS: stakeholders assumed around 75% opposition, the actual figure around that time was around 25% (e.g., Reiner et al., 2006) – a significant overestimate of public opposition. While public support for CCS is lower than amongst expert stakeholders, misunderstanding public views may pose challenges for constructive dialogue, especially if experts see publics as opponents and behave accordingly. Instead, opposition and support account for a minority of views, with ambivalence still prevalent amongst the public (Whitmarsh et al., 2015) which presents an opportunity for genuine understanding and dialogue.

2.3   Aims of present study

The evidence reviewed here suggests a need to bridge the potential disconnect between the public and experts in their perceptions of CCS and thus inform CCS policy development in a manner which is more inclusive and socially robust. There are also indications that there may be a disconnect between the social science literature on public participation – particularly advocating substantive and early engagement –and the – often more superficial – approach in practice to engaging communities and publics with CCS. However, to date, little if any work has examined the views of the CCS academic and practitioner community, including those dealing directly with the public, in relation to the perceived reasons for, benefits, challenges and experiences of public engagement with CCS. Doing so will provide vital insights into how the theory of public engagement might better be translated into practice by those charged with delivering it. The current research therefore aims to explore CCS experts' views on public engagement with CCS to examine whether the policy rhetoric around the importance of public engagement with CCS is being assimilated into the CCS research community, and to infer whether best practice and relevant social science insights on CCS public engagement are used by CCS experts. The significance of understanding experts' views of public engagement with CCS is partly because there is increasingly an expectation for (CCS and other) researchers to engage with the public; but also that those seen as 'experts' appear to be particularly influential in public decision-making about CCS (Koot et al., 2016). We employed a mixed-methods approach comprising semi-structured interviews and an online survey of CCS experts to examine their beliefs about CCS and their attitudes to and experiences of public engagement with CCS.

3 Expert interviews

3.1 Methods

3.1.1 Interviewee recruitment

Potential CCS experts from across Europe suitable for interviewing –i.e. with past and present involvement with CCS, as researchers, practitioners or consultants- were identified through Internet searches and recommendations from colleagues, as well as 'snowballing' (i.e., asking interviewees to suggest further participants). This combination of recruitment methods resulted in 39 participants being directly contacted between October 2015 and February 2016; 13 were selected for interview to ensure a range of backgrounds (Figure 1) and countries. Nine interviewees were based in the UK, while of the remaining four, one was based in Norway, and three in the Netherlands. The mainly UK focus was chosen due to the project requirements (funded by the UK EPSRC and with a UK focus for the natural science elements of the project)[2].

Experts were identified as suitable for interviewing if they had past and present involvement with CCS as researchers, practitioners or consultants. Experience varied between three and over ten years. They were all familiar with European CCS projects such as Barendrecht, Vattenfall, Ketzin, and others, and some had been involved in one or more of these projects. Most were senior members in their respective organisations. Every effort was made to acquire a diverse sample within our ability. Participants were contacted twice (initial contact and reminder) and interview was arranged if participant responded within our timeframe. About one third of our contacts never responded, and one third declined to participate.

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[2] However, it must be noted that as CCS is a global industry, the physical location of our experts was of secondary importance. For example, one of our experts was of German origin, working in the Netherlands and focusing on a UK based CCS project.

Background \ Sector	Industry	NGO/Think tank	Academia	Freelance	Research organisation
Communications/PR	UK		UK		
Social science			UK		
Geoscience	NL NL		UK		UK UK N
Geography			UK		
Engineering			UK		NL
Natural Sciences		UK			

Figure 1: *Expert sample distribution by sector, background, and country.*

3.1.2 Interview protocol

Interview questions were aimed at recording experts' perceptions of barriers to CCS deployment in the UK[3], their experiences with public engagement, challenges to public engagement with CCS – and possible solutions – and finally to look for the level of importance attached to public engagement and its perceived utility; we did not assume that all experts would agree on the importance of public engagement. The full list of questions is presented in the Appendix. Interview questions were piloted for comprehension and clarity with CCS and engagement experts.

Interviews, conducted by phone/skype, lasted between 23 and 88 minutes. Time variation did not appear to reflect qualitative differences in participants' knowledge; rather, a good proportion of time was dedicated to either anecdotes or transgressions to tangential topics. Interviews were transcribed using "intelligent verbatim" (i.e., without linguistic fillers, repetitions or interjections).

3.1.3 Interview analysis

Interviews were read three times by two independent researchers who performed thematic analysis on the text. The first reading removed content-irrelevant text, such as interjections and fillers, organised interviews by question and improved the general flow of the text. The second reading identified emerging themes and larger thematic clusters. These were further refined in the third reading until they reached saturation, and the number of thematic clusters was reduced further. Irrelevant themes were also eliminated at this stage. Finally, thematic clusters were also word-counted and percentages of time taken per theme and question were calculated. The latter analysis is not common in qualitative research, but was deemed necessary in order to (a) adjust for the large time variation between

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[3] Apart from project funding requirements, the UK focus was chosen because the UK public are fairly typical of European attitudes to CCS (e.g., Upham & Roberts, 2011) making it an appropriate case study from which some generalisation is possible.

participants and (b) to provide a means of comparison of the relevant prominence of each theme. Hence, thematic "tree maps" were produced, reflecting the proportion of time dedicated to each theme, as well as the absolute proportion of each theme relevant to all emerging themes.

3.2   Results

3.2.1   Barriers to CCS deployment

The first question (Q1) examined experts' perception of the main barriers to CCS roll-out in the UK. The aim of this question was to estimate the relevant position of public engagement as a barrier, in relation to other barriers to CCS deployment. After the final thematic analysis and aggregation of clusters, there were 50 identified themes, organised into 10 thematic clusters. There were two clearly dominant thematic clusters in this topic, i.e. the lack of policy continuity and political support, and the absence of established funding mechanisms that will cover the cost of deploying CCS technologies. This is not a surprising finding, given that interviews took place in the aftermath of the UK government's cancellation of the CCS competition in November 2015. Even more intriguing was the relatively limited concern attached to public acceptance and the lack of public awareness, possibly reflecting the top-down nature of the CCS development and deployment process.

Given that our respondents' experience varied between those with mainly direct public contact – e.g. science communicators, and those with indirect contact with the public on CCS e.g. through the media, we decided to disaggregate across these two categories. We assumed that those who were exposed directly to the public e.g. having to interact and explain CCS with a live public, may have a different appreciation of the value of public engagement and whether the public influences the CCS process. For this disaggregation, we used three criteria: (a) whether the expert had experience in local/face-to-face engagement (b) whether the expert had experience with the media and (c) whether the expert had experience with policy makers. Eight participants scored in category (a), and five did not. We did not have a-priori assumptions on this parameter/dimension, and so did not specifically target participants on the basis of their direct contact with public, although we recorded it.

The results of this disaggregation are shown in Figures 2 and 3. The two groups did not differ greatly in terms of their perceived primary barriers for CCS roll out in the UK. Lack of political support and policy continuity emerged as the primary concern in both groups, followed closely by the absence of funding mechanisms. Note that many experts contextualised this barrier not in terms of immediate lack of funds, but rather as the absence of a clear funding mechanism and market signals which would make a business case for the industry, and allow it to recuperate the necessary investment.

In terms of less unanimous barriers, experts with direct exposure to the public identified the lack of operating CCS projects, which would have allowed the public to familiarise with the process either directly (e.g. via open days) or indirectly (e.g. via acquaintances) employed by a CCS site. Another

barrier unique to this group was onshore CO_2 storage, although this was de-prioritised as CO_2 storage in the UK is expected to occur under the seabed.

Table 1: *Emergent themes and clusters count for Question 1 by direct or indirect public experience. Bold indicates clusters unique to one subgroup.*

		Direct public engagement	
Question 1 emergent clusters	Themes (total)	Yes	No
Policy/political support	16	11	5
Cost/funding mechanisms	10	6	4
Other barriers	4	2	2
No demo projects	**3**	**3**	**0**
No public awareness	4	2	2
No trust on technology	2	1	1
Onshore storage not accepted	**3**	**3**	**0**
Public acceptance	3	2	1
Confusion with fracking	2	1	1
Communications not optimised	3	1	2
Total themes	50	32	18

Figure 2: _Directly_ public-exposed expert responses to Question 1 "From your experience, what do you think the main barriers are to CCS roll-out in the UK?".

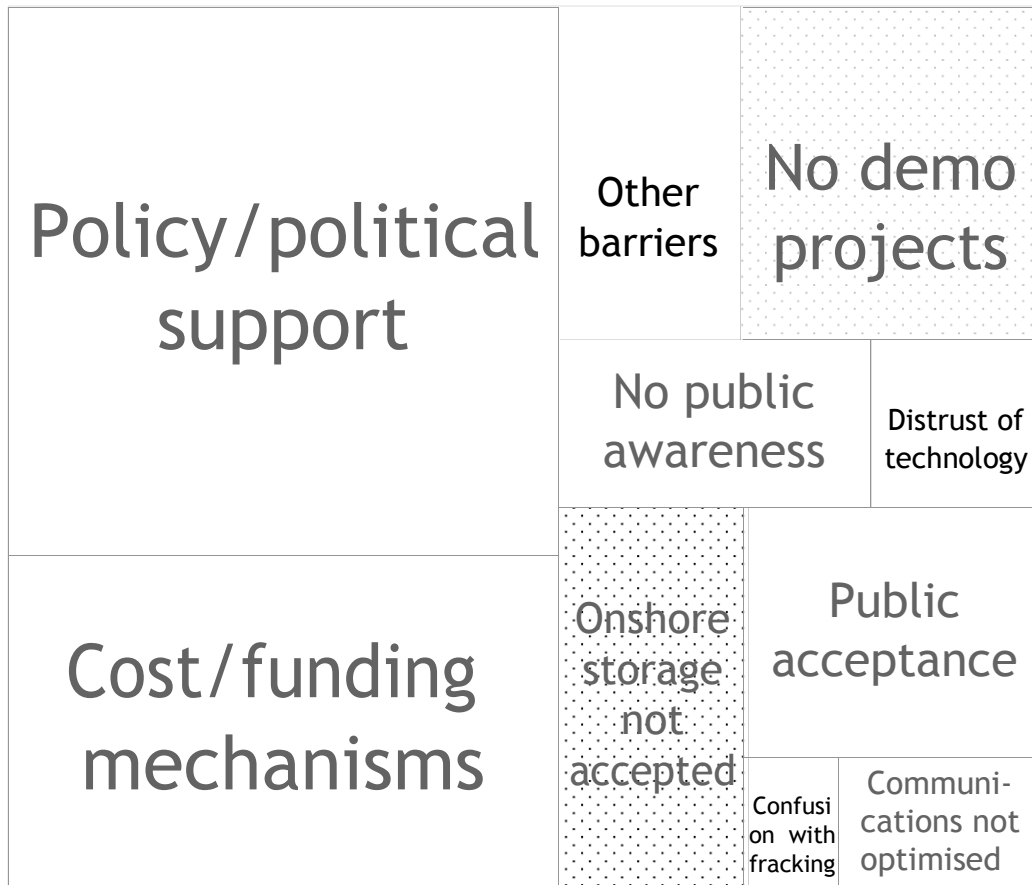**Figure 3:** _Indirectly_ public-exposed expert responses to Question 1 "From your experience, what do you think the main barriers are to CCS roll-out in the UK?".

