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Initial Public Perceptions of Carbon Sequestration:

Implications for engagement and environmental risk communication strategies

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Abstract

Despite widespread scientific acceptance, little is known about how the public perceives carbon capture and storage (CCS) technology designed to reduce greenhouse gas emissions by capturing and storing carbon dioxide in underground sites. Thus, through an online survey (n=1273), this study investigated Australians' knowledge and perceptions of CCS. Most believed it was important for Australia to reduce carbon emissions, yet only 18% had previously heard of CCS and only 5% closely followed the greenhouse debate. People were keen to participate in public discussions and learn more before forming a definite opinion, although many had "not-in-my-backyard" reactions and raised concerns about the risks and effectiveness of the technology and the trustworthiness of organisations. By highlighting current perceptions and knowledge about CCS, this research informs environmental risk communication strategies and emphasises the importance of early engagement, education and partnerships between stakeholders for fostering informed decision-making about its use in the Australian context.

Introduction

There is general consensus amongst the scientific community that "climate change from the accelerating build-up of greenhouse gases in the atmosphere is the most substantial threat this century to our future" (The Premier's Round Table on Sustainability 2004, 4). Despite this, the general public tends to underestimate the magnitude and impact of the greenhouse problem, understanding neither the causes nor consequences of global warming (Curry, Reiner, Ansolabehere & Herzog 2004). Indeed, the Intergovernmental Panel on Climate Change warns that our fossil-fuel driven lifestyles mean the rate of carbon dioxide in the atmosphere is the highest it has been for the past 420,000 years (IPCC 2001). However, research repeatedly demonstrates that people believe that the effects of global environmental problems are not their responsibility, are out of their control and will not eventuate within their lifetime (Beck 1992; Bush, Moffatt & Dunn 2002; Sterman & Sweeney 2002).

The lack of public recognition of the greenhouse problem, and the continued reliance on fossil fuels for power generation and transport, has encouraged the development of post-production solutions which remove carbon from the atmosphere. An increasingly popular option to achieve substantial reductions in greenhouse gas emissions is underground carbon sequestration or carbon capture and storage (CCS). CCS involves capturing carbon dioxide and securely storing it long-term in pre-determined underground sites, such as depleted oil and gas reservoirs or saline aquifers under the sea-bed (IPCC 2005). For many, CCS presents "one of the earliest acceptable options available, and based on scientific evaluation is likely to be considered the most technologically sound, environmentally responsible and economically attractive" (Bradshaw, Bradshaw, Allinson, Rigg, Nguyen & Spencer 2002, 25). CCS, which does not rely on extensive

behaviour modification from governments, industry or consumers, is generally viewed as an ideal "bridging option" – a means to immediately minimise the impact of greenhouse gases on the atmosphere whilst alternative energy technologies are developed (Australian Greenhouse Office 2003) or new societal norms in energy demand reduction emerge (Department of Environment Food and Rural Affairs (DEFRA) 2005; Herzog 2001).

Currently, there are over 10 trial CCS sites in operation worldwide, including the North Sea, USA, Canada, Japan, China, Poland and Australia (IPCC 2005; IEA 2004). Australia, due to its geological suitability (PESA News 2005), is viewed as an ideal site for CCS with the Federal Government actually naming geosequestration as a national research priority (Fyfe 2004). There are two trial CCS sites in Australia: the Gorgon project in Barrow Island, Western Australia, expected to start in 2009, and the Otway project in south-west Victoria which is currently underway (IPCC 2005; Carbon Sequestration Leadership Forum 2005). Thus, it is timely to explore public perceptions and the acceptability of CCS in Australia. This exploratory study investigates contemporary public perceptions of carbon sequestration in a large convenience sample of Australians (n=1273). Using the Public Acceptability of Controversial Technologies (PACT) framework as a conceptual guide, this study focussed on three issues that are likely to influence the public acceptance of the use of CCS in Australia: (1) the personal relevance of the greenhouse gas problem and CCS, including the willingness to be involved in public debates about greenhouse gas emissions; (2) current knowledge of proposed carbon sequestration technologies; and (3) the degree of trust in various organisations to provide truthful information about carbon sequestration. The findings are discussed in terms of their implications for the development of engagement and environmental risk communication strategies.

The greenhouse effect and carbon sequestration

The United Nations Economic and Social Council have emphasised the importance of public engagement and acceptance for CCS, acknowledging that "the viability of carbon sequestration as a tool to mitigate greenhouse gas emissions is largely dependent on public and policy acceptance and to achieve this will require early engagement through open and public dialogue" (2002, 9). Unfortunately, engaging the public in an informed debate on the potentially controversial issue of carbon sequestration is difficult as the greenhouse problem is a highly scientific and intangible global environmental challenge and the proposed CCS solution has risks but no easily "visible" benefits. Moreover, with Slovic (2000) arguing that perceived risk is influenced by the imaginability of a hazard, in the context of CCS, the possibility (no matter how remote) of an explosion at a CCS site is infinitely more imaginable than the status quo of continuing greenhouse gas emissions with no immediately visible consequences. Indeed, the general public may already be aware of one naturally-occurring fatal example of rapid carbon dioxide leakage from Lake Nyos, Cameroon in 1986, where a natural mass carbon dioxide leakage from a lake asphyxiated all living things within a 25km radius and killed 1700 people (van den Nieuwenhof 2005). The potential risks of CCS, which include slow leaks or rapid escape of carbon dioxide, the acidification of water, structural changes in geological formations and possible terrorist targeting (IPCC 2005; Smekens & van der Zwaan 2004), ensures there will be strong public interest and debate about the acceptability of CCS technologies.

