Recommendations for engaging the public with CCS

CONTAIN: The impact of hydrocarbon depletion on the treatment of caprocks within performance assessment for CO_2 injection schemes

Deliverable 9

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Foreword

This report is the published product of research conducted as part of the EPSRC project CONTAIN: *The impact of hydrocarbon depletion on the treatment of caprocks within performance assessment for CO_2 injection schemes*. Specifically, the work reported here relates to Work Package 3: '*Social understanding and acceptance of CCS storage proposals'*. This Work Package was designed to complement the project's technical findings with the human dimension – that of perceptions relevant to CCS – as stipulated by the EPSRC.

The research was conducted by Prof. Lorraine Whitmarsh and Dr. Dimitrios Xenias of Cardiff University. Although care has been taken in the production of this manuscript, the first author is ultimately responsible for any errors or omissions.

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Summary

Carbon Capture and Storage (CCS) comprises a suite of technologies that capture carbon dioxide (CO_2) from power generation and heavy industrial processes and direct it into long-term geological storage. In doing so, CCS facilitates the mitigation of CO_2 which contributes to climate change, thus aiding UK and global carbon abatement efforts. The EPSRC-funded CONTAIN project has undertaken both natural and social science research into CCS. In this brief report we outline lessons for engaging the public with CCS that derive from the social science investigations in CONTAIN, including (a) expert interviews and survey, and (b) a cross-national, experimental study of public perceptions of CCS. We also draw on the broader literature on public engagement with CCS to inform our recommendations. We provide the following conclusions based on this evidence:

- *Basic awareness is limited*. There is a need to provide basic information about CCS if the public are to be involved in decision-making about CCS investment, use and siting.
- *Framing effects are powerful*. For example, highlighting costs of CCS or pairing CCS with fossil fuels or industry seem to reduce support for CCS; while discussing CCS with CDU or with bioenergy increases support. It is also important to highlight the role of CCS in the context of a broader low-carbon societal transition.
- *Recognise diversity in audiences*. Strong national, regional, demographic, and attitudinal variations in CCS attitudes highlight the importance of understanding the local context in which information about CCS is provided or CCS developments are proposed. Targeting information to audience values is likely to be more effective than untargeted communication.
- *Engagement process is critical*. Two-way engagement (dialogue) is likely to be more effective than one-way (information provision). Early, sustained and substantive engagement is also likely to lead to more positive outcomes.
- *Trust is also important for engagement and information provision*. Industry tends to be less trusted than scientists or environmental organisations, but trust in particular sources or organisations varies between communities and individuals (according to prior experiences and values).

1 Introduction

1.1 CONTAIN PROJECT

Carbon Capture and Storage (CCS) comprises a suite of technologies that capture carbon dioxide (CO_2) from power generation and heavy industrial processes and direct it into long-term geological storage. In doing so, CCS facilitates the mitigation of CO_2, which contributes to climate change, thus aiding UK and global carbon abatement efforts (IEA, 2013; IPCC, 2014).

The CONTAIN project, lasting from 2013 to 2017 and funded by EPSRC, was conceived in three parallel levels, with three corresponding work packages (WPs). WP3 aims to better understand how the views of the CCS expert community may differ from those of the general public, and to identify ways forward in engaging the public with CCS. This includes understanding the factors shaping public acceptance of CCS and how different types of information may influence attitudes. In this brief report we outline lessons for engaging the public with CCS that derive from the WP3 investigations, including (a) expert interviews and survey, and (b) a cross-national, experimental study of public perceptions of CCS. We also draw on the broader literature on public engagement with CCS to inform our recommendations.

Briefly, the methods we used in CONTAIN WP3 include:

1) *Expert interviews.* Thirteen CCS experts were recruited for interview through Internet searches, colleague recommendations and snowballing. Nine interviewees were based in the UK, one in Norway, and three in the Netherlands. Experts represented a range of relevant backgrounds and sectors. Questions addressed perceptions of barriers to CCS deployment in the UK, experiences with public engagement, challenges to public engagement with CCS and possible solutions, and the importance and utility of public engagement with CCS. Interviews lasted between 23 and 88 minutes and were analysed using thematic coding. Further details can be found in CONTAIN deliverable D7.
2) *Expert survey.* A survey (N=99) was undertaken of CCS experts from private, public and third sectors across Europe (almost half were academics). Forty-five per cent were from England; the remainder were from across Europe, Australia, North America, and India. Around half the sample had direct experience of engaging the public with CCS. The survey included questions about barriers to CCS rollout, risks and benefits from CCS, factors influencing public support for CCS, attitudes towards energy sources and the role of CCS in climate change mitigation.