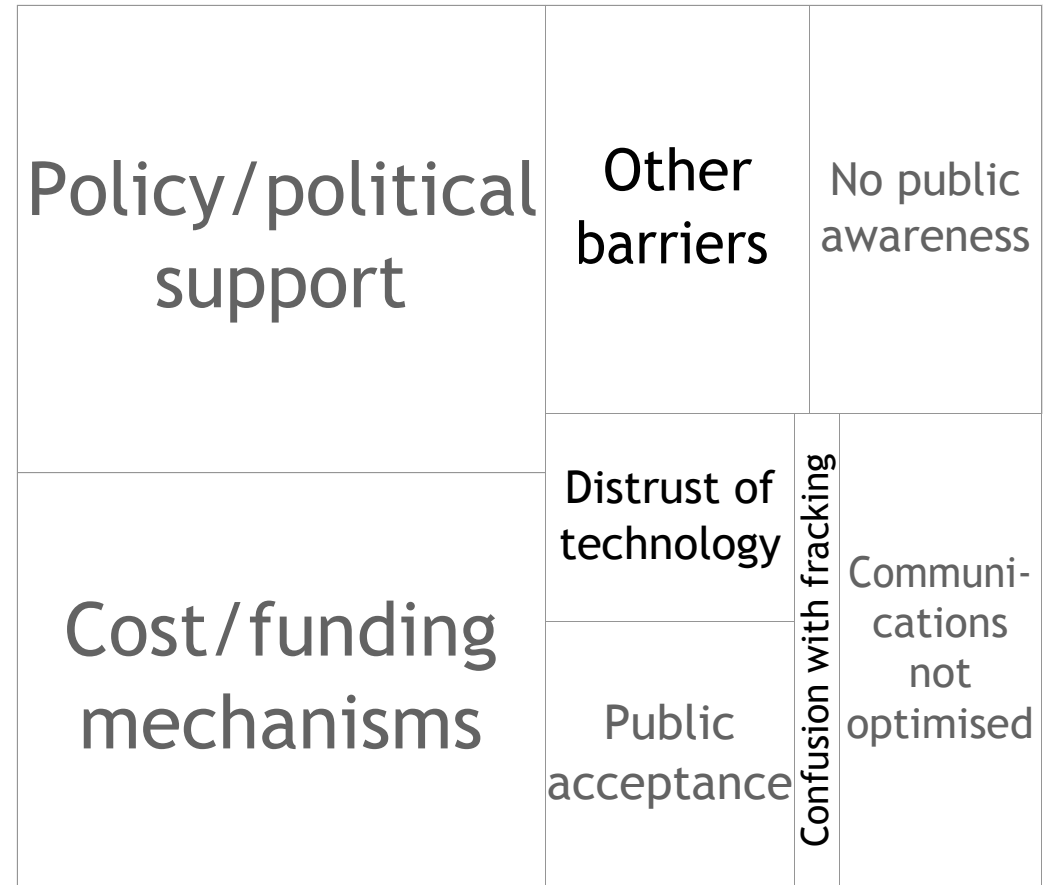[Surface area of rectangles represents the proportion of incidence of each theme, to the total number themes for Question 1, adjusted for mean time spent on this theme. Light rectangles indicate themes unique to one group.]

Table 2: *Illustrative quotes for the five top thematic clusters for Question 1 "What do you think are the main barriers to CCS roll-out in the UK?"*

Thematic cluster	Quote
Policy/political support	"Right now I'd say the Government!" "Lack of political will"
Cost/funding mechanisms	"There is no way of making money'" "If there was a commercial incentive to do CCS then the industry would just get on with it"
Public acceptance	"Public acceptance will be highest on the list of barriers" "The public don't want to have storage [onshore]"
No demo CCS projects	"There is no demo project anymore" "What we need to do now is to actually build something at scale"
No public awareness of CCS	"It's not something that's really known; people don't know what it is." "It's an unknown technology for the vast majority of people in the UK"

3.2.2   Challenges for public engagement with CCS

The second substantive question (Q4) examined experts' perception of key issues and challenges relating to public engagement with CCS. After the final thematic analysis and aggregation of clusters, there were 57 identified themes, organised into 10 thematic clusters. The main emergent issues in this question revolve around the broader problem of appropriate communication of a complex and technical topic to the general public. On the one hand, experts feared the possibility of communicating complex information in the wrong way, thus creating a wrong impression about the risks and benefits of CCS – especially where these are communicated by industry. On the other hand, the public is perceived as generally unaware of both CCS technologies, and the subsurface. Both need to be addressed before the risks and benefits of CCS can be discussed. Specifically looking at the benefits of CCS, climate change scepticism presents an additional challenge, as abatement of greenhouse gases is the main reason for the pursuit of CCS.

Further disaggregation analysis was performed between experts with direct public contact, and those who only had indirect contact (e.g., through the media) with the public relevant to CCS. The results of this disaggregation are shown in Figures 4 and 5. There are several observable differences between the two groups. Experts with direct exposure to the public were more aware of the miscommunication risks, lack of subsurface awareness and climate change scepticism, compared to the group of experts with indirect public exposure.

On the other hand, the latter group cited issues of NIMBYism, potential perception of CCS as 'greenwash', and the lack of suitable materials and communicators as the primary challenges for public engagement with CCS. This group also generally had more disparate comments, many of which did not cluster around specific topics but rather might reflect each interviewee's particular field of expertise.

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Table 3: *Illustrative quotes for the five top thematic clusters for Question 4 "What do you think are the key issues and challenges, for public engagement with CCS?"*

Thematic cluster	*Quote*
"Why do it'?/ CCS is 'greenwash'	"The biggest challenge is to explain to the people what the point of CCS is" "…so you apply an expensive climate change mitigation measure which is only made less expensive because you're getting more oil out of the ground."
Risk of miscommunication	"…you are essentially engaging with the whole world; which again is an opportunity and a challenge" "Trying to get across the complexities of the energy networks and industrial CCS as well […] is the real challenge."
Lack of awareness of CCS and the subsurface	"There is a hyperbole about 'how bad CCS is perceived' -actually lack of awareness is more of an issue than anything else" "Most people have no clue of what the subsurface looks like or what goes on underneath their feet"
Climate change scepticism	"Climate change scepticism comes up from adults but more likely in older people" "The main reason for doing CCS is climate mitigation, reducing CO_2, and this is sold as a positive, that 'we're helping to reduce climate change by doing this' – and some people don't even believe in climate change!"
Suitability of communicator / materials	"Who can bring the message? There is a lack of champions on CCS" "On the one hand you have all that stuff coming out of the big oil companies,[…]but it's tainted by being produced by oil companies. And on the other hand you have [materials from] those who choose not to accept CCS"