Already, the need for effective engagement and risk communication strategies about CCS has been clearly demonstrated at an experimental ocean carbon sequestration site in Hawaii, run jointly in 1998 by governmental representatives from the United States, Japan and Norway (de Figueiredo, Reiner & Herzog 2002). Despite intentions of a public outreach campaign, no campaign had been launched until a newspaper article announced "*Feds to Test Impact of Dumping CO2 into Kona Waters"*. The public, feeling excluded and opposed to the technology for

various reasons, including the cultural importance of the ocean, impacts on fishing and tourism, NIMBY ("not-in-my-backyard") concerns, distrust of scientists and international organisations involved, ensured the site was closed (de Figueiredo et al. 2002). Whilst the experiences at the Hawaii site emphasise the importance of public engagement, to date, the literature on public knowledge, understanding and acceptability of CCS as a solution to the greenhouse problem is extremely limited, with researchers generally focussing on the technical, economic or environmental aspects (Bradshaw et al. 2002; Working Party on Fossil Fuels 2003; Smekens & van der Zwaan 2004; IEA 2004). Very few researchers have investigated public perceptions of carbon sequestration, in part because CCS is in the very early stages of development and is currently remote from most people's concerns (Shackley, McLachlan & Gough 2004). Using a qualitative approach and convenient sampling, Gough, Taylor & Shackley (2002) conducted two focus groups to investigate the public opinion of carbon sequestration in Britain. Most participants were not opposed to the technology, particularly when they balanced it against the greater risk of climate change, although concerns about trust, regulation, ownership and risk of leakage were common. Similarly, utilising citizens panels and an intercept survey at Liverpool airport, Shackley, McLachlan and Gough (2005) found that most people were neutral on the issue of CCS, yet when provided with limited information were generally supportive of the technology. This is reinforced by a handful of studies from the annual International Conference on Greenhouse Gas Control Technologies which show that although people have not initially heard of CCS, and raise concerns about risk and NIMBY, providing detailed information generally eased fears (Curry et al. 2004; Itaoka, Saito & Akai 2004; Uno, Mori, Tokushige & Furukawa 2004).

Environmental risk communication

Communicating with the public about CCS technology will be a particularly challenging undertaking, for several inter-related reasons. First, environmental risk communication is difficult

as people often fail to understand how their actions, choices and behaviours contribute to global environmental problems. Meijnders, Midden and Wilke (2001) emphasise that unlike health risk communication, which can utilise personal health threats to motivate people to stop smoking or use condoms, the distance in time and space of the greenhouse problem means people are less personally involved and concerned about the environmental threat of climate change. Second, with environmental risk "localised in the sphere of physical and chemical formulas" (Beck cited in Lupton 1999, 21), the scientific complexity of global environmental problems makes understanding and contributing to the debate difficult for a public with limited maths, science and systems thinking knowledge (Sterman & Sweeney 2002).

Interestingly, despite extensive research identifying key factors in risk assessment and acceptance, there is only one conceptual framework that specifically guides risk communication and interactions in the context of novel scientific technologies. Developed by Wolfe, Bjornstad, Russell and Kerchner (2002), the Public Acceptability of Controversial Technologies (PACT) framework posits that the acceptability continuum or willingness to consider the technology is determined through dialogue, which consists of three key stages: participant's initial position on the technology; the dialogue process and, finally, their ultimate decision about the technology. Three key dimensions are said to influence participants position and movement along this acceptability continuum: the constituent dimension (i.e., the values, motivations, strategies, personal gain or loss of participating groups); the technology dimension (i.e., potential harm, predictability and comparative risk attributes of the technology) and the context dimension (i.e., the physical, social and institutional setting in which the technology is used). Unfortunately, whilst the PACT offers a useful way to conceptualise public perceptions and predict public acceptability of CCS, it is currently being empirically tested and there are no specific guidelines about which questions should be included in a quantitative survey (Wolfe et al. 2002). Nevertheless, PACT

offers a useful conceptual framework through which to investigate contemporary public perceptions and acceptability of CCS. Given the relatively low profile of CCS in both the mass media and academic literature, this exploratory research focuses on Stage 1 of the PACT dialogue continuum, participants' initial position on the technology. For clarity, we focus on three key elements that previous research suggests may interact to determine risk perceptions, with each element broadly grouped within the PACT dimensions of constituents, technology and context. It is important to note that the issues investigated in this research do not represent the entirety of issues that may be relevant in terms of the constituent, technology and context dimensions of the PACT framework. Indeed, many of these are only identifiable through dialogue amongst stakeholders. However, using a quantitative method to establish the public's current position on CCS is a useful means to develop the most appropriate engagement and risk communication strategies in the future.