3) *Public survey.* Participants (N=5,406) were recruited via Qualtrics, an online participant panel provider. Two samples in five countries (UK, USA, Canada, Norway, Netherlands) – a national sample and a local sample – were recruited. The national sample was demographically representative in terms of gender and age. The local samples were identified as living close to current or proposed CCS processing, pipeline or storage sites. The survey comprised various questions on support for energy sources, attitudes to CCS, risk and benefit perceptions and various psychological constructs (e.g., place attachment, technophilia, environmental identity, environmental worldview) and demographic measures. Participants were randomised to one of three conditions in which different messages about CCS were provided – CCS without lifestyle change ('business as usual'); CCS with carbon dioxide utilisation (CDU); and CCS with lifestyle change – after which CCS support and attitudes were again measured. Further details of the survey methodology can be found in CONTAIN deliverable D8.

1.2 PUBLIC PERCEPTIONS OF CCS

While CCS likely offers environmental and economic benefits, it remains controversial (van Egmond & Hekkert, 2012) and there has been high-profile public opposition to particular CCS developments (Oltra et al., 2012). For example, public opposition to the CCS project in Barendrecht, near Rotterdam, where a total of 10 million tons of CO_2 were to be stored in a depleted oil field under a residential area, ultimately led to the project being cancelled (e.g., Bellona, 2010). As a result of public 'engagement failures' of this kind, it is increasingly accepted that public acceptance of CCS as a vital precondition for its rollout (RCUK, 2010; 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).

A huge body of knowledge has emerged in the last decade on public perceptions of CCS, comprising both qualitative and quantitative studies across various European countries, the US, Canada, Australia, Japan and China. These highlight **low public awareness** of CCS across all countries (e.g., Demski et al., 2013). In CONTAIN, we also found in low levels of awareness of CCS, although there were cross-national differences, with Norway (where CCS technologies are more established) showing more awareness than elsewhere (see CONTAIN deliverable D8).

Of those who have views, these are often **mixed**: concerns include the long-term viability ('temporising') of CCS, its safety (e.g., risk of CO_2 leaks, explosion), association with coal mining, cost, and the ability of institutions to regulate/monitor storage sites (e.g., de Best-Waldhober et al.,

2011). However, people are positive about the potential of CCS to reduce carbon emissions (Duan, 2010) and offer economic benefits (L'Orange Seigo et al., 2014). It is also clear that support for CCS is contingent on CCS being not only safe but also just one part of a wider strategy for achieving significant cuts in CO_2 emissions (e.g., Dütschke et al., 2016). Consistent with this, one of the strongest determinants of support for CCS is belief in and concern about climate change (L'Orange Seigo et al., 2014), something we also found during the CONTAIN project (CONTAIN deliverable D8). In CONTAIN, we also found that attitudes to CCS are mixed though overall are rather more positive than negative (see CONTAIN deliverable D8). For example, more of the public (around half the sample) agree that CCS should be implemented in their country than disagree (around one-quarter). Strongest agreement (over three-quarters of the sample) was with the question about leaks ('CO_2 stored underground might leak back into the atmosphere'); this reflects the sample's ambivalence because almost the same proportion agreed that 'CCS helps to keep an important greenhouse gas out of the atmosphere'. There was also overall agreement that CCS is risky, will benefit the economy and that the risks are underestimated.

The literature also shows that, when it comes to CCS perceptions, the public is highly **heterogeneous**. Along with climate change beliefs, trust in industry developing CCS projects, demographic factors (age, gender, education), newspaper readership and political values are key factors driving acceptance (e.g., Poumadere et al., 2011). In CONTAIN, we found nationality was by far the strongest influence on CCS support (either before or after information provision). After nationality, the strongest predictors of CCS support were place attachment, climate change belief, technophilia, and environmental identity, as well as working in the energy industry, living near a CCS site and age. Following provision of the CCS messages, we found environmental worldviews, education, rurality, gender, and left-wing ideology, become significant negative predictors (see CONTAIN deliverable D8).

The literature also shows areas of both convergence and divergence between **expert and public views** of CCS. While public support for CCS is generally lower than expert stakeholder acceptance (e.g., Shackley et al., 2007), both consider CCS to be a partial solution to climate change. For example, a UK survey of energy experts found only 9% rated CCS as the most important solution to meeting emissions targets; most favoured renewables, nuclear and energy efficiency (Energy Institute, 2016). In CONTAIN (see deliverable D8), we similarly found the public across the five surveyed countries were more supportive of renewable energy sources and reducing energy demand than CCS and nearly three-quarters agreed that 'CCS will encourage the prolonged use of fossil fuels'.