Figure 4: _Directly_ public-exposed expert responses to Question 4 "What do you think are the key issues and challenges for engagement with CCS?".
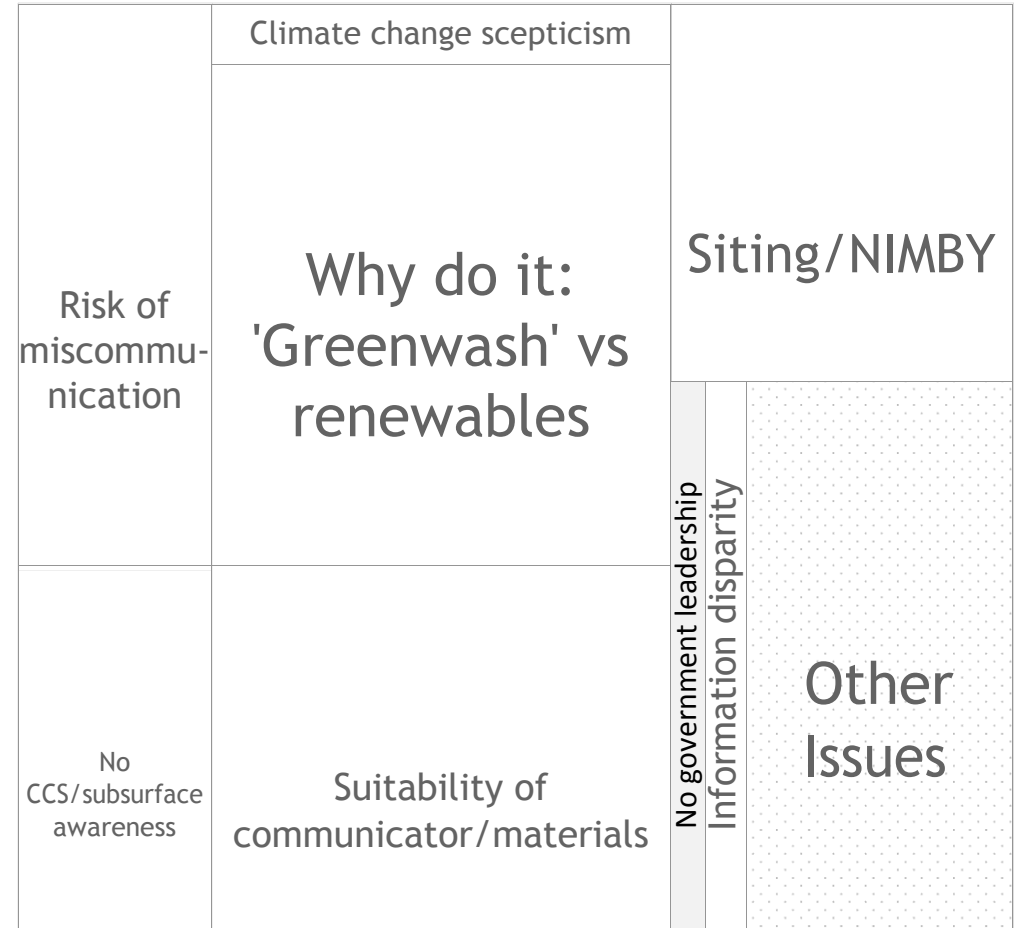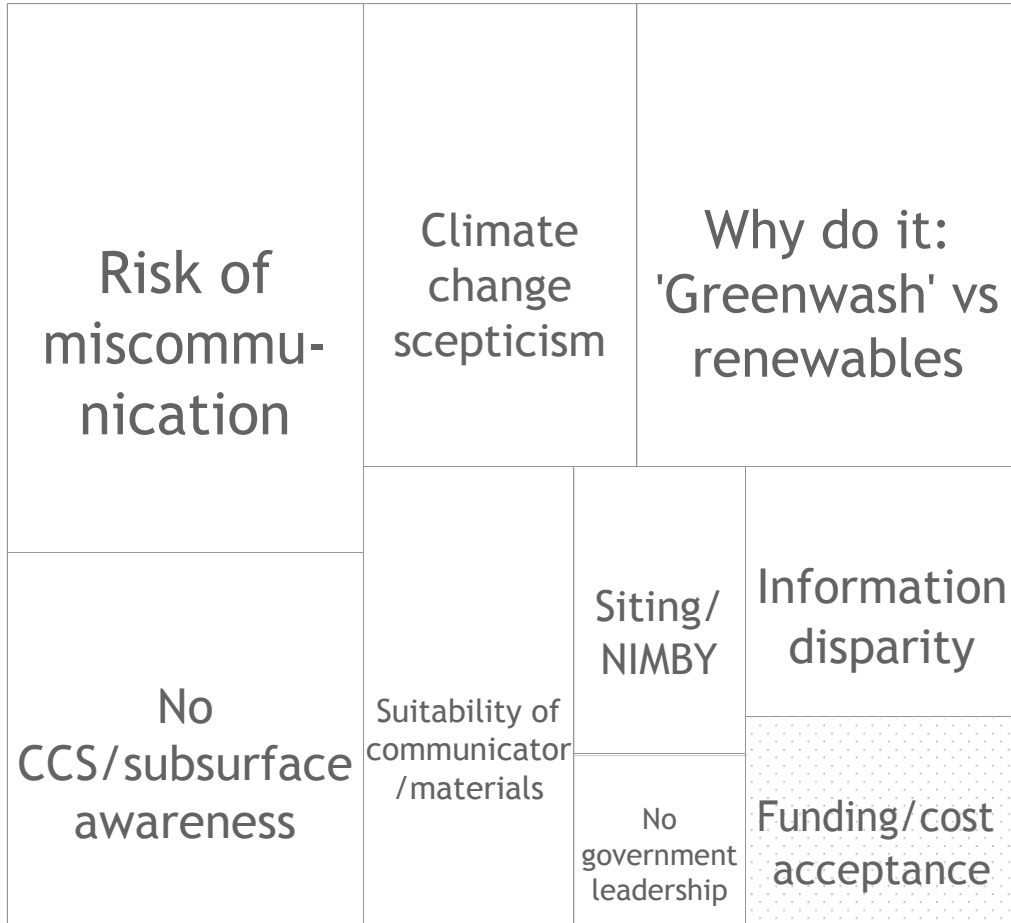
Figure 5: _Indirectly_ public-exposed expert responses to Question 4 "What do you think are the key issues and challenges for engagement with CCS?".

[Surface area of rectangles represents the proportion of incidence of each theme, to the total number themes for Question 4, adjusted for mean time spent on this theme. Light rectangles indicate themes unique to one group.]

Table 4: *Emergent themes and clusters count for Question 4 by direct or indirect public experience. Bold indicates clusters unique to one subgroup.*

		Direct public engagement	
Question 4 emergent clusters	Themes (total)	Yes	No
Risk of miscommunication	10	7	3
Why do it: 'Greenwash' vs renewables	10	5	5
Climate change scepticism	7	6	1
No CCS/subsurface awareness	7	5	2
Suitability of communicator/materials	7	3	4
Siting/NIMBY	5	4	1
No government leadership	3	1	2
Information disparity	3	2	1
Other Issues	3	0	3
Funding/cost acceptance	**2**	**2**	**0**
Total themes	57	35	22

3.2.3   *Effective approaches for public engagement with CCS*

The third interview topic (Q5) explored ways of addressing the key challenges and issues with public engagement that emerged previously. After the final thematic analysis and aggregation of clusters, 54 themes emerged, organised into 10 thematic clusters. Looking at the main perceived solutions to the issues raised above, our experts identified the need to explain the necessity of CCS, which as we have seen in the previous question might be a complex matter. Political commitment to the cause of CCS was also regarded as a way forward, in order to signal the importance of CCS to the public as well as to industry. Appropriately tuned messages for each audience were also deemed very important – but generally hampered by the lack of trusted communicators or materials.

As can be seen in Figures 6 and 7, experts with direct experience with the public raised the need to explain the necessity for CCS as the primary way forward for public engagement, followed by providing information appropriate for each audience. The use of good analogies and visualisations emerged only in this group, which is not surprising since these experts would have experienced the difficulty of explaining the complexities of CCS without good visual materials. The other group, however, placed more emphasis on the need for politicians to support and commit to CCS and, uniquely, the need to broaden the CCS discussion to include heavy industry and non-power generation processes in CCS. This was deemed necessary to raise the profile and utility of CCS as well as to circumvent traditional green power generation arguments advocated by environmental groups.
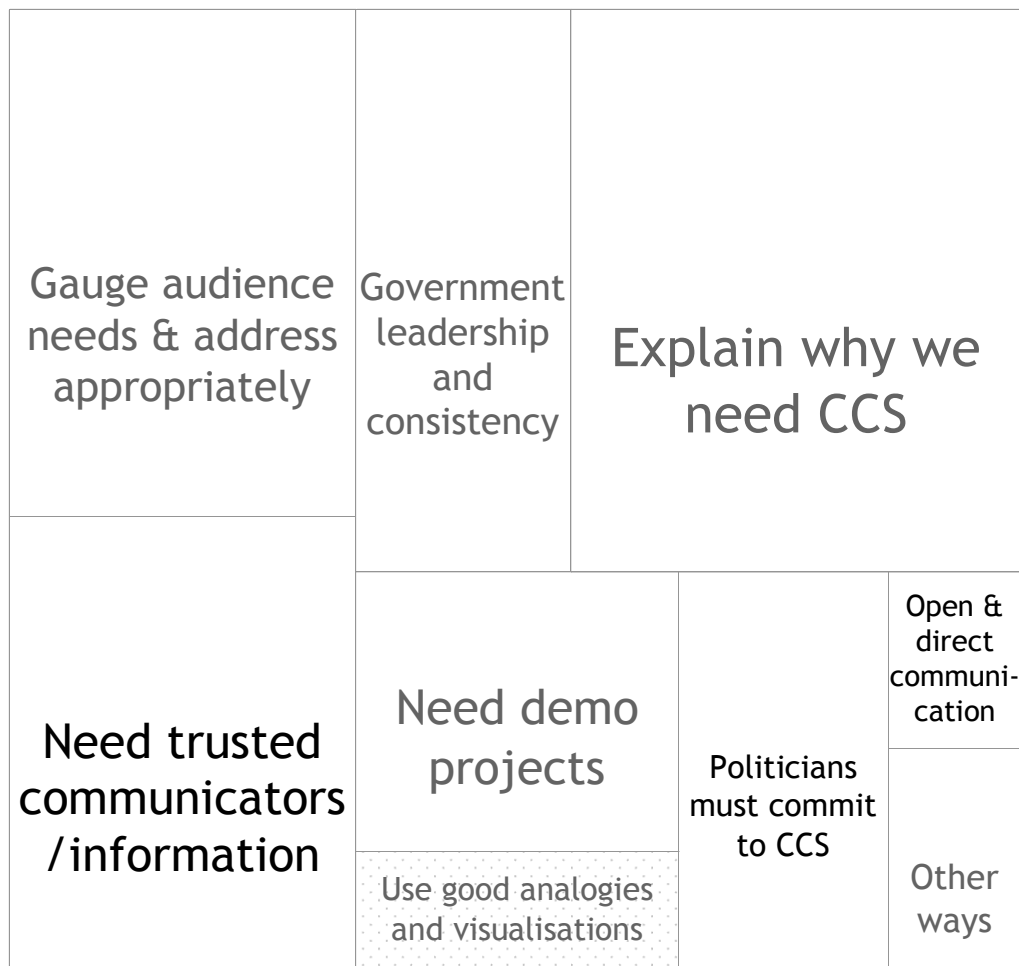
Figure 6: *Directly* public-exposed expert responses to Question 5 *"What could be done to address these issues?"*.

Figure 7: *Indirectly* public-exposed expert responses to Question 5 *"What could be done to address these issues?"*.

[Surface area of rectangles represents the proportion of incidence of each theme, to the total number themes for Question 5, adjusted for mean time spent on this theme.

Light rectangles indicate themes unique to one group.]