The Constituent Dimension

The public should not be viewed as one entity, but rather as 'sphere of publics' with differing values, priorities and views of risk. In the context of CCS, the degree to which people will become engaged with the issue will most likely be determined by differences in worldview (Dake 1991; Siegrist 2000), particularly ideological beliefs about the seriousness of the greenhouse gas problem, how the problem should be addressed, and the degree to which people are willing to accept local risk for the sake of addressing a global problem. When people are confronted with an unknown risk, their primary concern is the personal relevance of the risk, with Stempeck noting that "there is serious concern that citizens will raise not-in-my-backyard protests about the sequestration sites, similar to opposition raised against proposed wind power sites" (2005, para 9). Similarly Bush, Moffatt et al. (2002) reported that people living in highly industrial areas accepted the risk of air pollution because of the benefit of local employment from the industrial

sites. Hence, the perceived risk/benefit ratio of CCS will likely depend on the inter-relationship between values and priorities associated with the global risk posed by high levels of greenhouse gas emissions with the potential risks of CCS that may be experienced at a more local level.

The Technology Dimension

Within the technology dimension, the focus is on identifying current levels of knowledge and approval of CCS. The impact of levels of knowledge on the public perceptions and acceptability of a new technology is well-established, with Joffe (1999) finding the perception of risk diminishes with increased knowledge. Numerous studies have demonstrated that knowledge can have a powerful influence on public acceptance or non-acceptance of novel technologies such as nuclear power (Sjoberg 2001; Ogawa 1997) and genetic engineering (Scully 2003). In this case, knowledge of two issues may influence people's acceptance of CCS. In the first instance, knowledge about the greenhouse gas problem will affect the public's capacity to assess the need for post-production technologies such as CCS. Several studies have already shown that the greenhouse gas problem is poorly understood (Curry et al. 2004; Sterman & Sweeney 2002). Secondly, people's knowledge of CCS, including its reliability, predictability and potential harms, will influence how people weigh up its potential risks and benefits.

The Context Dimension

The context dimension incorporates the full array physical, social and institutional circumstances surrounding the use of the technology. Within this framework, trust in risk managers, information providers, relevant authorities and institutional advocates/opponents of the technology is a salient predictor of the public's acceptance of CCS. According to Gough et al. (2002), given that CCS may be viewed as a "quick fix" solution to a long-term environmental problem, levels of trust in carbon sequestration promoters may be a key determinant of the technology's acceptance. They

note that "whilst there were no pre-formed opinions of geological sequestration, the same cannot be said in relation to some of the agencies who wish to implement sequestration" (2002, 14). In the Australian context, whilst the scientific and policy community generally accept CCS as the best option to mitigate increasing carbon dioxide (CO_2) emissions, many environmental organisations are not supportive, with a representative from Greenpeace Australia stating that CCS is "diverting attention from what needs to happen" (cited in Earthbeat 2003). Research suggests that commonly "mistrusted" groups include the government (Lenstra & van Engelenburg 2003), scientists (Lang & Hallman 2005) and large corporations (Gough, Taylor & Shackley 2002). If this holds true in the Australian context, and if these groups are viewed as the only promoters of CCS, it is likely to obstruct public acceptance of CCS.

Methodology

An Australian market research company was commissioned to survey members of a national online panel about their perceptions of geological carbon sequestration. In August 2005, online panel members were emailed an invitation to complete the on-line survey and go into a monthly prize draw to win $2000 of gift vouchers. At the start of the survey, respondents were provided with the following brief information about carbon sequestration:

> Geological sequestration of carbon dioxide is a new scientific technique that proposes storing carbon dioxide gases deep in the earth, specifically through the injection of semi-liquid carbon deep into the earth. It is described as one of the most environmentally-friendly ways to address the issue of increasing CO_2 emissions, yet there is a small risk of leakage.

Participants provided standard demographic information including age, gender, education, income, marital status, and birth-place (see Table 1). Next, participants indicated how much they agreed with a series of statements assessing their knowledge, awareness and involvement with the greenhouse problem and CCS, and their opinions regarding the safety, risks and effectiveness of CCS (see Table 2). Participants indicated how important they believed it was for

Australia to reduce its greenhouse gas emissions, as well as how closely they had followed the debate about reducing greenhouse gas emissions, anchored at “very closely” and “not at all”. Finally, they indicated the extent to which they trusted various sources to tell the truth about CCS (see Table 3).

Results

Participant Profile

A total of 1273 people responded to the on-line survey, with more females responding (79%) than males (21%). The majority (80%) were born in Australia, with an average age of 37 years, ranging from 18 to 79. Over half (60%) were married or defacto, with the remaining single (32%), divorced or widowed. As Table 1 illustrates, participants reported relatively high levels of educational achievement and household income.

INSERT TABLE 1 ABOUT HERE

Personal Relevance and Willingness to be involved in Greenhouse Debate and CCS

Whilst nearly all believed it was very (58%) or fairly (36%) important for Australia to reduce its greenhouse gas emissions, only 5% followed the greenhouse gas emissions debate very closely. The majority had not been following the debate very closely (43%) and approximately one in five (19%) had not followed the debate at all. Table 2 shows that most people believed involving the public in discussions regarding greenhouse issues and CCS was important.

INSERT TABLE 2 ABOUT HERE

Figure 1 illustrates that location of the CCS site determined acceptance of the technology, with participants reporting typical “NIMBY” concerns. Approximately half responded with a neutral

"maybe" response to whether storing carbon underground was a good idea or not (53%), yet over half did not want this technology used near their community.

