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Public perceptions of CCS: Emergent themes in pan-European focus groups and implications for communications

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ABSTRACT

This paper reports on European public perceptions of carbon capture and storage (CCS) as determined through six focus groups, one held in each of the UK, the Netherlands, Poland, Germany, Belgium and Spain. The development of opinion and the emergence of concerns were observed via phased exposure to a specially commissioned film providing an overview of CCS technology, its rationale and associated debates, supplemented by additional information on national energy mixes. In general there was a high level of commonality in opinion and concerns across the six countries, with only minor differences. The concerns that emerged were not allayed by the information provided. On the contrary, there was evidence of a shift from initial uncertainty about CCS to negative positions. CCS was generally perceived as an uncertain, end-of-pipe technology that will perpetuate fossil-fuel dependence. Noting the political context to CCS, we conclude that advocates will likely find the European public opinion context a challenging one in which to achieve deployment, particularly for onshore storage, except where local communities perceive real economic or other benefits to CCS.

1. Introduction

In perhaps the most important respects, public perceptions research on CCS has been generally consistent in its findings. From the days of early work (e.g. Gough et al., 2001, 2002; Shackley et al., 2005), studies internationally have tended to find that publics are unfamiliar with CCS technology relative to other climate mitigation options, though this is changing over time; that publics tend to prefer energy efficiency, renewable energy and to some extent nuclear power over CCS; that they have specific concerns about the safety and reliability of CCS; but that despite this, if given enough information, the majority will express somewhat reluctant acceptance for CCS, principally as a bridging technology away from fossil fuels (e.g. Reiner et al., 2006; van Alphen et al., 2007; Tokushige et al., 2007; Ha-Duong et al., 2009; de Best-Waldhober et al., 2009a,b; Oltra et al., 2010; Fleishman et al., 2010). To this general picture, other studies have added detail on specific influences: for example, the role of gender in relation to risk perception by stakeholders (Stephens et al., 2009); and the way in which communication about CCS to the public may be rated as more trustworthy (though not necessarily more persuasive) when stakeholders from a variety of backgrounds are involved in communicating about CCS in collaboration rather than separately (ter Mors et al., 2009).

The reluctant acceptance of CCS has resonances in the changes in British public views of nuclear power (at least, pre-the Fukishima, tsunami-related incident in 2011), in part paralleling the growing understanding of the significance and urgency of climate change (Bickerstaff et al., 2008). Yet it is important to bear in mind that few studies, particularly in Europe, have had the opportunity to study public opinion of CCS in relation to prospective or actual CCS storage sites. Where this has been possible, trust in statutory decision-makers, developers, other actors and planning processes are key factors involved in public perceptions (Huijts et al., 2007; Desbarats et al., 2010). Despite this, Shackley et al. (2009) were surely justified in observing that efforts at understanding, engaging and communicating with the European public and wider stakeholders on CCS have been weak to date (Shackley et al., 2009).

With this in mind, the EC-funded '$NearCO_2$' project was commissioned in the period shortly prior to the funding of twelve CCS demonstration projects in Europe, in order to inform communication and engagement practice. $NearCO_2$ work has been designed with an acute awareness of the role of information framing when

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eliciting and testing public responses. For the present study, previous public perceptions work that sets CCS in the context of climate change urgency and alternative technologies is particularly relevant (e.g. Fleishman et al., 2010). More generally, the literatures on risk perception, science and technology studies, social psychology and others suggest that public perceptions of CCS are unlikely to be a special case: despite CCS having particular characteristics, public perceptions of CCS are likely to be amenable to understanding within existing conceptual frameworks. Below, we draw on such work to support the interpretation of the results of six focus groups with the public, one held in each of the UK, Belgium, the Netherlands, Germany, Spain and Poland. A summary of the results is also available (Upham and Roberts, 2011); here we add further detail on the method and results, qualitative and quantitative analysis, discussion in relation to contextual literatures and access to the materials used in the focus groups.

2. Methodology

The research method centred on focus groups with pre- and post-group questionnaires, with public responses stimulated by a DVD as described below. As a method of opinion elicitation and exploration, focus groups have the characteristics of being social and discussion-based (Morgan and Spanish, 1984). As Bryman (2001, p. 338) argues, focus groups allow the researcher to develop an understanding of why people feel the way they do. It is possible to allow "...people to probe each other's reasons for holding a certain view" and as a discussion progresses in a focus group, participants may end up talking about issues that would not have arisen in an individual interview. For this reason, focus groups are helpful for eliciting a wide variety of different views in relation to a particular issue (Bryman, 2001). Furthermore, of particular importance for the current research, focus groups provide an environment where the participants can learn and absorb new information (Bedford and Burgess, 2001).

Focus groups are not intended to provide data that is nationally representative in terms of statistical significance, but are commonly used alongside large scale surveys, where resources permit. With or without such surveys, they provide insights into participants' thinking in participants' own terms. Focus groups are susceptible to a variety of influences, particularly the interventions of the facilitator and vocal participants (Stewart et al., 2007). While this may present a problem, depending on the purpose of their use, it can also be seen as mimicking aspects of natural or everyday conversations.