Table 5: *Illustrative quotes for the five top thematic clusters for Question 5 "What do you think could be done to address these issues?"*

Thematic cluster	Quote
Gauge audience needs & address appropriately	"You can gauge some of their knowledge already" "It really varies with your audience – some can absorb more information than others"
Explain why we need CCS	"It is useful to first set the context on climate change and how the UK energy sector contributes to the UK carbon emissions, or talk about CCS" "Explain *why* it is done rather than making people accept *how* it's done"
Need trusted communicators/ information	"[it is important to] enable people to be champions. That means giving them access to easily understandable facts, presentations and materials, catchy and useful, and making it easy and possible for them to talk and understand and communicate with others about CCS" "It is important to find people which communities trust"
Need government leadership and consistency	"We need the governments and the international community to accept that CCS is not just one part of the solution, it is absolutely crucial" "The UK context is interesting in that it's part of a massive set of incoherencies around government energy policy and the government isn't really engaging in a mature and coherent way with the challenges of decarbonisation,"
Politicians must commit to CCS	"…put the matter high in the agenda by top figures like state leaders." "Activities and statements from politicians are really important"

Table 6: *Emergent themes and clusters count for Question 5 by direct or indirect public experience. Bold indicates clusters unique to one subgroup.*

		Direct public engagement	
Question 5 emergent clusters	Themes (total)	Yes	No
Gauge audience needs & address appropriately	10	7	3
Explain why we need CCS	10	8	2
Need trusted communicators/information	8	5	3
Government leadership and consistency	7	4	3
Politicians must commit to CCS	5	2	3
Need demo projects	4	2	2
Need to include heavy industry CCS	**3**	**0**	**3**
Other ways	3	1	2
Use good analogies and visualisations	**2**	**2**	**0**
Open & direct communication	2	1	1
Total themes	54	32	22

The fourth topic (Q6) asked whether experts thought it was important to engage the public with large CCS projects at all, and if so, why would that be important. This question was important to evaluate interviewees' point of view on the value of public engagement as a process, beyond any technical or political viewpoints. After the final thematic analysis and aggregation of clusters, this question yielded 60 identified themes, organised into 15 thematic clusters.

This was the most difficult question in terms of coding. Responses varied more than in other questions, and arguments did not always follow a straightforward reasoning or any major clustering. However, upon further analysis what appears most interesting in this question was the emergence of two 'super clusters' of themes; namely one cluster on 'why' public engagement with CCS might be important, and a second cluster addressing 'how' to do this, and any attached caveats. This analysis offered much more meaningful clustering of statements and emerging themes, and is presented in Figures 8 and 9.

Furthermore, we also disaggregated this question into experts with direct public contact, and those who only had indirect contact with the public, for comparison with the previous questions. The emergent thematic clusters are presented in Figures 10 and 11. We did not find it useful to analyse the differences between experts' direct and indirect exposure with the public within each 'super cluster' (i.e. 'why' and 'how') because such disaggregation would result in very small thematic units which would not advance our analysis meaningfully.

Table 7: *Illustrative quotes for the five top thematic clusters for Question 6 "To what extent do you think it is important to engage the public with CCS? If so, why is it important?"*

Theme	Quote
To avoid public opposition	"[in Barendrecht] there was just the arrogance of big companies that simply thought they could do it and they completely forgot the public and then the public realised it, and then it was a big mess;" "It is also important to engage the public to make sure that you don't annoy them"
Change discourse to one of decarbonisation	"…perhaps another way into CCS is to talk about industrial emissions" "The narrative has to change completely on how we sell CCS. Just look at the Climate Action Plan in the US"
To address the lack of awareness on CCS	"And people don't really know much about CCS and on average there is below 10% of people who know *anything* about it"

	"I don't think that CCS means a lot to people in their communities or their homes for most of the country."
To address local concerns and outline benefits	"Public engagement is important to see how risk will affect them." "If you do your public engagement or you don't do it well, then your pilot project can be scuppered by a lack of public approval for it."
Need early and long-term engagement	"It is important to engage the public as early as possible" "There needs to be a continuous conversation and relationship that is topped up continuously."

Table 8: *Emergent themes and clusters count for Question 5 by direct or indirect public experience. Bold indicates clusters unique to one subgroup.*

		Direct public engagement	
Question 6 emergent clusters	Themes (total)	Yes	No
To avoid opposition from risk averse public	8	2	6
Change discourse to decarbonisation	7	2	5
Address lack of CCS awareness	6	2	4
To address local concerns and benefits	**5**	**5**	**0**
Early and long term engagement	5	3	2
For democratic & moral reasons	4	3	1
Engagement not always necessary	4	3	1
Media very influencing	3	1	2
Public pays the bills	3	2	1
Prioritise top-down	**3**	**3**	**0**
To build future scientific capacity	**3**	**3**	**0**
Supportive public pushes decision makers	3	2	1
Adjust messages to audiences	**2**	**0**	**2**
Key influencers are critical	2	1	1
Other reasons	2	2	0
Total themes	60	34	26

To avoid opposition from risk averse public

For democratic & moral reasons

To address local concerns & benefits

To address lack of awareness on CCS

Engage-ment not always neces-sary

To build future scientific capacity

Public pays the bills

Key influencers are critical

Supportive public pushes decision makers

Change discourse to one of decarbonisation

Media very influencing

Early & long term engagement

Prioritise top-down engagement

Adjust messages to audiences

Other ways

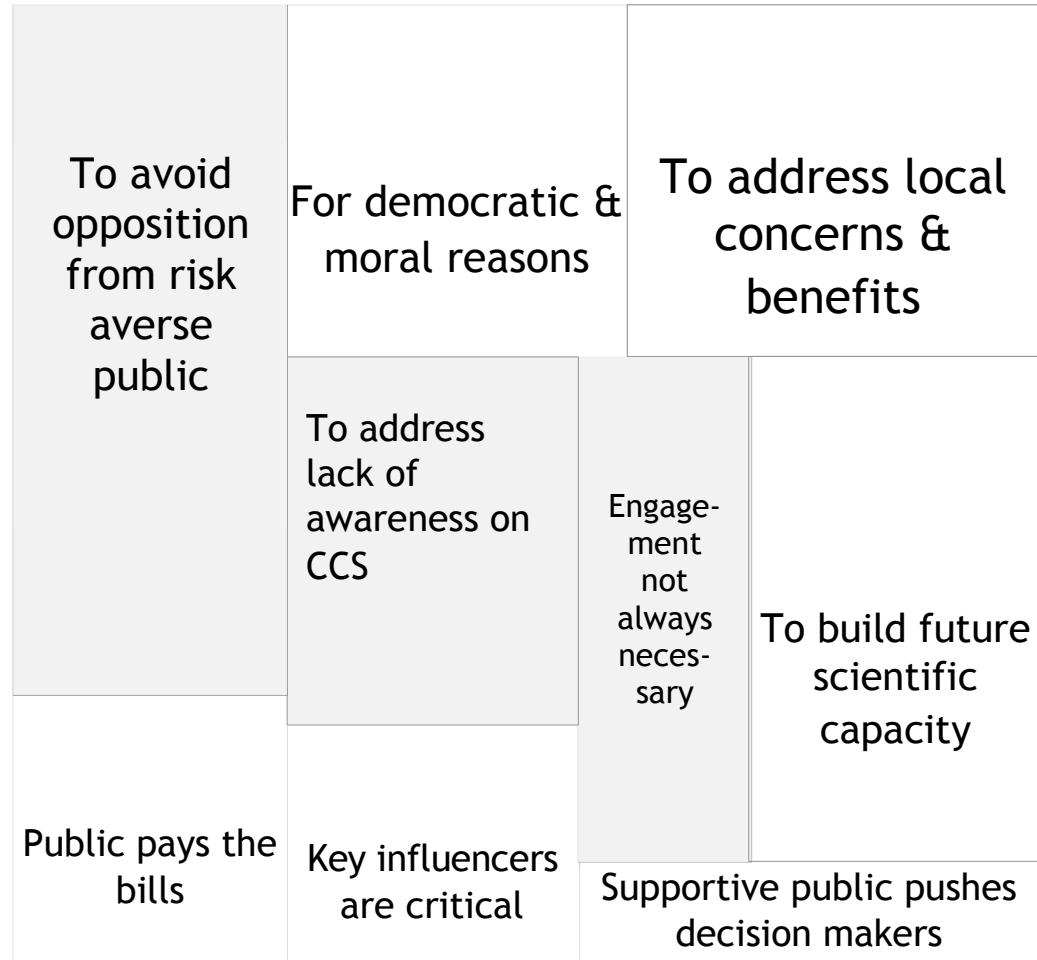**Figure 8:** *All experts responses to Question 6 "*Is public engagement important?"*.

Figure 9: *All experts responses to Question 6 "*Is public engagement important?"*

[Surface area of rectangles represents the proportion of incidence of each theme, to the total number themes for Question 6, adjusted for mean time spent on this theme. *Clusters are mutually exclusive*.]

Figure 10: *Directly* public-exposed expert responses to Question 6 *"Is public engagement important?"*.
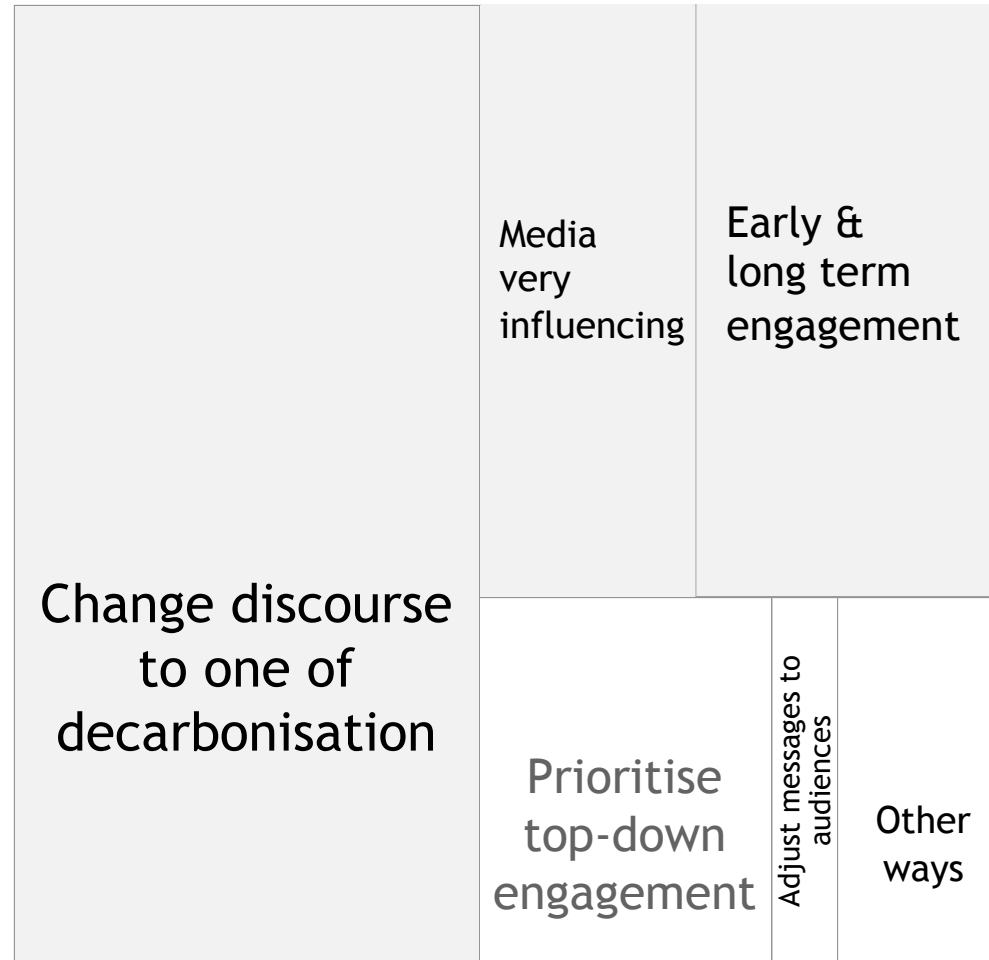
Figure 11: *Indirectly* public-exposed expert responses to Question 6 *"Is public engagement important?"*.