Furthermore, 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 (e.g., Huijts et

al., 2007). As with other energy developments (e.g., nuclear, wind), different publics and communities will respond differently to CCS in general versus to proposed sites; '*public acceptance of CCS in the global sphere does not necessarily translate to local support for a CCS storage site'* (Poumadere et al., 2011, p.720). For example, while climate change belief seems to predict acceptance of CCS in general, it does not predict opposition to local CCS developments (Terwel et al., 2012a). Barendrecht residents were concerned about transport and storage of CO_2 and fall in property prices, felt decision-making about the local CCS scheme had been unfair and distrusted decision-makers (Terwel et al., 2012b). However, local attitudes may vary greatly from one site to another according to project-specific characteristics: smaller pilot projects arouse less concern than larger, commercial scale projects; local history of the site (e.g., previous gas storage may facilitate acceptance); and bioenergy with CCS is more acceptable than fossil energy with CCS (e.g., Dütschke et al., 2016). In CONTAIN, we also found differences in CCS attitudes between local communities living near current/proposed CCS sites and the general public. However, overall, we found support was *stronger* at the local than national level, perhaps because of their history and dependence on energy industry for employment and greater familiarity with the technology (cf. Parkhill et al., 2010). Consistent with the literature, we also found these local-national differences varied by country; in particular, local communities in the UK (in and around Peterhead) were more likely to be positive than local samples in the other counties.

Previous work has also found **cross-national differences** in attitudes to CCS, although this evidence is limited. For example, Canadians seem to be more accepting than Swiss publics, perhaps due to their different experience of (and dependence on) fossil fuel industries (L'Orange Seigo et al., 2014). Across Europe, there appears to be similar perceptions of CCS (Upham & Roberts, 2011), whereas there are more differences between continents (L'Orange Seigo et al., 2014; Ashworth et al., 2013). For example, in a survey of Australian, Canadian, Dutch and Scottish publics, awareness of CCS was highest in the Netherlands (84%) and lowest in Scotland (36%); whereas support (on a scale of 1=strongly disagree to 7=strongly agree) was lowest in the Netherlands (4.24) and highest in Canada (4.52), although all countries preferred renewables to CCS. In CONTAIN, we conducted one of the most detailed cross-national studies of CCS attitudes amongst the public, and found strong cross-national differences. Specifically, the UK showed much higher support for implementation, followed by Norway and the US. The Netherlands showed slight opposition overall to implementation, consistent with previous work (Ashworth et al., 2013).

1.3 ENGAGING THE PUBLIC WITH CCS

Both the way in which CCS information is framed (e.g., van Knippenberg & Daamen, 1996) and audience characteristics (e.g., knowledge, values, cultural worldviews) influence public views on the technology (e.g., Yang et al., 2016). Consequently, providing information about CCS does not always allay fears or change attitudes (e.g., Braun et al., 2017). For example, if CCS is presented along with other climate change mitigation options (e.g., energy efficiency, renewables), it is likely to be evaluated less favourably than without these comparators (e.g., de Best-Waldhober et al., 2012b). Similarly, bioenergy with CCS is more acceptable than fossil energy with CCS; mentioning pipelines or CO_2 monitoring elicit more concern than not mentioning them (e.g., Wallquist et al., 2012a). Contention around shale gas may also contribute to less favourable attitudes to CCS (Moutenet et al., 2012). Similarly, in CONTAIN, we found that pairing CCS with biofuels led to higher acceptability than asking about CCS alone, whereas pairing CCS with heavy industry or fossil fuels (especially shale gas) led to lower acceptability (see CONTAIN deliverable D8).

Consistent with pervasive confirmation bias in information processing (Corner et al., 2012) whereby initial beliefs or feelings filter whether or how further information is perceived (de Bruin & Wong-Parodi, 2014), information may also exacerbate or confirm concerns or, conversely, reinforce positive attitudes. Dutch and Scottish participants in one study became more negative after more information about CCS, whereas Canadian and Australian participants became more positive (Ashworth et al., 2013). Consistent with the climate change framing literature (Whitmarsh & Corner, 2017), framing CCS as dealing with 'waste' is more persuasive than framing it in terms of climate or economic benefits (Broecks et al., 2016). We similarly found in CONTAIN that framing CCS as dealing with waste improved perceptions; when CCS was specifically discussed in conjunction with **carbon dioxide utilisation** (CDU), we found a significant increase in support for CCS implementation in respondents' country (see CONTAIN deliverable D8 for details).