INSERT FIGURE 1 ABOUT HERE

Public Knowledge of the Greenhouse Problem and CCS

Levels of current knowledge about CCS were extremely low, with 82% not heard of underground carbon storage before the survey. Therefore, the only information these respondents had received regarding this technology was the short paragraph provided at the beginning of the survey. Not surprisingly, the majority (85%) felt they needed more information to form a clear opinion about CCS. Responses to the "trust in technology" questions in Table 2 above illustrates how participants have yet to form strong opinions regarding safety, risks and effectiveness of the CCS technology. However, over 40% said they would be afraid if CCS was to be used near their community and were sceptic about the technology's effectiveness, suspecting it might be a 'quick fix' that would not solve the greenhouse gas problems.

Trust in organisations

In terms of "trust in organisations", the organisations people trusted to tell the truth about carbon sequestration are listed in Table 3, in order of most to least trusted. The most trusted was the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the national government was least trusted.

INSERT TABLE 3 ABOUT HERE

Discussion

As the first large-scale study to quantifiably explore public perceptions of CCS, the findings provide an invaluable benchmark of current perceptions and initial reactions to CCS technologies.

In terms of awareness, whilst most people believe it is important for Australia to reduce carbon emissions, only 20% had heard of CCS and only 5% had closely followed the greenhouse gas debate. Crucially, however, people were open-minded and neutral about the potential risks and benefits of CCS technologies, wanting to learn more before forming a definite opinion on the appropriateness and acceptability of CCS. Given the potentially controversial nature of CCS, the finding that Australians did not have strong or preformed opinions about it implies that now may be an ideal time to implement engagement and risk communication strategies.

The IPCC believe two factors will need to be met before the public will consider CCS as a credible technology; (1) anthropogenic global climate change has to be regarded as a relatively serious problem; (2) there must be acceptance of the need for large reductions in carbon dioxide emissions to reduce the threat of global climate change (IPCC 2005). Notably, this study suggests that people acknowledge the severity of the greenhouse problem and, consistent with a small body of research investigating public perceptions of carbon sequestration technologies (Gough et al. 2002; Shackley et al. 2005), indicates that the general public is not diametrically opposed to CCS as a potential intervention. However, recognition of the seriousness of the greenhouse gas problem and acceptance of the need for large reductions in emissions does not guarantee ultimate acceptance of CCS technologies. With the technology currently positioned at stage 1 of Wolfe et al's (2002) Public Acceptability of Controversial Technologies framework, the quality of the progression through Stages 2 and 3 of PACT - the dialogue process and ultimate decision about the technology - will be determined by the extent to which engagement and risk communication strategies are responsive to the public's current position on CCS technologies. The findings of this study provide an invaluable benchmark of perceptions and initial reactions to CCS technologies in Australia. Further, these findings can be used to extrapolate some principles for the development of effective engagement and risk communication strategies that appropriately

address the specific needs and concerns of the Australian public. While our findings are obviously limited in scope and generalisability, the principle of benchmarking the public's initial position on controversial technologies can be applied in any setting in order to develop context-sensitive (rather than one-size-fits-all) engagement and risk communication strategies.

The Constituents Dimension: Personal relevance and global versus local risk

The potentially controversial nature of CCS, which involves the storage of hazardous wastes and impacts on the social, economic and environmental wellbeing of local communities, was highlighted in this research. Respondents demonstrated the typical "Not-In-My-Backyard" responses with support for carbon sequestration halving when the location for the proposed technology was 'near their community' rather than the more generic 'somewhere in Australia'. As such, addressing NIMBY reactions and concerns about the safety, risks and effectiveness of CCS technology is an essential component of any risk communication strategy. Personal relevance heightens the necessity for local communities to be actively involved in the decision making process and the development of a comprehensive model for engagement that embraces, rather than side-steps, personal relevance issues is a fundamental step in this process. People need to be empowered to appropriately weigh-up the risks associated with the global threat of increased greenhouse gases in the environment with the potential local impacts, such as the threat of leakage.

With people keen for their opinions to "directly affect important decisions" (Uno et al. 2004), it is essential that the public, particularly those located near potential sites, are involved early on in the process and learn about the potential consequences, benefits and risks associated with CCS technology. Precisely how the risk/benefit ratio and perceived socio-economic impact of developing CCS sites may impact on acceptance in the Australian context is not yet clear,

however, if people remain unengaged from the issue, the potential for a repeat of the Hawaii case remains. Indeed, given that the Hawaiian experimental site was forced to close due to extensive public opposition and lobbying (de Figueiredo et al. 2002), the value of early public engagement and involvement cannot be underestimated.

Promisingly, people in our sample firmly believed that governments should encourage public participation and debate about new developments in science and technology, particularly about how to reduce greenhouse gas emissions. Since people's willingness to be involved, discuss, engage and learn about novel technologies is a crucial element in effective risk communication, the finding that nearly half of all participants were personally prepared to take part in a public discussion about reducing greenhouse gas emissions and storing carbon underground is heartening and suggests now is the prime time to engage with the community. Early and consultative engagement maximises the likelihood of balanced and informed consideration of the issues and minimises the likelihood of a repeat of the fear-based responses seen in Hawaii.

The Technology Dimension: Knowledge of CCS technologies

This research has highlighted the general public's lack of knowledge about both the greenhouse gas problem and CCS technologies. Whilst most people believe it is important for Australia to reduce carbon emissions only 5% had closely followed the greenhouse gas debate. Furthermore, and despite that Australia is in the process of positioning itself as an ideal site for CCS (CO2CRC), a staggering 80% had not heard of CCS prior to completing the survey. With 65 viable CCS sites identified in Australia and an experimental site (the Otway project) storing 100,000 tonnes of carbon dioxide underground operational this year at a cost of A$30 million (ABC News Online 2006), the finding that the general Australian public remains largely unaware

about this novel technology raises significant questions about the extent of public involvement to date.