[Surface area of rectangles represents the proportion of incidence of each theme, to the total number themes for Question 6, adjusted for mean time spent on this theme. Light rectangles indicate themes unique to one group.]
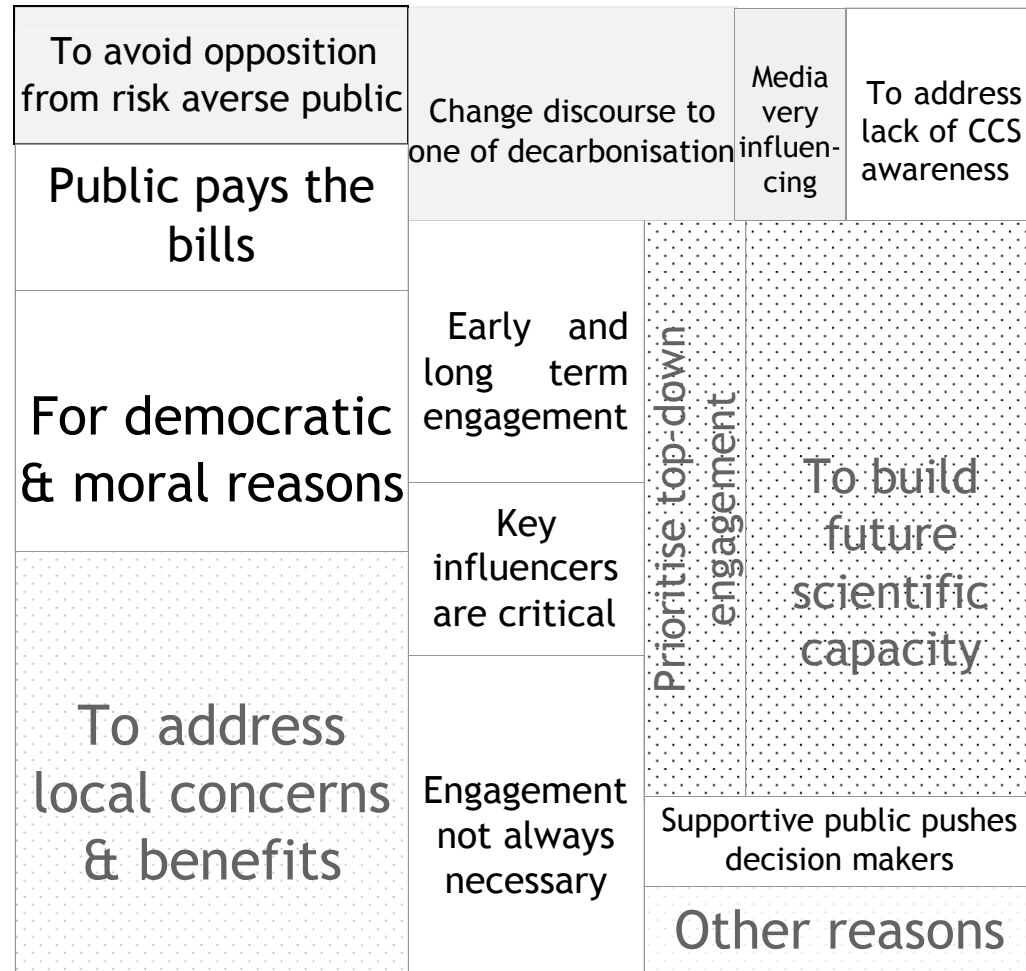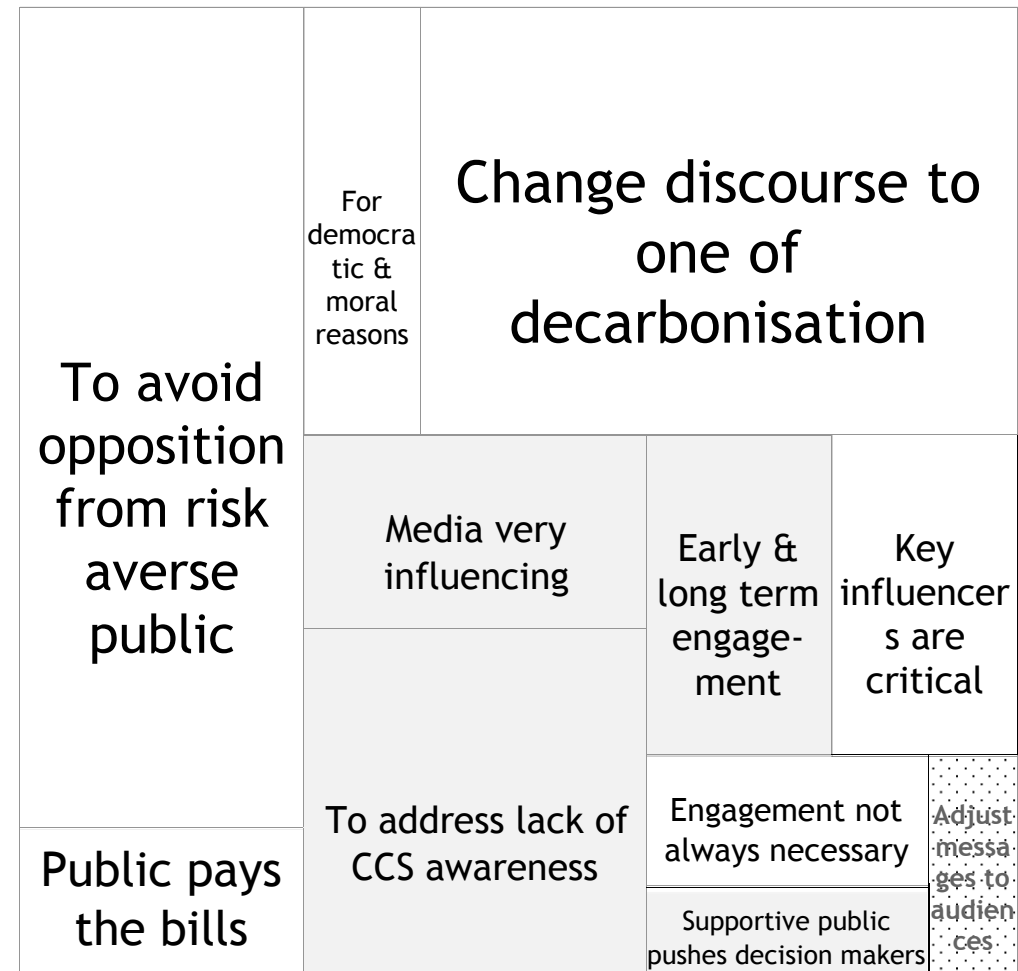
3.3 Interview Results Discussion

Our interviews revealed a few dominant issues for CCS roll-out, including lack of political commitment and support, dangers of miscommunication, and the need to explain why CCS is important. It is noteworthy that our interviews were undertaken shortly after the cancellation of the £1bn commercial CCS competition in the UK, which resulted in our respondents' comments being overshadowed by the need for policy continuity, although many of our experts stated that they have always been worried about sudden policy changes. On the other hand, public opposition or lack of support for CCS was seen as a far less significant barrier to CCS roll-out – both by those directly involved in public engagement and those not directly involved. How specific this finding is to the current political context is uncertain: had interviews been conducted immediately following the Barendrecht controversy, then public engagement may have been a more salient issue for interviewees, though this is out of scope for this paper. Nevertheless, interviewees did discriminate between onshore and offshore storage of CO_2 in terms of public acceptance, and some did refer to the Barendrecht case as a 'big mess' and an example of bad practice in public engagement.

An additional, unique aspect of our results was the separation between experts with direct versus indirect public exposure, which led to the emergence of different themes. More differences emerged between those with, versus without, public engagement experience in terms of challenges of public engagement and overcoming these. Experts with direct exposure to the public were more aware of the miscommunication risks, lack of subsurface awareness and climate change scepticism, compared to experts with indirect public exposure, who sited issues of NIMBYism, potential perception of CCS as 'greenwash', and the lack of suitable materials and trusted communicators as the primary challenges for public engagement with CCS. All of these have been raised in the public engagement literature (e.g., L'Orange Seigo et al., 2014), indicating a broad awareness amongst CCS experts of challenges of engagement.

In terms of solutions, experts with direct engagement experience stressed explaining the necessity of CCS to the public, providing tailored information, and using good analogies and visualisations. The other group emphasised political leadership and expanding CCS use to include non-power generation processes in order to address environmental concerns about CCS substituting renewables. Here, it is striking that early and substantive engagement was *not* raised as a potential solution, although this is seen as critical for effective (CCS) engagement by social science researchers (e.g., Coyle, 2016). On the other hand, some experts did suggest early engagement was critical when asked about reasons for engagement. Reasons for public engagement were diverse and included both substantive/normative (e.g., for democratic reasons; public pays the bill) and instrumental (e.g., to avoid opposition; to

address misperceptions). Notably, the former were more prominent amongst those with direct engagement experience, whereas the latter were more evident amongst those without. This is an interesting finding, perhaps suggesting greater sensitivity to the range of benefits of engagement amongst those who undertake it.