Focus groups also allow responses to topics (or products) to be explored with a degree of facilitator control that can be varied to suit the research objective. The intention here was to provide the groups with identical, carefully defined information and to channel discussion along the lines of pre-defined prompts, but to allow discussion to flow within these constraints relatively freely. As such, the context was, while not a close simulation of everyday life, and certainly not as close as an ethnographic design would allow, still somewhat similar to a real-world situation in which the participants might be exposed to and discuss news or factual information about CCS. Six such focus groups were held in spring 2010 and participants were representative of national populations, not drawn from carbon storage localities (actual or planned). Table 1 lists the number of participants per group, by gender.

The primary objective was to investigate the development of opinion of CCS through the course of being exposed to new and additional information on the technology, with a further view to informing CCS-related communications strategies. A standardised prompt and information sheet was given to the facilitators to encourage common questioning, and the application of a pre- and post-focus group questionnaire was used to support further inferences on opinion and opinion change. Recruitment and facilitation was by a commercial market research firm and facilitators had no specialist environmental or CCS knowledge. This is in contrast to the main alternative facilitation method of closely moderating discussion, correcting misapprehensions and responding to participant questions with scientifically defensible information.

Table 1
Focus group participants by gender.

Country	Gender		Total
	Male	Female	
Germany	5	5	10
Poland	4	6	10
United Kingdom	5	5	10
Spain	5	4	9
Netherlands	5	4	9
Belgium	5	3	8
Total	29	27	56

Focus group participants ($n = 56$).

Central to the focus groups was a specially commissioned, multi-lingual DVD that explains CCS in the context of climate change and other energy options and which is available in six European languages. The film (available at http://www.communicationnearco2.eu/home/) is intended to be as neutral and is divided into four sections. The first outlines the problem of climate change and the growing demand for energy; the second refers to the range of options for tackling climate change, including improved energy efficiency, renewable energy sources and an introduction to CCS; the fourth sections looks at CCS in more depth and outlines associated debates. The 'CCS story' thus builds progressively through the film, to elicit a phased response and to enable the influence of additional information to be observed. Responses were also sought to supplementary textual and graphical information provided after the DVD, specific to the nationality of each focus group, explaining why it will be difficult to avoid the use of CCS in Europe even with a major expansion of renewable and energy efficiency. In addition to the focus groups, the participants were asked to complete a questionnaire before and after the discussions, with questions intended to aid observation of the evolution of opinion and identify differences and commonalities between the groups.

The research generated a large amount of both quantitative data from the questionnaires and qualitative data from the focus group discussions. The data from the questionnaires was input to SPSS (statistical analysis software) to produce descriptive statistics, which were used to provide an overview of how the participants' perspectives changed as a result of their focus group discussion. These trends were then used as the starting point for the qualitative data analysis.

Analysis of qualitative data can be problematic and often uses less structured processes than those used by quantitative researchers. Consequently the qualitative research software *AtlasTI* was used as an aid. Such software provides a useful tool for the systematic analysis of data and allows the researcher to assign codes to segments of text; these codes can then be grouped, annotated and linked together to investigate and develop lines of argument. The pre- and post-questionnaire results need to be interpreted cautiously and in context. Some of what we observed, particularly differences between nationalities, may be specific to the particular location or respondents involved. Indeed the results of the study as a whole are not intended to represent the opinions of the whole population. Studies with small numbers of participants exchange the higher certainty and replicability obtainable with large scale, controlled studies, for more detailed information on the variety of possibilities. In other words, while large scale controlled studies

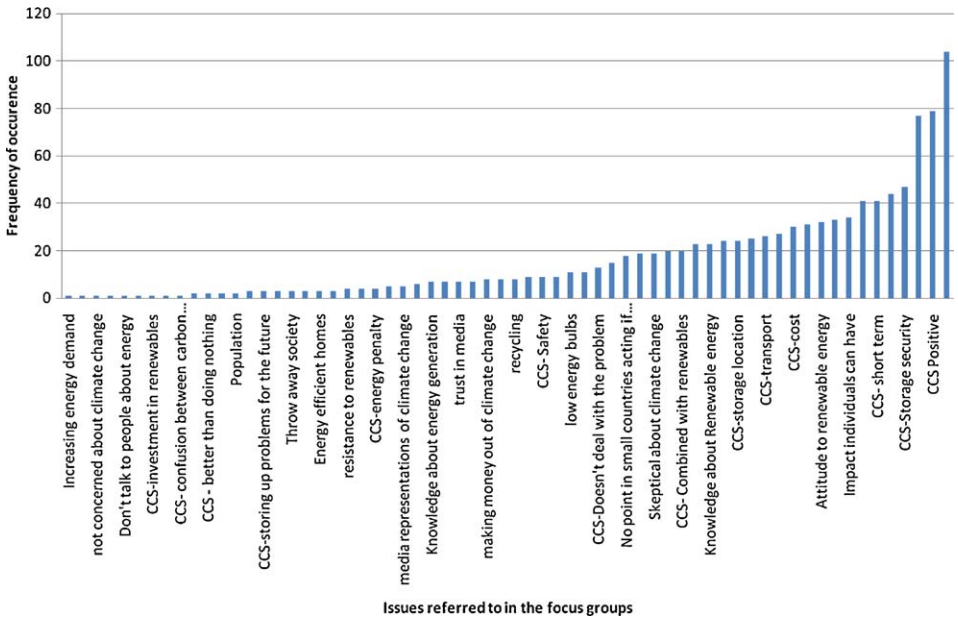

Fig. 1. Semi-prompted CCS discussion themes by frequency (all groups).

provide replicability when repeated under very similar conditions (which may not always pertain in the 'real-world'), qualitative studies provide an indication of the types of issues and responses that a topic may elicits – responses that may vary somewhat from group to group.