Importantly, most people seemed to feel that due to their lack of knowledge they could not really offer a firm opinion on the safety or risks of CCS, thus reported neutral opinions on these issues. This indicates that, currently, many people are open-minded about the technology and are prepared to reserve judgement until they learn more. Still, over a third of participants said they would be afraid if CCS was used near their community and were sceptical about CCS, viewing it as a quick-fix solution that will not solve the greenhouse gas problem. Such findings suggest that there is an underlying level of distrust towards this new technology. Despite this, people reported a desire for knowledge and informed decision-making, with the majority (85%) agreeing that they needed more information to form a clear opinion on CCS technology. However, the public's relative lack of knowledge about the greenhouse problem and CCS raises significant issues in relation to identifying engagement and risk communication strategies that appropriately address this knowledge deficit, while ensuring that community views legitimately influence decisions about whether and/or where to implement CCS in Australia.

The challenge, therefore, in the development of effective engagement and environmental risk communication strategies is simple: if people don't understand the problem of greenhouse gas emissions, what will enable them to make informed decisions about CCS? Numerous studies demonstrate that knowledge can facilitate public acceptance of novel technologies (e.g., (Sjoberg 2001; Ogawa 1997; Scully 2003) however the fact that the greenhouse gas problem is poorly understood means CCS proponents face the dual challenge of simultaneously educating people about the greenhouse problem *and* the proposed intervention. In this case, the public's expressed desire for knowledge, and willingness to engage with the issues, presents an ideal scenario for

risk communicators and information providers. However, effectively engaging the public in the CCS decision-making process is complicated by two factors.

First, the scientific complexity of the greenhouse effect and highly technical discourse combine to "inhibit the public's ability to participate meaningfully in democratic discussions of the issue, to understand how their own actions affect the climate and to fully and accurately appreciate how climate change will affect our future" (Seacrest, Kuzelka & Leonard 2000). Thus, although the survey respondents report being willing to engage on greenhouse issues, only five percent of respondents reported closely following the greenhouse debate, perhaps because the "highly technical and undifferentiatedly global basis of its appeal simply turns people off" (Demeritt 2001, 329). Hence, it is essential that risk communication strategies do not alienate, patronise, confuse or disempower community members who may not have the appropriate scientific knowledge or linguistic resources to understand or actively engage in a discussion on the greenhouse problem or CCS. Thus, an important first step in the engagement process involves identifying knowledge-building techniques to present salient scientific information in a manner that is easily understood by the general public. This relates as much to *who* presents the information as it does to the type and format of information presented.

Second, the need to educate as a part of the engagement process, places a significant burden on knowledge providers to ensure that community members receive balanced and impartial information about the potential benefits and risks associated with the greenhouse gas problem and CCS technologies. The fact that currently people are relatively uninformed about both (particularly CCS) presents an opportunity to ensure that people are appropriately skilled to make informed contributions to a participative democratic decision-making process. However, it is often the case that individuals and organisations responsible for the development and management of

engagement and risk communication strategies are also involved in the development, use or promotion of the relevant technology. It is therefore essential that organisational goals and incentives do not unduly influence the nature of information provided – the public must be provided with objective, accurate and thorough information about CCS. This burden applies equally to individuals and organisations who oppose the use of CCS. Although not directly responsible for engaging the public in the decision-making process, an undue emphasis on the risks of CCS without providing appropriate information on the greenhouse gas problem is likely to raise levels of fear and mistrust without providing a platform for informed decision-making. This draws into focus the context dimension of the PACT framework, specifically the levels of trust the public has in institutional stakeholders in CCS technologies.

The Context Dimension: Trust in Organisations involved with CCS

Within the context dimension the key factor investigated was trust in the organisations involved with CCS, which plays a salient role in shaping public perceptions. As the majority of respondents had not heard of CCS, it can be reasonably assumed that levels of trust in the different organisations are not reflective of the actual conduct of these organisations in relation to CCS. Hence, levels of trust are most likely based on a range of other factors such as past experiences, the current Australian political climate and personal values and preferences. Nevertheless, understanding the degree to which different organisations are trusted by the public can be invaluable to developing engagement and risk communication strategies that are conducive to informed debate and decision-making – as opposed to knee-jerk and cynical reactions.

Tellingly, this research suggests Australians have doubts about the trustworthiness of certain organisations, including the biotechnology industry, local authorities and the national government,

to “tell the truth” about CCS. As public acceptability of carbon sequestration may be determined, at least in part, by source credibility and perceived trustworthiness, the finding suggests that if, for example, the Australian Federal Government were to engage with the public about CCS, it would be beneficial to incorporate trust building mechanisms into risk communication strategies. Without engendering public trust in the organisations most equipped to provide honest and reliable information about the benefits and risks of CCS, information received from these agencies– no matter how truthful - may be viewed quite sceptically by the general public. As such, an ideal scenario for effective risk communication is when the organisation responsible for engagement and risk communication is already a trusted source. In this case, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), university researchers and environmental organisations were the most trusted to “tell the truth” about CCS. Interestingly, these groups have already taken disparate view on CCS, with CSIRO and some university researchers involved in the development of CCS technologies, while many environmental organisations have opposed CCS for its potential to discourage motivated action to reduce emissions in the long-term (Earthbeat 2003). Ostensibly, it may appear that the different positions taken on CCS by these organisations would inevitably complicate the engagement process. However, in many ways this presents an ideal opportunity to ensure that the public is provided with a balanced perspective on the issues through which to draw their own conclusions. Developing partnerships between CCS proponents, opponents and the public can enable a relationship of give and take between all parties concerned. Partnerships, as an underlying principle for engagement, would enable informed discussion about the benefits and risks of CCS, and facilitate cooperative problem-solving and the development of appropriate risk management strategies. However, while it is simple enough to make this claim, negotiating and formulating effective partnerships between all stakeholders will require an honest and transparent approach, that incorporates