The disaggregation of interview experts depending on their direct or indirect exposure to general publics was a new and significant contribution to the field, which helped identify specific barriers, needs, and rationales for engagement that can vary significantly among those who have engaged publics face-to-face and those who have not. While it may be more important for those who already engage with the public to have a clear, evidence-based understanding of how and why to do so, as discussed earlier, there is increasing recognition amongst policy-makers, research funders and academics that a CCS roll-out requires public acceptance of CCS and its application, so it is relevant to explore whether those developing and assessing CCS technologies agree on this point. Further, CCS researchers are increasingly required by funders to engage (with publics and other groups) in their research, so understanding their views on this seems pertinent to how they might –now and in the future conduct such engagement. The small sample size, however, did not permit statistical comparison according to engagement experience; this is therefore addressed in the subsequent survey stage.

4   Expert survey

4.1   Aims

Following the interview stage, we undertook an online survey with CCS experts in order to gain a more representative view, and in particular to provide a statistical comparison of those with versus without public engagement experience. Building on study 1, the survey questions address relative importance of public support for CCS roll-out (4.2.1), as well as how publics might be affected by CCS (4.2.2) and factors shaping support for CCS (4.2.3) which together provide further insights into how and why to engage the public.

4.1.2 Interviewee recruitment

Personal recruitment (e.g. in relevant conferences), internet searches and recommendations from CCS colleagues were used to contact several hundred CCS experts from private, public and third sectors across Europe. Recruitment emails were sent directly to around 100 experts, but also circulated via other distribution lists such as through industry bodies and journals (including the UKCCSRC and the Carbon Capture Journal). These strategies yielded a useable sample of 99 experts. Of these, 45% were

from England, 9% from Scotland, 8% the Netherlands, 6% Australia, and the remainder (<4% per country) from across North America, Europe and India. Further breakdown of the sample is provided in table 9. Participants were asked specifically to 'rate how knowledgeable you feel about CCS related issues', and most stated 'expert' (57%) or 'knowledgeable' (30%); this was also triangulated with other questions on the length of involvement with CCS, their level of seniority and whether CCS was their primary focus.

Table 9: *Expert sample breakdown by country, area of expertise and sector.*

| | | Please select the country you work in: | | | | | | | |
		England	Scotland	Wales	The Netherlands	Germany	Norway	Other	Total
Sector	Academic	34%	2%	1%	2%	2%	0%	10%	51%
	Community with experience of CCS related technologies	0%	0%	0%	1%	0%	1%	1%	3%
	Power generator	1%	0%	0%	0%	0%	0%	2%	3%
	CCS interest group	0%	3%	0%	0%	0%	0%	0%	3%
	Policy maker	0%	1%	0%	0%	0%	0%	1%	2%
	Regulator	0%	0%	0%	0%	1%	0%	0%	1%
	CCS technology developer	1%	1%	0%	0%	0%	0%	0%	2%
	Oil or gas industry	1%	1%	0%	4%	0%	0%	3%	10%
	Non Governmental Organisation	1%	0%	0%	0%	0%	0%	1%	2%
	Energy - related agency / think tank	3%	0%	0%	0%	0%	0%	1%	4%
	Other	7%	1%	0%	1%	0%	0%	9%	17%
Total		48%	10%	1%	9%	3%	1%	28%	100%
Expertise	Business	2%	1%	0%	0%	0%	0%	0%	3%
	Engineer	14%	2%	0%	2%	0%	1%	8%	27%
	PR	0%	1%	0%	0%	0%	0%	1%	2%
	Social science	2%	0%	0%	0%	0%	0%	1%	3%
	Other	1%	0%	0%	1%	0%	0%	3%	5%
	Scientist	28%	5%	1%	5%	3%	0%	15%	59%
Total		48%	10%	1%	9%	3%	1%	28%	100%

Our primary independent variable was direct experience of engaging with the public in relation to CCS. We operationalised this with the question 'do you have experience with public engagement with CCS?' and four response options shown in Figure 12. We aggregated those with no CCS communication experience and those with experience of communicating CCS only to experts or policy-makers into the 'indirect public contact' group (49%); versus those with experience of communicating CCS to the public ('direct public contact'; 51%).

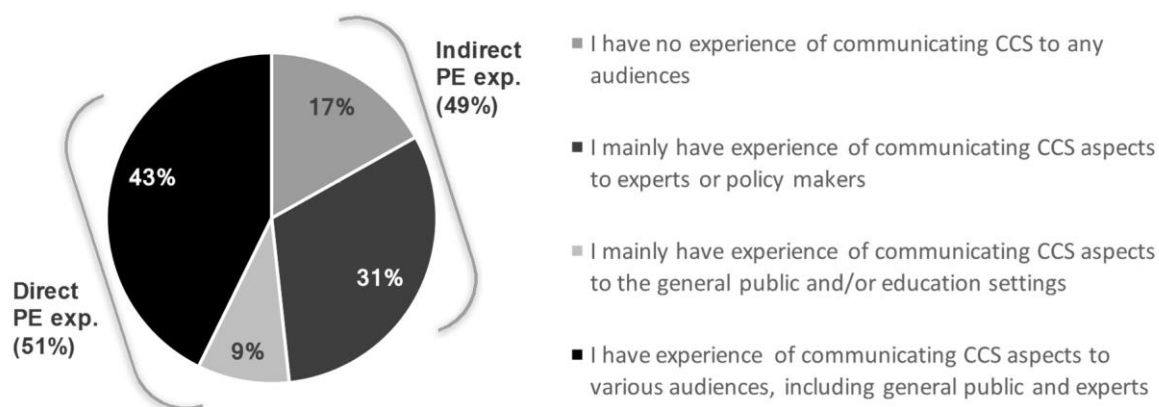'Do you have experience with public engagement with CCS?'

- I have no experience of communicating CCS to any audiences
- I mainly have experience of communicating CCS aspects to experts or policy makers
- I mainly have experience of communicating CCS aspects to the general public and/or education settings
- I have experience of communicating CCS aspects to various audiences, including general public and experts

Figure 12. *Survey sample disaggregated by public engagement experience*

Table 10: *Expert sample breakdown by public engagement experience.*

		Exposure with direct publics			
		No	Yes	Unknown	Total
Sector	Academic	24	23	0	47
	Community with experience of CCS related technologies	1	2	0	3
	Power generator	1	2	0	3
	CCS interest group	1	2	0	3
	Policy maker	1	1	0	2
	Regulator	1	0	0	1
	CCS technology developer	2	0	0	2
	Oil or gas industry	4	5	0	9
	Non Governmental Organisation	1	1	0	2
	Energy - related agency / think tank	2	1	1	4
	Other	6	10	1	17
Total		44	47	2	93
Country you work in	England	23	20	1	44
	Scotland	3	6	0	9
	Wales	1	0	0	1
	The Netherlands	4	4	0	8
	Germany	2	1	0	3
	Norway	0	1	0	1
	Other	11	15	0	26
Total		44	47	1	92
Expertise	Business	1	2	0	3
	Engineer	14	10	1	25
	PR	0	2	0	2
	Social science	0	3	0	3
	Other	3	2	0	5
	Scientist	26	28	1	55
Total		44	47	2	93
For how long have you been working on CCS?	Up to 1 year	2	0	0	2
	Between 1 - 3 years	3	3	0	6
	Between 3 - 5 years	13	4	0	17
	More than 10 years	1	4	1	6
	Between 5 - 10 years	4	2	1	7
Total		23	13	2	38

The survey was conducted using an online survey platform and included questions about barriers to CCS roll-out, risks and benefits from CCS, factors influencing public support for CCS, attitudes towards energy sources, and the role of CCS in climate change mitigation. Item wording is given in the following sub-sections, along with results.

4.2   Results

4.2.1   Barriers to CCS roll-out

In relation to factors influential in the UK's CCS roll-out (Figure 13), funding and policy/political aspects are rated most important, while public support is also considered very important (72% on a 0-100% slider scale). As can be seen in Figure 13, comparing experts with direct public engagement to those without, a Multivariate Analysis of Variance (MANOVA) showed: (a) a significant difference for 'technical barriers' which was lower for experts with direct public experience, and (b) a marginally significant difference for 'policy coherence-continuity' which was higher for experts with direct public experience.
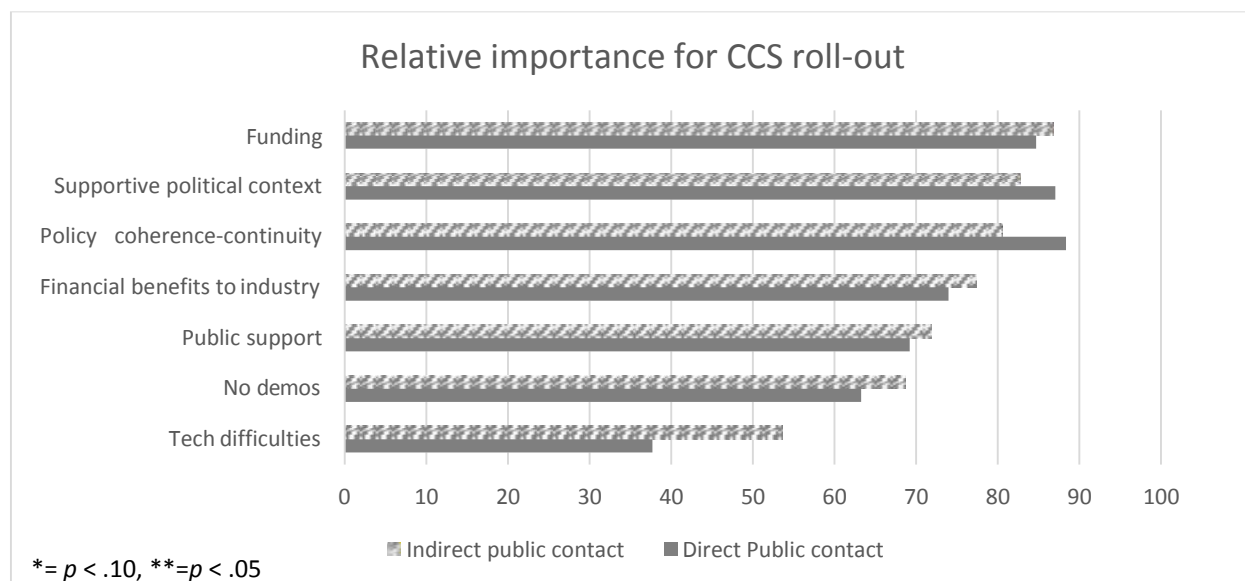

Figure 13. *"How important are the following factors for CCS roll out in the UK?"*