3. Results

3.1. Perception of information quality

The level and quantity of information provided to the participants reflected the constraints of the research design (time, expectation that participants would know little about CCS, the intention to expose participants to contextual as well as CCS-related information in stages, so that the evolution of opinion could be observed). In addition it was important that the information was presented in a manner that permitted lines of discussion to evolve without close moderation, in order to simulate real-world conditions of people being exposed to information on CCS and then discussing it with non-experts. The information was intended to be as neutral as possible, in the sense of being consistent with majority scientific opinion. In this regard, IPCC was used as a benchmark source: anthropogenic climate change is treated as conclusive, a wide range of lower carbon energy options are seen as likely to be helpful in avoiding 'dangerous climate change' and CCS is seen as having considerable potential in this regard, while at the same time being associated with a variety of non-trivial uncertainties (IPCC, 2005, 2007).

While the questionnaire ratings indicated that participants were generally positive about the quality of the information provided, it was also clear that most felt that they would need a lot more information, probably from a wider range of sources, before they felt able to make a firm decision on CCS. This is highlighted in Table 2 and was not unexpected, being consistent with the findings of previous research. Providing sufficient information would be possible but would require a different research design (e.g. citizens' panels or a detailed information choice questionnaire). In short, participants considered the information of good quality but insufficient in and of itself to help in coming to a firm conclusion.

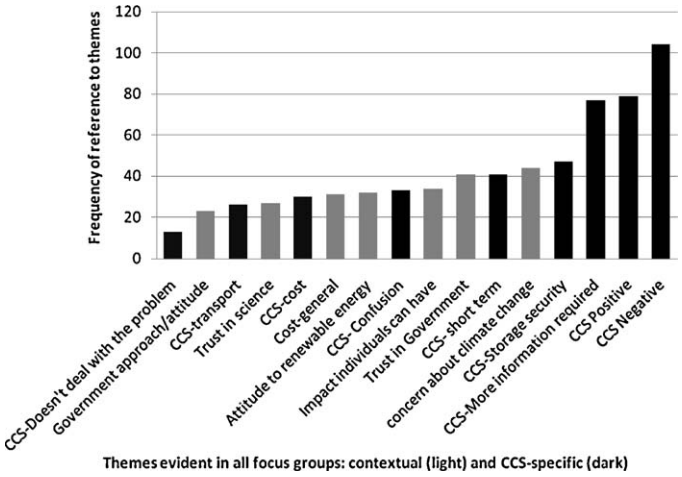

Fig. 2. Frequency of topics referred to in all groups: contextual and CCS-specific.

3.2. Themes evident in the discussions

A broad range of themes emerged in the discussions; their frequency of occurrence, as identified via the coding process, is shown in Fig. 1. Whereas Fig. 1 shows all themes, regardless of whether they were mentioned in only some of the groups, Fig. 2 shows only those themes that were raised in all of the groups. Fig. 3 then shows

Table 2
Focus group participants' perceptions of the information provided.

	Agree (%)	Neutral (%)	Disagree (%)
The information was neutral and balanced	71	21	8
The information was clear	77	18	5
The information was appropriate	73	22	5
The information was misleading	14	50	36
The information was insufficient	74	13	13

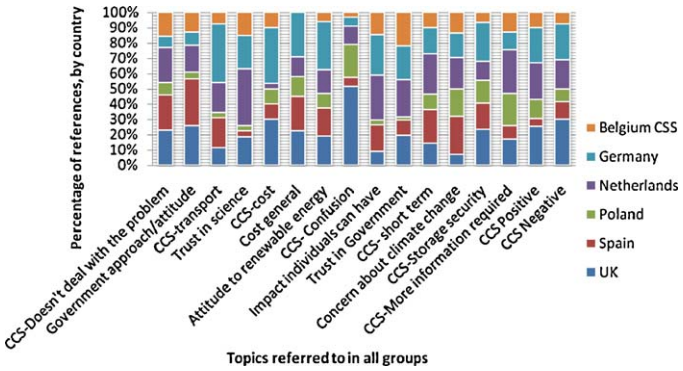

Fig. 3. Relative contribution of each focus group to topic reference frequency.

the relative contribution of each group to those shared themes. Notable observations include: some 50% of the 'confusion' references are in the UK group; some 35% of the CCS cost references are in the German group; the small percentage of positive CCS references in the Spanish group; the small percentage of trust in government, government approach and individual self-efficacy (impact) references in the Polish group; and the relatively large number of trust in science references in the Netherlands group.

3.3. Notable contextual themes

3.3.1. General acceptance of climate change

With the exception of the Netherlands (40%, for which there is no obvious explanation), 70–100% of the participants stated that they were concerned about climate change in the pre-focus group questionnaire and this was also reflected in the focus group discussions. The discussions about climate change in the Netherlands group centred on the 'climate-gate' debacle that emerged just before the UN COP-15 climate change conference in Copenhagen (for scientific discussion, see e.g. Heffernan, 2010). It was clear that a number of the participants had been heavily influenced by the associated debates evident in the news media.

