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Public preferences to CCS: How does it change across countries?

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Abstract

The aim of this research was to extend an Australian developed large group process which proved effective in engaging the general public on issues related to climate change, energy technologies, and the overall shift towards a low carbon society. The results from Australia, the Netherlands, Canada and Scotland found that in each of the geographic locations the context varied, and participants reported different experiences and understanding of each topic. This paper explores how context may have impacted on the results, the differences that arise and discusses the implications for policy makers and research developers.

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1. Introduction

In previous research, Ashworth and colleagues [1] developed a large group process for sharing information and engaging the public on climate change and energy technologies. The process was reported to be effective at improving individual self-rated knowledge on climate change and the range of energy technologies, as well as shifting individual perspectives about these topics. In particular, it seemed to have an increased impact around new and emerging low carbon energy technologies such as carbon

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capture and storage (CCS). Early research has shown that for any energy technology to be accepted for carbon mitigation, it helps to present the technology in the context of climate change as well as the portfolio of low carbon options [2, 3]. In many ways this establishes the social license [4] for considering the technology as one within a range of technologies, rather than advocating for a single technology over and above alternative options. Such an approach also assists in introducing the requirement for a range of technologies to achieve a reduced emission profile for energy generation over the longer term.

The large group process was delivered again in Australia (Collie, Sydney), and replicated in Scotland (Edinburgh), Canada (Calgary) and the Netherlands (Utrecht), through additional funding from the Global CCS Institute. The aims of the process included to: 1) explore the views of individuals on climate change and the range of energy technologies; 2) provide background information on climate change and energy technologies and enable the opportunity for discussion with peers; 3) assess the impact of the information and the process on individual knowledge, attitudes and behaviours; and 4) assess individual views on the potential solutions for mitigation, including CCS and how they change as a result of the workshop.

Individual country results have previously been reported separately [5, 6, 7, 8], this paper presents a comparative analysis of the results from across the four countries focusing on CCS. Initially the paper provides an overview of the current literature on the acceptance of energy technologies and outlines the methodology used in this research. Findings from the workshop, with a particular focus on results relating to CCS are presented. Observations are made about inter-country differences and the implications are considered for policy makers, and science and technology developers with an interest in CCS.

2. Design process and theoretical underpinnings

In their paper on acceptance of energy technologies, Huijts, Mollin and Steg [9] define *acceptance* as behaviour that enables, supports or promotes an energy technology, in contrast to open and expressed resistance to it, while *acceptability* is referred to as an attitude or evaluative judgement towards an energy technology. The researchers also highlight a third category of *tolerance*, where people are in favour of a technology and do not take action against it, perhaps best characterising the most common status of societal acceptance of energy technologies to date. There are many examples where local community opposition to deployment of specific energy projects, such as wind, nuclear, and biomass have occurred [10, 11, 12].

As such, it is clear that, as issues of security of supply, carbon emissions, rising electricity prices and general increased accountability of governments intensify, decisions around the final portfolio of options for low carbon energy are likely to require increased levels of societal acceptance. Therefore, processes to engage communities in ways that enable them to become more informed about the technologies, while at the same time documenting their reactions to them, are likely to be preferred by industry, government, research, and development organisations alike. Such processes will be particularly important when new and emerging technologies, such as CCS, are being considered.

CCS is still relatively unknown compared to more established technologies such as wind, solar, coal fired power, and hydro electricity. However, awareness of the technology has grown over time, especially in areas where CCS projects have been proposed, deployed or opposed. This is best evidenced in the recent “Special Eurobarometer 364”, which examined public awareness and acceptance of CCS across 12 European countries[2] by surveying 13,091 European Union citizens [13]. Only 10% of respondents overall said they had heard of CCS and knew what it was, with a further 18% having heard of it without knowing

[2] Eurobarometer countries included Germany, United Kingdom, Italy, Spain, the Netherlands, Poland, Finland, France, Greece, the Czech Republic, Bulgaria and Romania.

what it was. Yet in the Netherlands, where there has been controversy associated with the Barendrecht CCS project in that country, 52% of the Dutch surveyed indicated they knew what CCS was.

This result is in contrast to polls in Canada and Australia where, in a recent poll of 1,548 Canadian citizens, 14% had heard of CCS and knew what it was, while a further 30% had heard of CCS but did not know what it was [14]. In the Australian survey, conducted in June 2011 across a representative sample of 1,907 participants, 25% indicated they had no knowledge of gas or coal with CCS, while 22% indicated a moderate knowledge. Only 2% thought they had high knowledge of CCS, with 13% overall indicating more than moderate knowledge [15]. Given the generally low levels of knowledge of CCS, the validity of results from large scale surveys has been questioned, with findings sometimes purported to reflect "non-opinions" or "pseudo-opinions" at best [16, 17].

To better understand public opinion towards CCS, more qualitative forms of social research have been undertaken over time, for example, citizens' panels and focus groups. Building on these processes, the large group process was designed to include a mix of information provision, discussion and some deliberation, with up to 100 individuals in the room. It has the advantages of being more economical than smaller group processes, as more participants are engaged and more informative to the researchers than using quantitative surveys.

3. Methodology

3.1. Recruitment

The four countries were tasked with recruiting up to 100 participants for their large group workshop. In the Netherlands, Scotland and Canada participants were recruited through an external recruitment agency with experience in recruiting for focus groups and opinion polls. The recruitment process described the workshop topic as climate change and low carbon energy technologies. The agency was required to ensure the sample was representative on at least gender and age of the region.