Table 11: *MANOVA statistics for differences between experts with directs vs indirect public experience for factors influencing public support for CCS.*

			Policy coherence-continuity	Tech difficulties
	df		1,92	1,92
	F		2.378	5.448
	p		0.099	0.006
	η^2		0.05	0.108
Contact with public	*Indirect*	*M (SD)*	80.40 (*20.24*)	54.21 (*28.38*)
		N	42	42
	Direct	*M (SD)*	87.84 (*14.86*)	37.73 (*23.04*)
		N	45	45

4.2.2   Risks and benefits from CCS developments

In relation to risks and benefits from CCS (Figures 14-15), proximal ecosystems were thought to bear the greatest risks and the least benefits. Local communities were thought to bear the next highest risks, while only benefiting a modest amount. Greatest benefits were thought to accrue to global populations and ecosystems. MANOVA shows responses on risks did not differ by public exposure; whereas almost all responses differed for the benefits question.
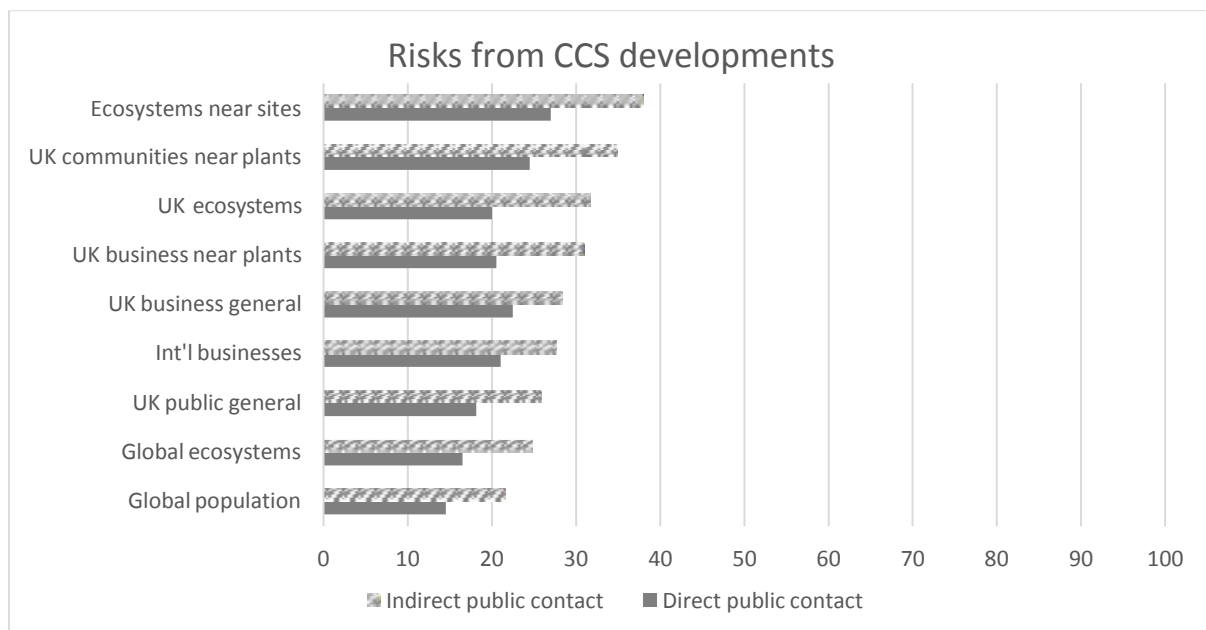

Figure 14. *"To what extent will each of the following experience risk from CCS developments?"*

Specifically, those with direct public engagement experience gave significantly higher ratings of benefits to all groups.
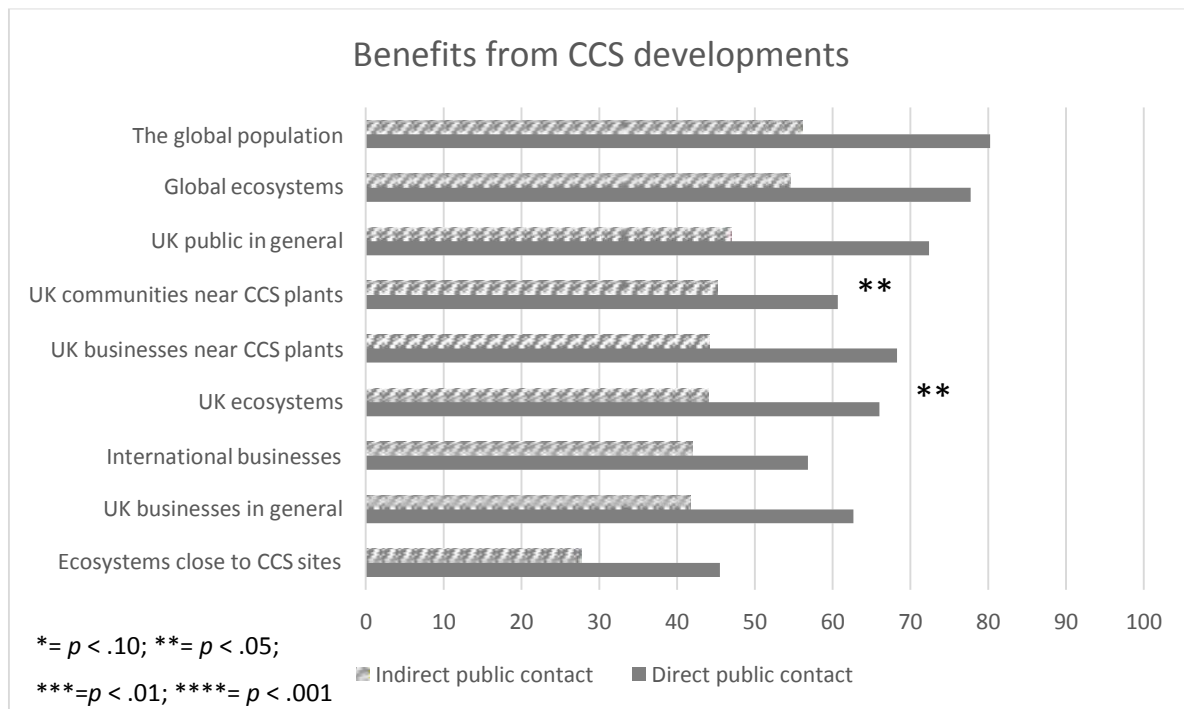

Figure 15. *"To what extent will each of the following experience benefits from CCS developments?"*

Table 12: *MANOVA statistics for differences between experts with directs vs indirect public experience for perceived benefits from CCS.*

			The global population	Global eco-systems	UK public in general	UK communities near CCS plants	UK businesses near CCS plants	UK eco-systems	Internat'l businesses	UK businesses in general	Ecosystems near CCS sites
	df		2,75	2,75	2,75	2,75	2,75	2,75	2,75	2,75	2,75
	F		7.376	6.278	9.123	4.082	8.017	4.225	3.859	5.815	2.705
	p		0.001	0.003	0	0.021	0.001	0.018	0.026	0.005	0.074
	η^2		0.168	0.147	0.2	0.101	0.18	0.104	0.096	0.137	0.069
Contact with public	*Indirect*	*M (SD)*	56.11 (*31.73*)	54.58 (*31.01*)	47.06 (*28.42*)	45.17 (*30.91*)	44.11 (*29.65*)	44.00 (*31.03*)	32.91 (*26.80*)	32.48 (*27.31*)	27.75 (*29.76*)
		N	36	36	36	36	36	36	36	36	36
	Direct	*M (SD)*	80.26 (*20.15*)	77.74 (*25.80*)	72.41 (*23.86*)	60.68 (*28.27*)	68.29 (*27.44*)	66.00 (*32.24*)	46.77 (*28.82*)	62.68 (*25.03*)	45.53 (*33.12*)
		N	34	34	34	34	34	34	34	34	34

4.2.3   *Factors influencing public support for CCS*

When asked about factors influencing public support for CCS, environmental values, need for emissions reduction, fairness in decision making, financial compensation, electricity price increase, and knowledge of CCS were rated top by our expert participants. As seen in Figure 16, most factors were rated at least reasonably important (on a 0-100% importance scale). A Multivariate Analysis of Variance (MANOVA) showed a significant difference between experts with different types of public exposure; specifically, financial compensation and knowledge of CO_2 impacts were rated higher by those with indirect engagement experience, environmental values, need for emissions reduction, knowledge of CCS and CCS as a transition measure were rated significantly higher by direct engagers.
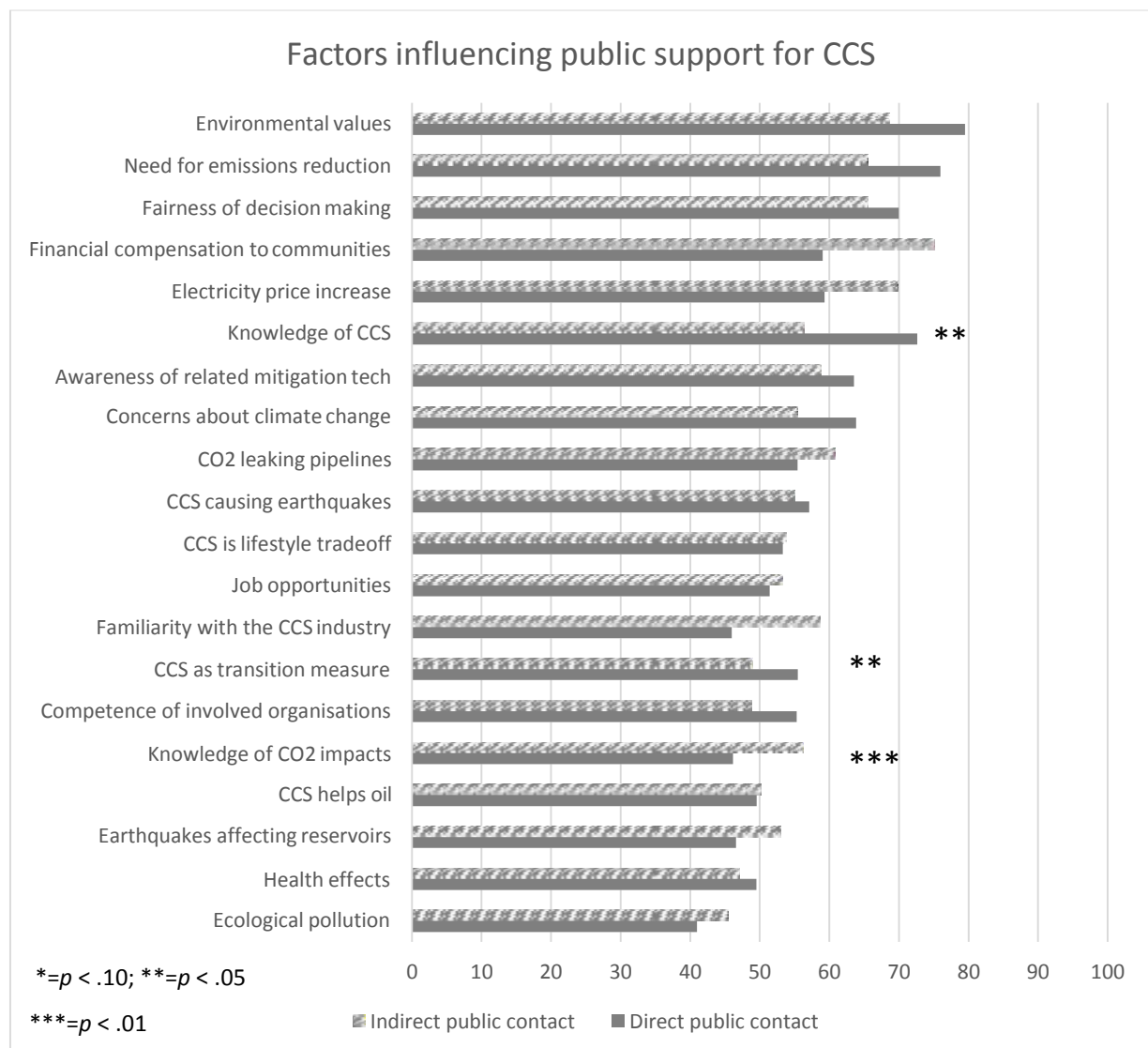