The participants in the Spanish focus group appeared particularly concerned about the impacts of climate change and repeatedly referred to the hot summers that they had experienced recently and the increasingly regular water shortages. Across all the focus groups much of the discussions about climate change focused around the scale of the problem. In particular, many of the respondents felt that there was very little they could do as individuals or even as individual countries to tackle climate change. In the majority of the focus groups, except Poland, the participants continually commented that they felt there was little point in 'us' taking action as countries such as China, India and the USA are unlikely to pull their weight.

3.3.2. The high salience of energy cost

According to the results of the pre-workshop questionnaire, with the exception of Spain, the most important factor in determining which electricity production methods should be used was 'cost' (the Spanish participants considered helping to prevent climate change the most important). Indeed, participants in the UK, Germany and Poland thought that the costs associated with CCS were a major disadvantage of the technology. The Polish focus group was particularly concerned about cost: participants strongly felt that Poland was still a relatively poor country compared to some other European nations and did not have sufficient financial resources to invest in new energy technologies. Indeed, the strongly held view across all of the groups was that the financial resource for new energy technologies is limited and that it would be better if this was invested in renewables than in CCS.

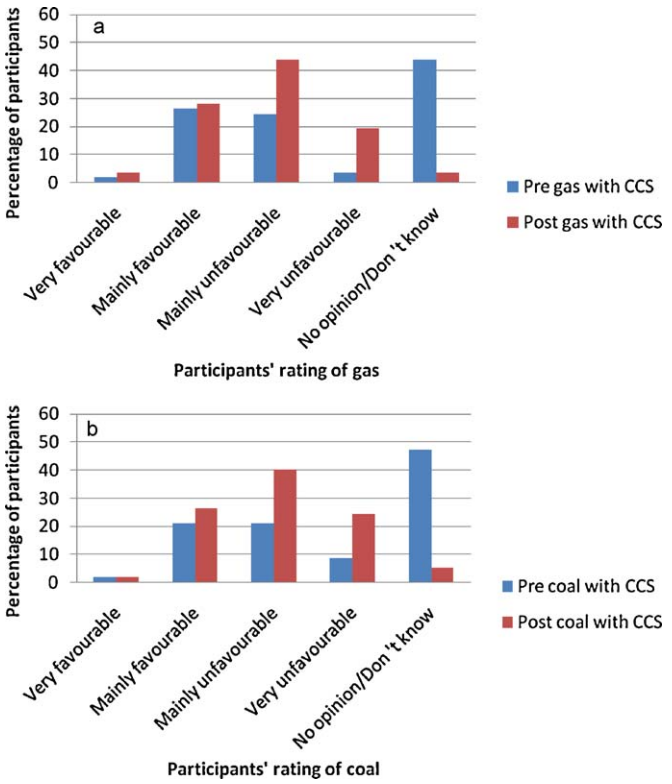

Fig. 4. (a) Gas CCS: a shift from undecided to negative opinion after film and discussion. (b) Coal CCS: a shift from undecided to negative opinion after film and discussion.

There was, moreover, a general consensus that new low carbon energy technologies will be expensive and in general people were unhappy about the prospects of higher energy bills. The Polish participants were particularly concerned about rising costs and pointed out that many people in Poland were already struggling to pay their energy bills. More specifically participants in all countries were concerned that the financial risks associated with CCS were significantly greater than with renewable technologies. Participants in the German and Belgian groups were concerned that if we invest in CCS now, we would still have to invest in renewables in the future. Hence there was a general feeling that in the long run it would be cheaper to invest in renewables now. Furthermore, participants from the UK and Germany were worried about the long term costs of monitoring the stored CO_2. These debates about cost led to further discussions about who should pay for new technologies; there was consensus that if CCS was to be deployed, the bill should be predominately met by the power companies. However, the participants were equally sceptical that this would be the case and considered that CCS would inevitably lead to higher energy bills.

3.3.3. Use of technology analogues

Participants' general lack of knowledge of CCS led many of them to use more familiar energy technologies as reference points, and these differed according to the local contexts. In the UK, Spain, Netherlands, Poland and Germany a direct comparison was made between the storage of nuclear waste and the storage of CO_2. The Chernobyl nuclear power station disaster was quoted numerous times in Poland, Belgium and the UK. In Poland the participants appeared to be particularly nervous about nuclear waste, as Poland was considered as having suffered particularly from the Chernobyl disaster. These fears about nuclear waste appeared to transcend to the disposal of other waste products from power generation,

providing further evidence to support the argument that many of the participants failed to properly understand the nature of CO_2. In contrast, a number of the participants from the UK argued that when people discuss nuclear power they automatically consider it to be dangerous because of Chernobyl. However, they went on to conclude that it was actually a relatively safe method of power generation and gave several examples, including Sellafield and Dungeness nuclear power stations in the UK, which they felt had good safety records. This line of discussion eventually led some of the participants to argue that if the technology was in place to safely operate a nuclear power station, then CCS should also be able to operate safely.

In Belgium, Germany and the UK, the examples of natural gas storage and transport were referred to by the participants in their efforts to understand CCS. In the UK and Germany there was a general feeling that if natural gas could be stored safely and transported to people's homes, then the same should be possible with CO_2. However, in Belgium, the Ghilenghien gas pipe explosion which killed 24 in 2004 was used as an example of how dangerous gas pipelines could be.

3.3.4. Perceptions of CCS risks

As observed above, risk perception has become a key area of interest in understanding public perceptions of CCS. The NearCO_2 focus group participants were concerned about a wide range of risks associated with the technology, but these may be classified into three groups: physical risks (i.e. concerns about safety), financial risks and governance risks (i.e. concerns about the way the technology will be managed). While there were some differences in the ways that the participants conceptualised risks relating to CCS across the six countries, the commonalities were more evident.