consideration of organisational interests, yet is guided primarily by a commitment to the engagement and decision-making process.

Limitations of the Study

Whilst this study has provided important insight into an under-researched area, perceptions of the potentially controversial issue of CCS as a solution to a global environmental problem, we need to acknowledge both study limitations and important avenues for future research. First, and most significantly, this is not a random sample as respondents were members of a market research company's on-line poll. The participant profile demonstrates that they have relatively high levels of educational achievement and household income, and that the majority are female; the extent to which more representative sample might have different perceptions of CCS is a task for future research. Second, our explanation of CCS was very brief, and over three-quarters said that they needed more information to form a clear opinion about CCS. While this finding is significant in terms of the technology dimension, it may be beneficial to provide participants with more information about CCS to gain in-depth insight into perceptions of the technology. However, like in any engagement process, it is essential to ensure that the information provided is balanced, accurate and reasonably reflects a range of viewpoints. As such, future research investigating the technology dimension may require a qualitative approach. Third, this study outlines a snapshot of people's initial opinions about a potentially controversial technology that has, to date, received little mainstream attention. As public awareness increases, however, further quantitative and qualitative research is essential to better understand public perceptions and reactions to the proposed CCS solution.

Finally, it is important to emphasise that this article does not address the appropriateness of CCS as a strategy to address the greenhouse gas problem, the scientific validity of CCS or the politics

surrounding this option. We have focussed solely on assessing public perceptions of CCS, with the fact that CCS is described as the most popular and feasible solution by the majority of policy-makers (i.e., IPCC 2001) and scientists (i.e., Bradshaw et al. 2002), offered only as contextual information. Nevertheless, a priority for other researchers is to discuss and objectively assess whether the CCS option is the best solution to the greenhouse gas problem - while there is general scientific acceptance of CCS as a stopgap measure, there are some concerns that the development of this technology may diminish interest, funding and acceptance of advancements in alternative technologies or behaviour change programmes (Gough et al. 2002).

Conclusion

The issues and concerns raised in this research highlight the necessity for an engagement and risk communication approach that is balanced so that the community, relevant authorities and other stakeholders are appropriately empowered in the communication and decision-making process. The acceptability of CCS will depend on the publics' assessment of the competing risks associated with increasing greenhouse gas emissions on the one hand, CCS as a proposed intervention on the other. Our findings on peoples current perceptions of key issues associated with CCS technologies have significant implications for the development of engagement and risk communication strategies. First, whilst NIMBY concerns were highlighted in the research, people's willingness to learn more and engage in public discussion about CCS suggests that now is an ideal time to initiate a wide-spread engagement process. Second, the relative lack of knowledge about the greenhouse gas problem required knowledge building techniques that are non-technical, objective and balanced. Finally, an ideal opportunity exists for the development of partnerships between the three most trusted organisations – CSIRO, universities and environmental organisation – and the community to come to an informed consensus about the use of CCS technologies in Australia. While our findings are limited to the issue of CCS in the

Australian context, they highlight the benefits of utilising survey research to identify existing perceptions of a controversial technology and inform the development of tailored engagement and risk communication strategies in any context.

References

ABC News Online. 2006. *Carbon dioxide storage trial set to start*. http://www.abc.net.au/cgi bin/common/printfriendly.pl?http://www.abc.net.au/news/newsitems/200601/s1543933.htm (accessed 6 February, 2006)

Australian Greenhouse Office. 2003. *Renewable Energy Commercialisation in Australia*. http://www.greenhouse.gov.au/renewable/recp/index.html#foreword (accessed 25 January, 2006)

Beck, U. 1992. *Risk society : towards a new modernity,* Sage: London.

Bradshaw, J., Bradshaw, B. E., Allinson, G., Rigg, A. J., Nguyen, V. and Spencer, L. 2002. The Potential for Geological Sequestration of CO2 in Australia: Preliminary Findings and Implications for New Gas Field Development. *APPEA Journal,* 42 25-46.

Bush, J., Moffatt, S. and Dunn, C. E. 2002. Contextualisation of Local and Global Environmental Issues in North-east England: implications for debates on globalisation and the 'risk society'. *Local Environment,* 7 (2): 119-133.