Figure 16. *"How important do you think each of the following factors are in influencing public support for CCS?"*

Table 13: *MANOVA statistics for differences between experts with directs vs indirect public experience for factors influencing public support for CCS.*

			Environmental values	Need for emissions reduction	Financial compensation to communities	Knowledge of CCS	CCS as transition measure	Knowledge of CO_2 impacts
	df		2,75	2,75	2,75	2,75	2,75	2,75
	F		6.079	3.952	4.282	3.98	3.78	5.601
	p		0.004	0.023	0.017	0.023	0.027	0.005
	η²		0.143	0.098	0.105	0.098	0.094	0.133
Contact with public	*Indirect*	*M (SD)*	69.19 (*24.76*)	65.42 (*24.89*)	73.67 (*21.86*)	59.36 (*27.96*)	48.94 (*25.13*)	56.19 (*22.96*)
		N	36	36	36	36	36	36
	Direct	*M (SD)*	81.22 (*15.26*)	77.56 (*20.04*)	59.22 (*28.99*)	74.22 (*24.65*)	56.67 (*30.07*)	45.61 (*28.06*)
		N	36	36	36	36	36	36

4.3   Expert Survey Results Discussion

Regarding risks and benefits from CCS implementation, broadly speaking, experts perceive greater benefits at the global level and greater risks at the local level. Amongst those bearing greatest risk were local communities, while they were seen to benefit only a modest amount. This perception is noteworthy as it reinforces some of the challenges of engagement exposed during the interviews, such as 'convincing' publics of the need for and benefit of CCS. Experts we surveyed appear to have an appreciation of the diverse factors (knowledge, values, financial compensation, trust, and others) influencing public engagement with CCS, albeit – consistent with the interviews – they did not see public engagement as the most important factor for the roll-out of CCS in the UK (political and financial factors rating higher). This may be at least partly due to the fact that CCS roll-out is expected to be offshore in the UK, although we did not specifically test this hypothesis.

Our survey findings support the distinction we observed in the interviews between those with, versus without, direct experience of public engagement. The greater attention given to 'technical barriers' amongst those without direct public engagement experience possibly suggests a more techno-optimist view and less importance of social factors amongst non-engagers – or it could just be that their role is more technical so they are more aware of technical barriers. In terms of factors influencing engagement, the greater attention to financial compensation by non-engagers might suggest a more 'homo economicus' view of the public, whereas engagers' greater attention to environmental values indicates more awareness of other, non-economic motives for support for CCS projects – consistent

with the CCS perceptions literature (e.g., L'Orange Seigo et al., 2014). That various CCS benefits were rated significantly more highly by experts who engage the public than those who do not, is perhaps because public engagement requires 'selling' benefits to different audiences (or because people with a greater belief in the benefits of CCS choose to engage the public as part of their job).

5 General Discussion and Conclusions

Public engagement with CCS is important for a range of reasons, but previous work has not explored the perceived rationales for, or benefits of, public engagement amongst CCS experts (including those who engage the public themselves). We have presented mixed-methods research which sought to elucidate these rationales, along with views of CCS itself and of public engagement, in the CCS expert community, in order to infer whether CCS funder and policy rhetoric about the importance of public engagement is reflected in CCS expert views; and whether best practice and relevant social science insights on CCS public engagement are used by CCS experts.

Our interviews and survey point to a recognition of the importance of public engagement for the roll-out of CCS, but with more substantive and normative rationales (e.g., public voice in government expenditure) offered by those who engage the public directly and instrumental rationales (e.g., removing opposition) more prevalent amongst those who do not. Due to the correlational nature of this research, it is not possible to establish whether this apparent greater sensitivity to the range of benefits of engagement amongst those who undertake it was a result of or cause of their public engagement experiences. Nevertheless, our research also shows the CCS community in general is aware of the range of factors influencing public engagement – not only knowledge, as would exemplify the deficit model of public engagement (Burgess et al., 1998), but also values, trust in communicators, and other relevant factors (cf. L'Orange Seigo et al., 2014). Again, there would appear to be a more nuanced view of the challenges and solutions for public engagement with CCS amongst those experienced in engagement (e.g., that financial compensation is not necessarily the best way to facilitate community acceptance of CCS; cf. Coyle, 2016), though whether this has been learnt through experience or insight from social science evidence is not known and warrants further investigation. Nevertheless, the relatively low salience of early and substantive engagement amongst CCS experts suggests there is room for improving the flow of learning from the public engagement research literature to those charged with delivering it.

While it was not our primary aim to compare expert and public views on CCS our findings are consistent with previous research (e.g., Shackley et al., 2007; cf. Slovic, 2000), that finds some divergence in views, which might impede public engagement effort. Specifically, CCS experts, while

aware of CCS risks to local communities and ecosystems in particular, see greater (particularly global) benefits. Indeed, those who engage directly with the public seem to be even more convinced of the benefits of CCS than those who do not. Our analysis suggests perceived CCS risks (particularly at the local level, e.g. close to a CO_2 storage site) may not be as influential in shaping expert views as they are in influencing the public, particularly local communities (Bruin & Wong-Parodi, 2014). Examining these differences and the different information processing modes or decision-making criteria (Weber, 2010; de Vries et al., 2014) that may be applied by experts and publics in respect of CCS could be a fruitful avenue for future research.

There are limitations with the current study. Firstly, in terms of timing, our interviews and survey were undertaken shortly after the cancellation of the £1bn commercial CCS competition in the UK, which may have resulted in respondents' comments being overshadowed by the need for policy continuity-although most interviewees made a strong point that CCS was always of high policy risk, which is also predicted and confirmed by the work of Energy Institute (2015; 2016). On the other hand, public engagement was seen as important in both the interviews and survey despite this, and our participants included an international pool of experts who would have drawn on experience outside of the UK as well as within it. That said, most experts worked in Europe and cited European examples of engagement, which often do not reflect best practice in engagement (Desbarats et al., 2010); so future work should explore whether our findings can be generalised to North American and other contexts (cf. NETL, 2013). Finally, we did not employ an experimental design, so we do not know whether the differences we observed between those who directly engage the public and those who do not are a function of their engagement role (e.g., they identify more CCS benefits because they are required to 'sell' the benefits of CCS to the public), or pre-dating the role (e.g., they choose to engage the public because they are convinced of the significant benefits of CCS and want to disseminate these).

Our research has built on previous work highlighting some divergence between the public and experts in their views on CCS; and goes beyond this to examine CCS experts' views and experiences of public engagement. Our disaggregation of experts according to their direct or indirect engagement with general publics was a new and significant contribution to the field, which helped identify specific barriers, needs, and rationales for engagement that can vary significantly among those who have engaged publics face-to-face and those who have not. Our findings give some reassurance that experts engaging with the public are generally sensitive to their needs and values; and value the role such values and beliefs can play in the roll-out of CCS and – more generally – societal decarbonisation. Nevertheless, there is also great scope for developing this understanding further, and maximising the use of best practice methods of early community engagement with CCS projects to ensure CCS engagement failures are avoided in the future. As demands grow for CCS experts to engage with

publics and other stakeholders, it is vital that they are equipped with the (now considerable) evidence-based tools for undertaking this engagement effectively in order to fully realise the benefits of doing so.

6   References

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Appendix 1

CCS expert interviews protocol

Date:

Name:

Contact:

Organisation / relationship with CCS:

Q1: "From your experience, what do you think the main barriers are to CCS roll-out in the UK?" - to evaluate how public engagement and social support compares to other potential barriers for CCS roll-out. -expand-

Q2: "Do you have previous experience with public engagement on any subject?" - to estimate the expert's level of general public engagement. -expand-

Q3: "Do you have previous experience with public engagement on carbon capture and storage?" - to estimate the expert's level of public engagement with CCS. -expand-

Q4: "What do you think the key issues and challenges are, for engagement with CCS?" - to identify the expert's perception of social barriers, hampering public engagement with CCS.
-expand-

Q5: "What do you think could be done to address these issues?" – to capture how experts would address the issues that emerged in Q4.
-expand-

Q6: "To what extent do you think it is important to engage the public with CCS? If so, why is it important?" – to look for the level of importance attached to this process, the rationale (instrumental, normative, substantive), barriers and drivers for it – the question does not assume that all experts would agree on the importance of public engagement.
–expand-

[Thanks and summary of CONTAIN main aims and objectives, answering interviewee's questions and discussion of future steps of this research programme.]