In terms of physical risks, participants in all of the focus groups were most concerned about the storage aspect of the CCS chain. In total, concerns about the risks involved with storing CO_2 were raised 58 times across all of the focus groups, compared to 24 times for transport and 3 times for the process of capturing CO_2. In particular, there was a general consensus that it would be impossible to guarantee that the CO_2 would not leak out and that there is a danger that storing CO_2 could lead to significant problems for future generations. Many of the conversations focused on the potential impact of any leakage and were in a large part fuelled by the confusion about the nature of CO_2 identified above; a number of the participants appeared to think that CO_2 is highly flammable and/or explosive. In Poland and the UK specific concerns were also raised about the impact of future tectonic movement on stored CO_2. These concerns about the dangers of CO_2 leakage prompted extensive discussions about suitable locations for CO_2 storage. While the majority of participants were unhappy about any form of storage and particularly storage near their homes, others felt that providing appropriate risk assessments were conducted, it might be acceptable to store CO_2 offshore (in geological formations – deep-sea storage was not referred to in the DVD, nor raised by participants). The post-focus group questionnaire revealed that 53% of the participants would be more accepting of offshore storage than storage on land. There was an interesting debate between participants in both the Polish and Dutch focus groups, with some arguing that they felt storing CO_2 offshore would be a safe short term solution while others argued that 'dumping' waste at sea was dangerous, as we do not know enough about the marine environment to predict the impact of leakage.

3.3.5. Trust issues

The risks associated with the governance of CCS also provoked a high level of debate and is likely to represent a major challenge for future public acceptability. The focus group data indicated that many of the participants trusted neither government nor industry to manage CCS objectively and safely, and according to the post-focus group questionnaire, only 25% of respondents said that they trusted either government or industry in relation to CCS. There was a general sense across all of the focus groups that both industry and government have predominantly economic and financial priorities and that they are less concerned about whether CCS represents the best solution to the CO_2 problem. Scientists were regarded as a more reliable source of independent information on CCS, but there was concern that governments and industry were unlikely to act on scientific advice if it went against their interests. It was felt that governments were under a huge amount of pressure from oil industry lobbyists to find ways to extend our reliance on fossil fuels. Furthermore, a number of people from the UK and Spain commented that when it comes to environmental issues, governments seem unable to either make or keep to international agreements. This led to a number of people arguing that there would be no point in a few countries developing expensive CCS projects without some kind of guarantee that high absolute emitters such as the USA, India and China would also implement the technology. However, participants from Belgium argued that CCS was plausible across Europe, providing sufficient leadership was given by the European Union.

3.4. Attitude change in response to information exposure

While the account provided of CCS was scientifically defensible, it was anticipated that the focus group participants would bring their own frames of reference to the issues and that they would likely raise a variety of concerns. What was not known was how these responses would develop through the course of being provided with an increasing level of information, how these responses might differ between national groups, or how initial perceptions might shift in response to information exposure. Table 3 categorises the issues raised in response to particular film stages and discussion topics. All are potentially disruptive to CCS implementation and may well be raised by the public as issues in other CCS-related fora.

The pre-questionnaire provided an indication of the contextual environmental attitudes of the participants: more people said they were concerned than not concerned about a wide range of environmental issues, such as: acid rain; air pollution; climate change; deforestation; household waste disposal; species extinction; and the use of non-renewable resources. Participants viewed renewable energy (bioenergy, solar, wind, wave, tidal and hydroelectricity) more favourably than coal and nuclear. The majority viewed natural gas as mainly favourable.

Comparing the pre- and post-focus group questionnaires shows that 45% of the participants remained consistent in their attitude towards climate change, agreeing with the statement that 'the risks of climate change far outweigh the benefits'. However, after the focus groups, a sizeable minority – 29%, including nine more individuals than before the groups – either agreed with the statement that 'the benefits of climate change either equalled the risks of climate change', or agreed with the statement that 'the benefits of climate change exceeded the risks'. In other words, for a sizeable minority there was not only a persistent disbelief in the insignificance of climate change, but a shift in that direction.

Secondly, there was also an aggregate pre-post shift from no opinion/do not know to negative opinion for attitudes to both gas CCS and coal CCS: see Fig. 4a and b. After the discussion, while the percentage of people who were 'mainly favourable' in their attitude to coal and gas CCS maintained this attitude before and after the discussion, most of those in the no opinion/do not know category shifted to a 'mainly unfavourable' and a 'very unfavourable' stance.

Before the focus groups, opinion was fairly evenly split between unfavourable and favourable attitudes for coal CCS and gas CCS, with a large no opinion/do not know response for both. There was

Table 3
Themes potentially disruptive to CCS implementation, elicited in response to five sequential aspects of a CCS rationale.