On the other hand, in CONTAIN, we also found differences when we introduced **information about the cost of CCS**. Information was provided about current estimated costs of CCS per household (£6-12 per year) and the potential for future greater costs associated with climate change mitigation to be avoided if CCS was immediately implemented. Despite the focus on avoiding future, greater costs, compared to support for implementation before costs were mentioned, support for CCS actually reduced when the cost information was introduced (see CONTAIN deliverable D8).

As noted, a key factor influencing CCS attitudes is **trust** in industry developing CCS projects (e.g., de Best-Waldhober et al., 2011). Indeed, L'Orange Seigo et al (2014, p.31) conclude that *'trust plays a particularly important role for benefit perception in the case of CCS, more so than with*

other large technologies, whose benefits are more visible'. Academics, followed by government and then industry are most trusted in the UK (Roberts & Mander, 2010); environmental organisations are also more trusted than industry (Terwel et al., 2011). Trust can be engendered better through face-to-face contact with experts and developers; citizens' panels, engender trust better than via printed/online materials for example (Poumadere et al., 2011; Chrysostomidis et al., 2013), as well as through substantively involving communities in decision-making (Terwel et al., 2011). Trust is also critical to how information on CCS is perceived; this in turn is related to the perceived competence and integrity of the source (Vercelli et al., 2013).

Consistent with this, previous work also highlights that the **engagement process** can profoundly influence community perceptions of CCS (Oltra et al., 2012; Dütschke, 2011; Buhr & Wilbeck, 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., 2011a,b; 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). As an 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, 2009; cf. Brauer et al., 2014). 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, Bahrendrecht) have been assessed, they appear to have relied more on one-way information provision methods (e.g., letters, websites) than two-way dialogue. In these cases, 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). Other work suggests financial compensation can also help, under certain circumstances, to facilitate community support for CCS developments (Mors et al., 2014; Terwel et al., 2014). Summarising the literature on community engagement with CCS development, Oltra et al (2012) identify the key factors involved are: the characteristics of the project; the engagement process; risk perceptions; the actions of the stakeholders; the characteristics of the community; the socio-political context.

1.4 EXPERT VIEWS ON ENGAGING THE PUBLIC

Our work in CONTAIN also shed light on public engagement with CCS from the perspective of CCS experts, including those who directly engage the public with CCS as part of their work. The interviews and survey we conducted with experts (e.g., see CONTAIN deliverable D7) indicated

their views on CCS were more positive than the public's views on these technologies. Nevertheless, most felt it was not the only climate change mitigation strategy required, and that it posed risks as well as benefits.

Experts highlighted that the public are largely unaware of CCS, its risks and benefits, and felt that misperceptions needed to be addressed. Many, though, noted that this needed to be sensitive to different audiences, using tailored approaches and that visualisations and analogies could help communicate unfamiliar processes like CCS. They also felt that belief in and concern about climate change were 'gateway' beliefs to accepting CCS; that is, without accepting climate change as a problem, the purpose and benefits of CCS would not be appreciated. Indeed, this was supported by our public survey, as discussed above. Some went further to say that there should be a change in discourse from climate change issues to the broader vision of decarbonising society and contributing to healthier living.

Experts also felt that onshore CCS developments would always be more controversial and pose problems in terms of public engagement, compared to offshore developments, which would less directly affect communities. In as far as our public survey analysis shows, there appears to be some support for this as the two most positive countries were the UK and Norway where CCS developments (actual or proposed) are offshore. Somewhat less support was seen for actual/proposed CCS sites in Canada, the US and (particularly) the Netherlands.

The need for trusted communicators and open, direct communication was also highlighted by interviewees. In particular, many found that the public see CCS as industry 'greenwash' and so express scepticism about it; using non-industry communicators to highlight its role in climate change mitigation was seen as important for effective engagement. At the same time, having strong government commitment, demonstration projects and consistent media messaging can signal to the public that CCS is important as part of the UK's response to climate change.

While many experts focussed more on one-way forms of communication, others stressed the need for early and sustained two-way engagement with the public (consistent with the broader literature). A variety of rationales for engagement were expressed – ranging from instrumental (to overcome opposition to CCS rollout) to substantive and normative (e.g., for democratic public policy). However, most felt that public engagement was a lower priority for CCS implementation than policy support and investment.