Carbon Sequestration Leadership Forum. 2005. *CCS Related Activities Summary. CSFL Joint Policy & Technical Group Meeting,* Berlin, Germany

Curry, T., Reiner, D., M., Ansolabehere, S. and Herzog, H. 2004. How Aware is the Public of Carbon Capture and Storage? In *7th International Conference on Greenhouse Gas Control Technologies, 5-9 September 2004, Vancouver, Canada.* http://www.ghgt7.ca/papers_posters.php?topic=PUB-Panel

Dake, K. 1991. Orienting Dispositions in the Perception of Risk: An Analysis of Contemporary Worldviews and Cultural Biases. *Journal of Cross Cultural Psychology,* 22 61-82.

de Figueiredo, M. A., Reiner, D. M. and Herzog, H. J. 2002. Ocean Carbon Sequestration: A Case Study in Public and Institutional Perceptions. In *Sixth International Conference on Greenhouse Gas Control Technologies, October 1-4, 2002, Kyoto, Japan.*

Demeritt, D. 2001. The Construction of Global Warming and the Politics of Science. *Annals of the Association of American Geographers,* 91 (2): 307-337.

Department of Environment Food and Rural Affairs (DEFRA). 2005. *Tomorrow's Climate, Today's Challenge: working together to tackle climate change.* http://www.defra.gov.uk/news/2005/051201c.htm (accessed 25 January, 2006)

Earthbeat. 2003. *CO2 Underground: The Answer to Climate Change or Part of the Problem ?* http://www.abc.net.au/rn/science/earth/stories/s781633.htm (accessed 30 November, 2005)

Fyfe, M. 2004. *Out of sight, out of mind?* http://www.theage.com.au/articles/2004/04/08/1081326866024.html (accessed 30 November 2005, 2005)

Gough, C., Taylor, I. and Shackley, S. 2002. Burying Carbon Under the Sea: An Initial Exploration of Public Opinions. *Energy & Environment,* 13 (6): 883-900.

Herzog, H. J. 2001. What Future for Carbon Capture and Sequestration? *Environmental Science & Technology,* 35 (7): 148 A - 153 A.

IEA. 2004. *Prospects for C02 Capture and Storage*. http://www.iea.org/textbase/nppdf/free/2004/prospects.pdf (accessed 25 January, 2006)

IPCC. 2001. *Summary for Policymakers: A Report of Working Group I of the Intergovernmental Panel on Climate Change*. http://www.ipcc.ch/pub/spm22-01.pdf (accessed 25 January, 2006)

IPCC. 2005. *Carbon Dioxide Capture and Storage: Summary for Policy Makers and Technical Summary. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change.* http://www.ipcc.ch/activity/srccs/SRCCS_SummaryforPolicymakers.pdf (accessed 25 January, 2006)

Itaoka, K., Saito, A. and Akai, M. 2004. Public Acceptance of CO2 Capture and Storage Technology: A Survey of Public Opinion to Explore Influencial Factors. In *7th International Conference on Greenhouse Gas Control Technologies, 5-9 September 2004, Vancouver, Canada.* http://www.ghgt7.ca/papers_posters.php?topic=PUB-Panel

Joffe, H. 1999. *Risk and 'the Other',* Cambridge University Press: New York.

Lang, J. T. and Hallman, W. K. 2005. Who Does the Public Trust? The Case of Genetically Modified Food in the United States. *Risk Analysis,* 25 (5): 1241 - 1252.

Lenstra, W. J. and van Engelenburg, B. C. W. 2003. *Legal and Policy Aspects: Impact on the Development of CO2 Storage,* Intergovernmental Panel on Climate Change.: Regina

Lupton, D. 1999. *Risk,* Routledge: New York.

Meijnders, A., Midden, C. J. H. and Wilke, H. A. M. 2001. Role of Negative Emotion in Communication about CO2 Risks. *Risk Analysis,* 21 (5): 955 - 966.

Ogawa, K. 1997. Public Acceptance and Public Opinion. In *Energy Future and the Nuclear Fuel Cycle in the Asia Pacific Region, April 1997, Berkley, California, USA.* http://tauon.nuc.berkeley.edu/asia/1997/97ILP_Ogawa.pdf

PESA News. 2005. *Australia Has Capacity For Large Scale Carbon Storage*. http://www.pesa.com.au/publications/pesa_news/latest_edition/pesanews_7913.html (accessed 25 January, 2006)

Scully, J. 2003. Genetic Engineering and Perceived Levels of Risk. *British Food Journal,* 105 (1/2): 59-77.

Seacrest, S., Kuzelka, R. and Leonard, R. 2000. Global climate change and public perception: The challenge of translation. *Journal of the American Water Resources Association,* 36 (2): 253-263.

Shackley, S., McLachlan, C. and Gough, C. 2004. *The Public Perceptions of Carbon Capture and Storage,* Tyndall Centre for Climate Change Research: Manchester

Shackley, S., McLachlan, C. and Gough, C. 2005. The public perception of carbon dioxide capture and storage in the UK: results from focus groups and a survey. *Climate Policy,* 4 (4):

Siegrist, M. 2000. The Influence of Trust and Perceptions of Risk and Benefits on the Acceptance of Gene Technology. *Risk Analysis,* 20 (2): 195 - 203.

Sjoberg, L. 2001. Limits of Knowledge and the Limited Importance of Trust. *Risk Analysis,* 21 (1): 189-198.

Slovic, P. 2000. *The Perception of Risk,* Earthscan Publications: London.

Smekens, K. and van der Zwaan, B. 2004. Vol. 2005 Fondazione Eni Enrico Mattei, Milan.