1. Climate change	2. Energy options	3. Description of CCS	4. CCS debates	5. Energy mix detail
• Uncertainty over whether climate change is happening or natural	• Nuclear power as less polluting than CCS	• Low confidence in the integrity of CO_2 storage	• Doubts about the credibility of the EC as an information source	• CCS as a distraction from the need to advance renewable energy
• Doubts over IPCC's credibility	• Renewable energy as less polluting than CCS	• Earth movements may release stored CO_2	• CCS as a distraction from the need to advance renewable energy and pro-climate action	• Uncertainty over whether climate change is happening or natural
• Perception of limited self-and national-efficacy and responsibility	• Politicians leading affluent, high-emission lives	• 1 km storage depth is not deep enough (susceptible to Earth movements and too close to people)	• Distrust of the political motives of the oil industry	• Inequity in the international distribution of climate mitigation costs
• Difficulty in relating climate change to everyday lives		• Stored CO_2 as a potential soil pollutant		• Stored, pressurized CO_2 as potentially explosive/susceptible to leakage
		• Stored, pressurized CO_2 as potentially explosive/susceptible to leakage		• Not enough information on the pros and cons of CCS relative to alternatives
		• CCS as a short term solution		• CCS unproven
		• CCS unproven		• Perception of limited self-and national-efficacy
		• CCS as end-of-pipe		
		• More information needed on CCS risks		
		• Mistrust that CCS would be for bridging only		
		• The advantages relative to renewable are unclear		
		• Distrust of commercial motives of power suppliers		

Note: not all themes were evident in all groups.

no corresponding pre/post change for the several renewables and the pre/post change for nuclear (Fig. 5) was the reverse of that for CCS: the aggregate level of undecided nuclear opinion shifted to an increase in the number of those favourably disposed to nuclear. It is also notable that, of the range of energy options, coal and nuclear elicited the most evenly divided opinion: whereas a sizeable majority were in favour of other options, opinion was fairly evenly split on coal and nuclear, though bio-CCS (Fig. 6) elicited a very large no opinion/do not know response of 58% and post-focus group opinion shifted to the negative from an initial no opinion/do not know position. This was more likely through the association with CCS than through any considered understanding of bio-CCS.

Prior to watching the DVD, participant's attitudes to CCS were largely consistent across all of the countries. People were clearly interested in the potential of the technology but concerned about the risks involved, particularly related to the long term storage of CO_2. As the discussions about CCS developed and more information was provided, opinions on CCS started to become more diverse between the six countries. However, the general concern that participants did not have enough information to make a decision remained constant across all the focus groups. Participants from the UK and Netherlands were most supportive of the technology, but this was conditional on it being a short term option for reducing emissions while renewable technologies were developed. Participants from the remaining four focus groups appeared to become more negative and confused about the technology as they were provided with information. In Germany, Spain, Poland and Belgium, the participants repeatedly asked questions suggesting that they understood CO_2 to be flammable, explosive and toxic (e.g. 'What happens if it explodes?' 'Will it pollute the earth's core?'). These confusions stimulated further conversations that went on to dominate much of the discussions, emphasising the problem of information management in real world settings – a problem that controlled questionnaire surveys generally cannot reflect.

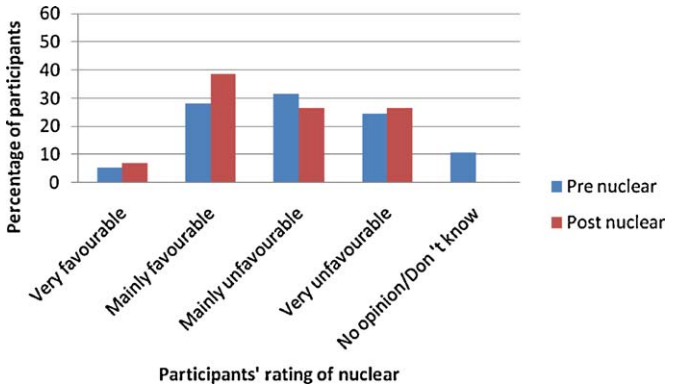

Fig. 5. Nuclear power: a shift from undecided/negative to positive opinion after film and discussion.

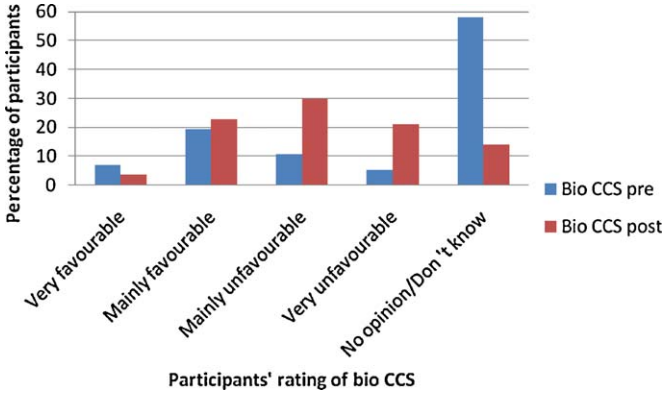

Fig. 6. Biomass CCS: a shift from undecided to negative opinion after film and discussion.

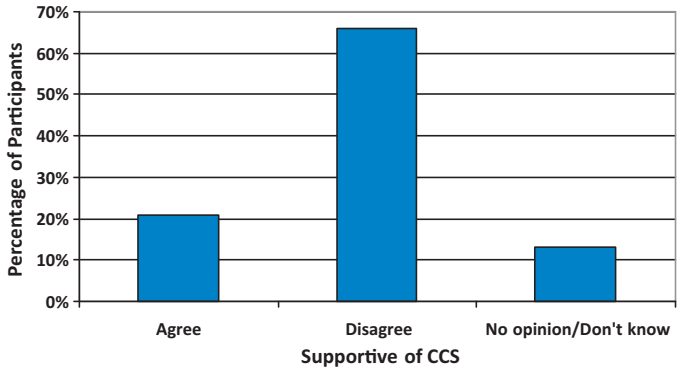

Fig. 7. Post-focus group level of support for CCS.