In respect of our expert survey results, it appears that experts expressed more positive and unambiguous support for renewables over CCS, and for CCS over (unabated) fossil fuels, compared to the general public. Moreover, those who engage directly with the public seem to be even more convinced of the benefits of CCS than those who do not. That is, experts directly

involved with publics perceived both local and global risks to be lower compared to experts with no direct public exposure. The inverse was true about CCS benefits (higher perceptions for directly engaged experts). This is an interesting find, and may be due to the function of direct public communicators in 'convincing' publics about CCS – compared to experts who do not face publics directly.

CCS experts also generally recognise the importance of public engagement for the rollout of CCS for both substantive and instrumental reasons and are largely aware of the range of factors (knowledge, values, trust, etc.) influencing public engagement. Here there was again an important distinction between experts directly exposed to publics and those indirectly exposed. Experts directly exposed to publics placed heavier emphasis on environmental values, knowledge of CCS and explaining the need to reduce emissions; experts indirectly exposed to publics placed heavier emphasis on financial compensation for communities as factors influencing public support for CCS.

Another interesting finding was that nearly half of all experts surveyed found that once the full CCS chain of technologies has been implemented, they should actively be ongoing for over 80 years or indefinitely. This contradicts the current view that CCS should be treated as a bridging technology that will temporarily aid decarbonisation of power generation and heavy industry and aid the transition to a low carbon future. It is not clear what drives such preference for an indefinite application of CCS, and this might merit further research.

Equally, further research and improvement is needed in engaging experts with best practice on public engagement: both our interviews and survey suggest that experts recognise the importance of engagement but for instrumental rationales (e.g. removing obstacles/opposition) by those who do not engage publics directly. Since there was relatively low salience of the need for early and substantive engagement amongst CCS experts, there seems to be room for improving the flow of learning from the public engagement research literature to those charged with delivering it.

2 Implications for engagement

Here, we bring together the evidence reviewed above and summarise the key implications for engaging the public with CCS:

- *Basic awareness is limited:* both the expert and public data show public awareness of CCS is low. Even in countries where the technologies are most established (e.g., Norway), beyond recognition of the term 'CCS', there is little self-reported knowledge about the technologies. *This indicates a need to provide basic information about CCS if the public are to be involved in decision-making about CCS investment, use and siting.*
- *Framing effects are powerful:* Our research and previous studies show that the way in which CCS is discussed (whether it is presented along with alternatives to mitigate climate change, and the nature/focus of the CCS information provided) can strongly shape people's attitudes towards it, and these can interact with prior attitudes in ways that can polarise audiences. *For example, highlighting costs of CCS or pairing CCS with fossil fuels or industry seem to reduce support for CCS; while discussing CCS with CDU or with bioenergy increases support.* Other work shows that, for example, small-scale CCS sites are more supported than large-scale. Framing effects include the alternatives provided, and since we and others have found that CCS is seen as a temporary, techno-fix solution to climate change that may prolong dependence on fossil fuels, it is important to highlight the role of CCS in the context of a broader low-carbon societal transition.
- *Recognise diversity:* Our work adds to the broader evidence demonstrating the heterogeneity of audiences in relation to CCS attitudes. In particular, we found strong national variation in support, as well as local and demographic differences and variation according to attitudes and values (e.g., climate change beliefs, environmental values, technophilia). This heterogeneity highlights the importance of understanding the local context in which information about CCS is provided or CCS developments proposed. Contrary to assumptions, local communities do not necessarily possess 'NIMBY' (Not in My Backyard) attitudes; rather, as we found, they may actually be strongly in favour of CCS implementation if they have positive experiences with similar technologies or the energy industry. Further, consistent with the persuasion literature (e.g., Petty & Cacioppo, 1986), targeting information to audience values is likely to be more effective than untargeted communication: technophiles and climate change believers are more likely to be receptive to CCS information, whereas those with 'deep green' values will tend to oppose it (however framed) as it does not offer deeper societal change believed to be required to tackle climate change.
- *Engagement process is critical:* While we did not conduct face-to-face engagement with publics in CONTAIN, the literature and expert interviews show that the process of engaging

communities or the general public with CCS can fundamentally shape acceptance of implementation. Two-way engagement (dialogue) is likely to be more effective than one-way (information provision); furthermore, early and sustained engagement in which the public is substantively involved is likely to lead to more constructive and supported outcomes.