Stempeck, B. 2005. *Polls finds public awareness on carbon sequestration sorely lacking*. http://knowledge.fhwa.dot.gov/cops/italladdsup.nsf/54be0d40ec7fbeae852568fc006f6b21/14cae353cea16e3685256fce00653763?OpenDocument (accessed 30 November, 2005)

Sterman, J. D. and Sweeney, L. B. 2002. Cloudy Skies: assessing public understanding of global warming. *System Dynamics Review,* 18 (2): 207-240.

The Premier's Round Table on Sustainability. 2004. *three, four, five: 3 Challenges, 4 Principles, 5 Actions for a Sustainable Future. Report to the Government of South Australia on implementing the State Strategic Plan.,* South Australia

United Nations Economic and Social Council. 2002. *Carbon Sequestration - Avoiding CO2 Emissions From Fossil Fuels: an overview of technology options and international initiatives*. http://daccessdds.un.org/doc/UNDOC/GEN/G02/323/76/PDF/G0232376.pdf?OpenElement (accessed 14 November, 2005)

Uno, M., Mori, Y., Tokushige, K. and Furukawa, A. 2004. Exploration of Public Acceptance Regarding CO2 Underground Sequestration Technologies. In *7th International*

Conference on Greenhouse Gas Control Technologies, 5-9 September 2004, Vancouver, Canada. http://www.ghgt7.ca/papers_posters.php?topic=PUB-Panel

van den Nieuwenhof, L. 2005. Time Capsule 21/08/1986: Freak Eruption Kills 1700. *Weekend Australia Magazine,* 20-21 August 2005.

Wolfe, A. K., Bjornstad, D. J., Russell, M. and Kerchner, N., D. 2002. A Framework for Analysing Dialogues over the Acceptability of Controversial Technologies. *Science, Technology & Human Values,* 27 (1): 134-159.

Working Party on Fossil Fuels. 2003. *CO2 Capture and Storage in Geological Formations,* Working Party on Fossil Fuels, International Energy Agency: Paris Cedex, France

Table 1. Demographic Profile of Respondents

Gender	n	Percent
Male	273	21%
Female	1000	79%
Age		
35 and younger	734	58%
36 and older	538	42%
Level of Education		
Secondary School	484	38%
Higher Education	789	62%
Income		
$50,000 and below	540	42%
$50,000 and above	733	58%

Table 2. Public Perceptions of CCS

	Disagree	Neutral	Agree
KNOWLEDGE			
I need more information to form a clear opinion about storing carbon underground	2.5%	12.5%	85.0%
INVOLVEMENT			
The government should encourage public participation and debate about new developments in science and technology	2.4%	12.3%	85.3%
The government should consult the public about how to reduce greenhouse gas emissions	4.8%	14.8%	80.3%
I would be prepared to take part in a public discussion about reducing greenhouse gas emissions and storing carbon underground	15.9%	40.5%	43.5%
TRUST IN TECHNOLOGY			
I would be afraid if underground carbon storage technologies were used near my community	11.9%	45.8%	42.4%
I am confident that, if it proceeds, the development of storing carbon underground will be safe and carefully regulated	24.3%	55.1%	20.6%
I think storing carbon underground is a quick fix solution that will not solve the greenhouse gas problems	7.4%	51.6%	40.9%

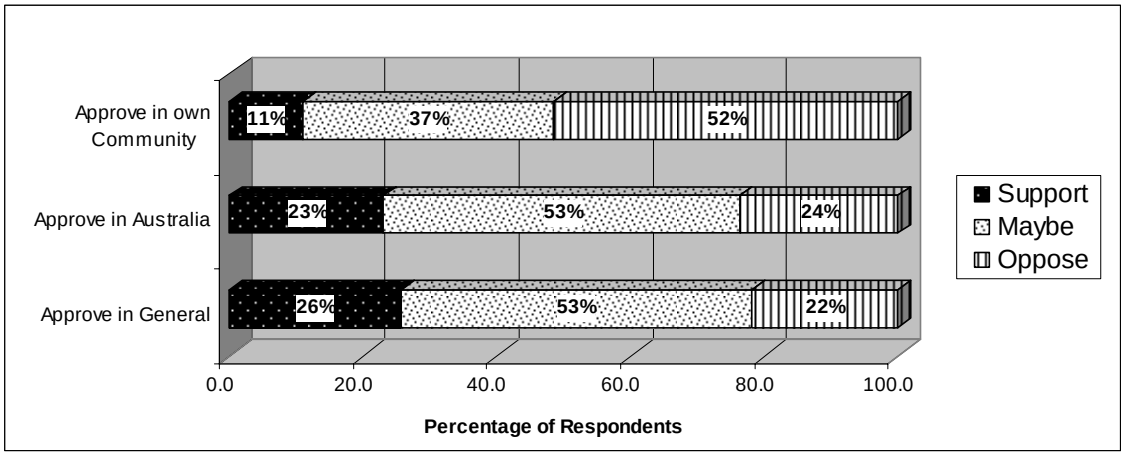

Figure 1: Approval for CCS in general, in Australia or near own community

Table 3. Who is trusted to tell the truth about CCS

	Distrust	Neutral	Trust
CSIRO	8.7%	22.7%	68.6%
Scientists/Researchers working for Universities	10.0%	22.4%	67.5%
Environmental Organisations	14.9%	21.0%	64.0%
Scientists/Researchers working for Government	33.3%	30.7%	36.1%
Biotechnology Industry	25.5%	38.6%	35.8%
Local Authorities	39.1%	37.0%	23.9%
National Government	48.9%	30.7%	20.4%