3.5. Post-focus group opinion on CCS

The more detailed post-focus group questions on CCS reflected the qualitatively expressed views, concerns, uncertainty and occasional contradiction. An example of the latter can be seen when comparing the level of post-focus group support for CCS (Fig. 7) with opinion on whether CCS should be included in National Energy Policy (Fig. 8). While over 60% of the participants did not support CCS, over 50% considered that CCS should be included in national energy policy. Furthermore, while 56% of participants agreed with the statement: 'I think that our government would not allow CCS to go ahead if they thought that the risk of substantial leakage was high' (though a sizeable 27% were neutral), 80% agreed with the statement: 'if I lived near a carbon dioxide storage site, I'd be very concerned about leakage', with only 10% neutral on this.

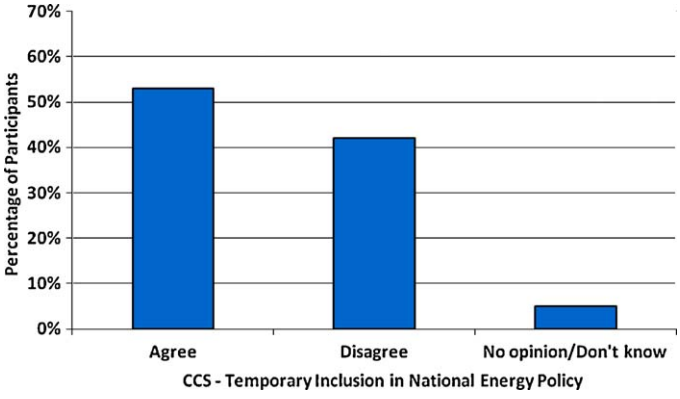

Fig. 8. Post-focus group support for temporary inclusion of CCS in national energy policy.

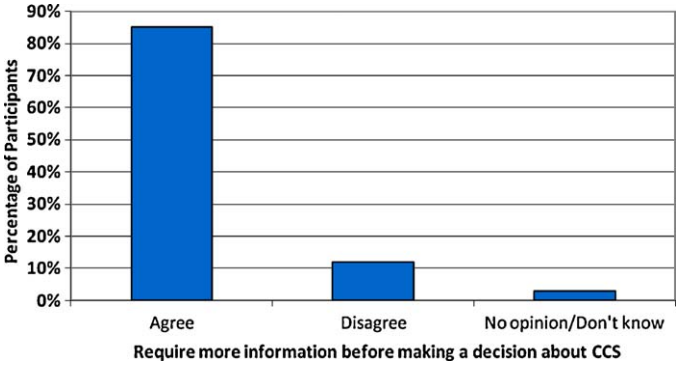

Fig. 9. Post-focus group percentage wanting more information about CCS.

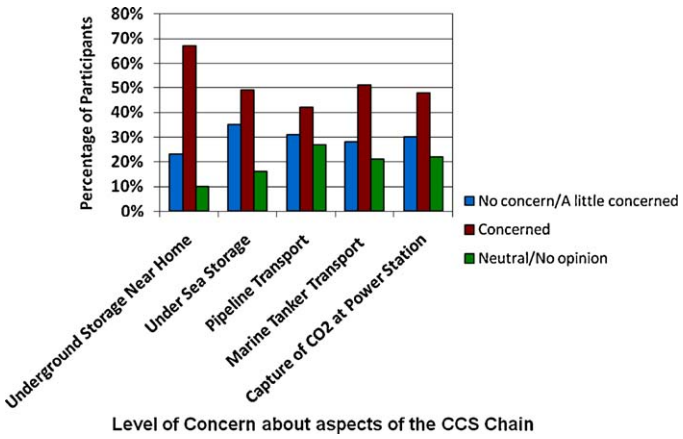

Fig. 10. Level of concern differentiated by stage in the CCS chain.

As Fig. 9 shows, the participants were less equivocal about the need for more information, a finding that is likely to explain some of the contradictions in the data. It is clear that by the end of the focus group, many of the participants were left with unanswered questions about CCS technology and the way it would be implemented. Fig. 10 shows that although the participants had concerns about all aspects of the CCS chain, concerns about storage were the most prominent; this was also reflected in the qualitative findings. It also shows that the participants were less concerned about undersea storage than storage under a residential area.

The post-focus group questionnaire supported one of the key messages from the focus groups, namely that there is a lack of trust in the institutions that would be tasked with implementing and monitoring CCS. Only 25% of the participants agreed with the statement: 'I think that our government can be relied upon to monitor and manage carbon dioxide storage in the long term', with 36% being neutral on this and 39% disagreeing. Trust in industry's capability was similarly low, with some 27% agreeing that 'industry can be relied upon to monitor and manage carbon dioxide storage in the long term', with 38% neutral and 36% disagreeing.

A final question on attitudes to CCS then asked for an overall rating of the technology on a scale of 1–10, where 1 was the worst rating and 10 the best rating. The response approximated a normal distribution, with a mode of 3, a median of 4.5 and a mean of 4.58. While open to alternative interpretations, we would suggest that this pattern indicates a high level of uncertainty among the participants. Only a third considered that the focus group had provided them with enough information to decide whether CCS should be used within Europe (32% yes, 68% no). Cross-tabulation shows no strongly positive or negative association between participants considering that they had been given enough, or not enough information, and their rating of CCS. Rather, considering that not enough information had been given was associated with rating CCS in the relatively large range of 3–7 out of 10, i.e. either side of the mean. This may be again interpreted as a state of open-mindedness or uncertainty, compared to having come to a firm conclusion.