- *Trust is also important:* Trust is critical both to engagement processes, and to effective information provision: industry tends to be less trusted than scientists or environmental organisations, but trust in particular sources or organisations varies between communities and individuals (according to prior experiences and values).

References

Ashworth, P., Boughen, N., Mayhew, M. & Millar, F. (2010). From research to action: Now we have to move on CCS communication, *International Journal of Greenhouse Gas Control, 4* (2), 426-433.

Ashworth, P., Einsiedel, E., Howell, R., Brunsting, S., Boughen, N., Boyd, A., et al. (2013). Public preferences to CCS: How does it change across countries? *Energy Procedia, 37,* 7410-7418.

Ashworth, P., Jeanneret, T., Romanach, L., & Ranasinghe, N. (2014). Understanding stakeholder attitudes to CCS in Victoria, Australia. *Energy Procedia, 63,* 6982-6990.

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

Bellona (2010). *CCS communication: lessons learnt from Barendrecht.* http://bellona.org/news/ccs/2010-11-ccs-communication-lessons-learnt-from-barendrecht. Accessed 15th August, 2017.

Brauer, D. C., & Larrick, D. (2014). *Public communication and collaboration for carbon capture, utilization, and storage technology: Acceptance, education, and outreach.* Paper presented at the 31st Annual International Pittsburgh Coal Conference: Coal - Energy, Environment and Sustainable Development, PCC 2014.

Braun, C. (2017). Not in My Backyard: CCS Sites and Public Perception of CCS. *Risk Analysis, in press*.

Braun, C., Merk, C., Pönitzsch, G., Rehdanz, K., & Schmidt, U. (2017). Public perception of climate engineering and carbon capture and storage in Germany: survey evidence. *Climate Policy, in press.*

Broecks, K.P.F., van Egmond, S., van Rijnsoever, F.J., Verlinde-van den Berg, M. & Hekkert, M.P. (2016). Persuasiveness, importance and novelty of arguments about Carbon Capture and Storage, *Environmental Science & Policy, 59,* 58-66.

Brunsting, S., De Best-Waldhober, M., Feenstra, C. F. J., & Mikunda, T. (2011a). Stakeholder participation practices and onshore CCS: Lessons from the Dutch CCS case Barendrecht. *Energy Procedia, 4,* 6376-6383.

Brunsting, S., Upham, P., Dütschke, E., De Best Waldhober, M., Oltra, C., Desbarats, J., et al. (2011b). Communicating CCS: Applying communications theory to public perceptions of carbon capture and storage. *International Journal of Greenhouse Gas Control, 5*(6), 1651-1662.

Brunsting, S., Mastop, J., Kaiser, M., Zimmer, R., Shackley, S., Mabon, L., et al. (2015). CCS acceptability: Social site characterization and advancing awareness at prospective storage sites in Poland and Scotland. *Oil and Gas Science and Technology, 70*(4), 767-784.

Buhr, K., & Wibeck, V. (2014). Communication approaches for carbon capture and storage: Underlying assumptions of limited versus extensive public engagement. *Energy Research and Social Science, 3*(C), 5-12.

Cheng, N., Fürth, M., Johnson, M. C., Tay, Z. Y., Ajit Shenoi, R., & Wilson, P. A. (2013). Engaging the community with a "Green Town" concept. *Energy Procedia, 37,* 7337-7345.

Chilvers, J. & Kearnes, M. (2016) *Remaking Participation: Science, Environment and Emergent Publics.* Routledge, Abingdon.

Chrysostomidis, I., Perumalpillai, S., Bohm, M., Crombie, M., Beynon, E., & Lee, A. (2013). CO_2 capture project's CCS stakeholder issues review and analysis. *Energy Procedia, 37,* 7832-7839.

Corner, A. Whitmarsh, L. & Xenias, D. (2012). Uncertainty, scepticism and attitudes towards climate change: biased assimilation and attitude polarisation. *Climatic Change, 114,* 463-478.

Coyle, F. J. (2016). 'Best practice' community dialogue: The promise of a small-scale deliberative engagement around the siting of a carbon dioxide capture and storage (CCS) facility. *International Journal of Greenhouse Gas Control*, *45*, 233-244

De Best-Waldhober, M., Paukovic, M., Brunsting, S., & Daamen, D. (2011). Awareness, knowledge, beliefs, and opinions regarding CCS of the Dutch general public before and after information. *Energy Procedia, 4*, 6292-629.

De Best-Waldhober, M., Brunsting, S., & Paukovic, M. (2012a). Public concepts of CCS: Understanding of the Dutch general public and its reflection in the media. *International Journal of Greenhouse Gas Control, 11*(SUPPL), 139-147.

De Best-Waldhober, M., Daamen, D., Ramirez, A. R., Faaij, A., Hendriks, C., & de Visser, E. (2012b). Informed public opinion in the Netherlands: Evaluation of CO_2 capture and storage technologies in comparison with other CO_2 mitigation options. *International Journal of Greenhouse Gas Control, 10*, 169-180.

De Bruin, W. B., & Wong-Parodi, G. (2014). The role of initial affective impressions in responses to educational communications: The case of carbon capture and sequestration (CCS). *Journal of Experimental Psychology: Applied, 20*(2), 126-135.

DECC (2012). *CCS Roadmap: Supporting deployment of Carbon Capture and Storage in the UK.* DECC, London. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48317/4899-the-ccs-roadmap.pdf. Accessed 15th August, 2017.

Demski, C., Spence, A. and Pidgeon, N. (2013) Transforming the UK Energy System: Public Values, Attitudes and Acceptability – Summary findings of a survey conducted August 2012. (UKERC: London).

Desbarats, J., Upham, P., Riesch, H., Reiner, D., Brunsting, S., de Best-Waldhober, M., Duetschke, E., Oltra, C., Sala, R. & McLachlan, C. (2010). *Review of the Public Participation Practices for CCS and Non-CCS Projects in Europe.* Deliverable 1.2: NEAR CO_2-New participation and communication strategies for neighbours of CO_2 capture and storage operations. Amsterdam.

Dietz, T., & Stern, P.C. (Eds.) (2008) *Public Participation in Environmental Assessment and Decision Making*. National Academies Press, Washington, DC.

Duan, H. (2010). The public perspective of carbon capture and storage for CO_2 emission reductions in China. *Energy Policy, 38*(9), 5281-5289.

Dütschke, E. (2011). What drives local public acceptance - Comparing two cases from Germany. *Energy Procedia, 4,* 6234-6240.

Dütschke, E., Wohlfarth, K., Höller, S., Viebahn, P., Schumann, D. & Pietzner, K. (2016). Differences in the public perception of CCS in Germany depending on CO source, transport option and storage location, *International Journal of Greenhouse Gas Control, 53,* 149-159.

Energy Institute (2016). *Energy Barometer 2016: Views from UK energy professionals*. Energy Institute, London.

Huijts, N.M.A., Cees J.H. Midden, Anneloes L. Meijnders, Social acceptance of carbon dioxide storage (2007). *Energy Policy, 35* (5), 2780-2789.

IEA (2013). *Technology Roadmap. Carbon Capture and Storage.* http://www.iea.org/publications/freepublications/publication/CCS Roadmap.pdf.

IPCC (2014). Climate change 2014. In: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T., Minx, J.C. (Eds.), *Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, New York.

L'Orange Seigo, S., Wallquist, L., Dohle, S., & Siegrist, M. (2011). Communication of CCS monitoring activities may not have a reassuring effect on the public. *International Journal of Greenhouse Gas Control, 5*(6), 1674-1679.

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.

L'Orange Seigo, S., Arvai, J., Dohle, S., & Siegrist, M. (2014). Predictors of risk and benefit perception of carbon capture and storage (CCS) in regions with different stages of deployment, *International Journal of Greenhouse Gas Control, 25,* 23-32.

Lofstedt, R. (2015). Effective risk communication and CCS: The road to success in Europe. *Journal of Risk Research, 18*(6), 675-691.

Mors, E. T., Terwel, B. W., & Zaal, M. P. (2014). Can monetary compensation ease the siting of CCS projects? *Energy Procedia, 63*, 7113-7115.

Moutenet, J. P., Bédard, K., & Malo, M. (2012). Public awareness and opinion on CCS in the province of Québec, Canada. *Greenhouse Gases: Science and Technology, 2*(2), 126-135.

NETL (2009) *Best Practices for Public Outreach & Education for Carbon storage Projects. US Department of Energy.* Available from https://www.netl.doe.gov/File%20Library/Research/Carbon%20Seq/Reference%20Shelf/BPM_PublicOutreach.pdf [Accessed on 10/11/2016]

Oltra, C., Upham, P., Riesch, H., Boso, À., Brunsting, S., Dütschke, E., et al. (2012). Public responses to CO_2 storage sites: Lessons from five European cases. *Energy and Environment, 23*(2), 227-248.