4. Discussion

To some extent, we can interpret the rather negative public opinion of CCS as consistent with the 'risk society' thesis, which posits that society has become pre-occupied with the future and with risk (Giddens, 1999). As Beck and Kropp (2007) note, it has now become almost trivial to state that risk is a social construction. Yet it would be wrong to imply that the low level of approval of CCS found in the six focus groups is simply culturally determined, in the sense of being a reflection of a time in which risk concern has

become exaggerated. Not only are there 'real' geological uncertainties – real in the sense of being scientifically-informed – but the public in-principle preference for renewable energy is a legitimate one. An example of such a geological uncertainty is the extent of CO_2 water solubility (Gilfillan et al., 2009), which potentially has substantial implications for CO_2 leakage and permanence under particular conditions. Similarly, public distrust of the power sector and EC policymakers could be considered to have some justification via the over-supply of emissions credits under the EU Emissions Trading Scheme and consequent windfall profits that have accrued to emitters. A Point Carbon estimate for WWF judges this profit to be in the region of 23–63 billion euros for the second allocation period (Point Carbon, 2008). Other, site-specific reasons for objection may relate to more than perception of risk alone: reviewing public participation procedures in CCS and analogous non-CCS proposals in Europe, Desbarats et al. (2010) note that while public opposition in Barendrecht did relate to perceptions of risk, it also related to other perceptions, such as over-industrialisation of the locality.

Nonetheless, Europe undoubtedly faces very significant energy and climate change challenges. It will need to replace half of its power stations by 2020 (or install alternative generation capacity), even assuming energy efficiency improvements are made across the economy (Market Observatory for Energy, 2008). Even with a major increase in renewable energy generation, plus new nuclear power plants, it is unlikely that Europe could avoid building at least some new power plants that use either coal or gas in the next 10 years. Similarly, although global energy scenarios from a variety of sources envisage differing supply mixes and levels of energy efficiency, coal and gas remain unavoidably prominent in all major scenarios for several decades to come (Luukkanen et al., 2009).

Given this, public objection to CCS in principle and on the ground may appear unreasonable and uninformed. Yet the disjunction between reality and the publicly perceived ideal of a largely and immediately renewable future can be viewed as partly a consequence of the substantially delayed timing of the policy response. Why is it that renewable energy has been seriously incentivised so late, relative to the EC aspiration of not exceeding a global surface temperature increase of 2 °C? We do not seek to answer this question here, but it should not be surprising to find public opinion lagging behind climate and energy supply issues to which policy has only belatedly and recently begun to respond itself. Rather than acting early and allowing time for the renewable sector to gradually replace at least the fossil fuelled power sector, energy policy-makers now face a variety of immediate and conflicting environmental and commercial pressures, in addition to public opinion that has significant doubts about CCS.

The result is a challenging environment for those tasked with convincing and delivering on new energy technologies, particularly where there are non-negligible scientific uncertainties. In terms of public communication and engagement in the broad sense, the situation requires that the case for CCS is successfully made in a short space of time at more than one level. That is, not only with respect to uncertainties relating to leakage risk and associated public concern, but also in relation to NGO and others' scepticism of CCS acting to intentionally or unintentionally extend fossil fuel lock-in. In particular the case for coal CCS presents a wealth of difficulties (Vergragt, 2009), as the life cycle energy penalty of CCS currently renders it little better in terms of CO_2 emissions than the best available existing fossil fuel technology (advanced gas-fired combined heat and power) (Viebahn et al., 2007).

In these respects, CCS advocates and developers in Europe may face political contexts similar to those experienced by advocates of other large infrastructure projects in which alliances of national NGOs, local citizens and mobile eco-protestors challenge national policy (e.g. airport expansion, nuclear power or waste facility siting). In this scenario, local siting proposals are used to challenge national policy in the absence of other fora for debate (Owens, 2001). On the other hand, there are a number of factors, options and associated perceptions that may mitigate against a similar situation, their significance likely varying by country and location: the option of offshore geological storage; the urgency of climate change; the ambivalence of some environmental NGOs with respect to CCS, particularly regarding its ability to substitute for nuclear power; and perceptions of the economic and employment value of CCS through its supply chain (e.g. Scottish Government and Scottish Enterprise, 2010). Nonetheless, while the chances of uncomplicated deployment of CCS throughout Europe are not high, in general the context should be characterised as difficult and sensitive rather than impossible.

5. Conclusions

Overall, the NearCO_2 focus groups confirm many of the key findings of previous qualitative studies of CCS perceptions in Europe. That is, the general public are relatively unfamiliar with CCS; have a preference for renewable energy over CCS; have significant concern relating to the risks involved with storing CO_2; and lack trust in government and industry to make the right decisions in this context. In terms of international comparison and the influence of contextual issues, the difference in opinion between countries was minimal and many of the same issues occurred in all of the groups. All of the issues raised pose potential problems for deploying CCS and many will not be straightforward to resolve. Given also the political and policy context of public concern, we conclude that there are likely to be substantial challenges to the deployment of what is becoming a controversial emissions mitigation option.

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