Parkhill, K.A. Pidgeon, N.F. Henwood, K. L., Simmons, P. Venables, D. (2010) From the Familiar to the Extraordinary: Local Residents' Perceptions of Risk When Living With Nuclear Power in the UK, *Transactions of the Institute of British Geographers, 35*: 39–58.

Petty, R.E. & Cacioppo, J.T. (1986). *The Elaboration Likelihood Model of Persuasion*. New York, Academic Press.

Poumadère, M., Bertoldo, R., & Samadi, J. (2011). Public perceptions and governance of controversial technologies to tackle climate change: Nuclear power, carbon capture and storage, wind, and geoengineering.. *Wiley Interdisciplinary Reviews: Climate Change, 2*(5), 712-727.

RCUK (2010). *Progressing UK Energy Research for a Coherent Structure with Impact. Report of the International Panel for the RCUK Review of Energy 2010*. RCUK, Swindon. http://www.rcuk.ac.uk/documents/reviews/reviewpanelreport-pdf/. Accessed 15th August, 2017.

Roberts T, & Mander S. (2010). Assessing public perceptions of CCS: benefits, challenges and methods. In: *10th International Conference on Greenhouse Gas Technologies (GHGT),* Amsterdam.

Rogers-Hayden. T., & Pidgeon, N. (2007) Moving engagement 'upstream'? Nanotechnologies and the Royal Society and Royal Academy of Engineering's inquiry. *Public Understanding of Science 16*, 345–364.

Shackley, S., Waterman, H., Godfroij, P., Reiner, D., Anderson, J., Draxlbauer, K. & Flach, T. (2007). Stakeholder perceptions of CO_2 capture and storage in Europe: Results from a survey. *Energy Policy, 35,* 5091–5108.

Terwel, B. W., Harinck, F., Ellemers, N., & Daamen, D. D. L. (2011). Going beyond the properties of CO_2 capture and storage (CCS) technology: How trust in stakeholders affects public acceptance of CCS. *International Journal of Greenhouse Gas Control, 5*(2), 181-188.

Terwel, B. W., & Daamen, D. D. L. (2012a). Initial public reactions to carbon capture and storage (CCS): Differentiating general and local views. *Climate Policy, 12*(3), 288-300.

Terwel, B. W., ter Mors, E., & Daamen, D. D. L. (2012b). It's not only about safety: Beliefs and attitudes of 811 local residents regarding a CCS project in Barendrecht. *International Journal of Greenhouse Gas Control, 9*, 41-51.

Terwel, B. W., Mors, E. T., & Koudenburg, F. A. (2014). Effects of consultations with local residents in the process of deciding about host community compensation measures. *Energy Procedia, 63,* 7116-7118.

Upham, P., & Roberts, T. (2011a). Public perceptions of CCS: Emergent themes in pan-European focus groups and implications for communications. *International Journal of Greenhouse Gas Control, 5*(5), 1359-1367.

van Knippenberg, D. & Daamen, D.D.L. (1996). Providing information in public opinion surveys: Motivation and ability effects in the Information-and-Choice Questionnaire. *International Journal of Public Opinion Research, 8*, 70-82.

van Alphen, K., van Voorst tot Voorst, Q.,, Hekkert, M.P., & Smits, R.E.H.M. (2007). Societal acceptance of carbon capture and storage technologies, *Energy Policy, 35* (8), 4368-4380.

van Egmond, S. & Hekkert, M.P. (2012). Argument map for carbon capture and storage, *International Journal of Greenhouse Gas Control, 11,* S148-S159.

Vercelli, S., Anderlucci, J., Memoli, R., Battisti, N., Mabon, L., & Lombardi, S. (2013). Informing people about CCS: A review of social research studies. *Energy Procedia. 37*, 7464 – 7473.

Wallquist, L., Seigo, S. L., Visschers, V. H. M., & Siegrist, M. (2012a). Public acceptance of CCS system elements: A conjoint measurement. *International Journal of Greenhouse Gas Control, 6*, 77-83.

Wallquist, L., Visschers, V. H. M., Dohle, S., & Siegrist, M. (2012). The Role of Convictions and Trust for Public Protest Potential in the Case of Carbon Dioxide Capture and Storage (CCS). *Human and Ecological Risk Assessment, 18*(4), 919-932.

Whitmarsh, L. & Corner, A. (2017). Tools for a new climate conversation: A mixed-methods study of language for public engagement across the political spectrum. *Global Environmental Change, 42,* 122–135.

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,* 69-79.