The Australian recruitment process varied slightly as it was not funded as part of this research. As such, participants for the workshop in Sydney were recruited from a marketing database where invitations were sent to 5,426 email addresses. From this 194 people registered and 130 were selected for participation based on their sex, age and education level. In total, 59 participants attended the workshop. To ensure a larger Australian sample for adequate comparison with the other countries, the Sydney results were combined with those from the South West Hub CCS Project, which undertook the same process but involved fewer people, because it was conducted in a small country town. Participants for this workshop were recruited through a range of open invitations, local paper advertisements, and community radio announcements.

3.2. Process

In each country, the large group process was kept as consistent as possible, with only small changes made to suit the specific country context. The process evolved from earlier research that found that small workshops of 8 – 10 people focusing on the topic of climate change and energy technologies successfully increased participant knowledge [18]. A lead facilitator attended to the overall process to ensure the day ran to schedule, while each table was assigned its own facilitator to ensure equal participation in group discussions [1].

A designated "expert" was used to communicate the science of climate change, the portfolio of options that may contribute to a low carbon energy supply, and then a specific focus on CCS. While the information presented was kept as consistent as possible across countries, each presentation used a local

expert and was adapted for the specific national context. Maintaining a consistent presentation content across each country was considered important to control for differences in delivery. Differences in presentation style was however unavoidable. In Canada, for example, the expert paid less attention to the full range of energy options during the presentation. Using the same expert in each location would be ideal however this was not practical given the cross section of countries in the study.

The design and timing of the process allowed participants to develop a sense of identification with both their table group and the larger workshop group. Electronic voting was used to assist in building the large group identity, and allowed participants the opportunity to compare their opinions with others in the room. It was also important to balance time for data collection through surveys, information provision from an expert, and group discussions to reflect on the information received and compare reactions with those at the table and the wider workshop group.

3.3. Data collection and analysis

In addition to completing a *pre* and *post* questionnaire at the beginning and end of the day, participants were asked to complete a *process* questionnaire before lunch. In these surveys participants were asked to answer *yes* or *no* to indicate their *awareness* of energy sources and technologies. The survey also asked participants to rate their *knowledge* (where 1=no knowledge to 7=high knowledge) and *attitudes* towards energy sources and related technologies (1=strongly disagree to 7=strongly agree).

All table discussions were recorded and transcribed, with facilitators documenting the key points from their table discussions. During the afternoon break, table facilitators convened to compare the main findings, and these were summarised into key messages and fed back to participants for purposes of clarification and representation.

4. Results

4.1. Demographic profile of participants

In total, 374 participants attended the workshops across the four countries. The workshop in the Netherlands had the highest number of participants (n=111), followed by Scotland (n=99), Australia (n=84[3]) and Canada (n=80). The gender distribution of participants in the Netherlands, Canada and Scotland was relatively even, with males slightly over represented compared to the population statistics of the relevant region. However, a number of ‘no shows’ in the Sydney workshop in Australia meant the gender distribution was skewed, with a greater representation of men (55%) than women (45%) than in the cross-national dataset. Similarly, all age groups were represented by the workshop participants and, with the exception of Australia, the country samples roughly reflected the age distributions of their local populations. In Australia, younger people were under represented while those above 55 years of age, in particular, were over represented.

Participants had a wide range of educational backgrounds but were generally highly educated. In Australia, two thirds (67%) of participants indicated they had completed tertiary education (diploma, bachelor’s degree or post-graduate degree). Education levels were similarly high in the Canadian workshop, with two-thirds of participants also having tertiary level qualifications (68%). The participants in Scotland and the Netherlands were also well-educated, with over half (55%) and almost one-third (31%) completing tertiary education, respectively. The majority of participants were either employed

[3] Combines Sydney and Collie participants

full-time, part-time, or self-employed. In Australia (58%) and Scotland (60%) those in paid employment accounted for just over half the participants. The percentage of employed participants was somewhat higher in the Netherlands (73%) and Canada (66%).

4.2. Awareness and knowledge of energy technologies

Participants were most aware of wind (99%), solar (98%), natural gas (97%), oil (97%) and coal (95%).They were the least aware of geothermal energy (62%), coal seam gas (64%) and CCS (65%). As shown in Table 1, participants were most aware of CCS in the Netherlands (84%), Australia (77%) and Canada (61%). Scotland showed least awareness of CCS with only 36% indicating they were aware of the technology.

Table 1 Awareness of energy sources/technologies by country

Energy Source/Technology	Australia	Netherlands	Canada	Scotland
Wind	99%	100%	99%	98%
Solar	99%	100%	96%	97%
Natural gas	98%	99%	98%	92%
Oil	94%	98%	98%	96%
Coal-fired	98%	93%	91%	97%
Hydro	98%	90%	95%	92%
Nuclear	96%	93%	90%	93%
Wave/tidal	86%	64%	63%	86%
CCS	77%	84%	61%	36%
Geothermal	75%	68%	66%	40%

Participants rated their overall knowledge of energy sources and related technologies as moderate. Respondents from Australia gave themselves the highest ratings of all participants at both the beginning and end of the workshop. Overall knowledge of energy sources and related technologies significantly increased during each of the workshops however, the degree of change varied across countries. As shown in **Error! Reference source not found.**, the largest increase in self-rated knowledge occurred in Scotland (Mean difference = 1.34, $p<.01$), followed by the Netherlands (Mean difference = 1.00, $p<.01$) - the two countries with the lowest knowledge scores at the outset. The shift in self-rated knowledge in the Canadian workshop was much lower when compared with other countries (Mean difference = 0.26, $p<.01$).

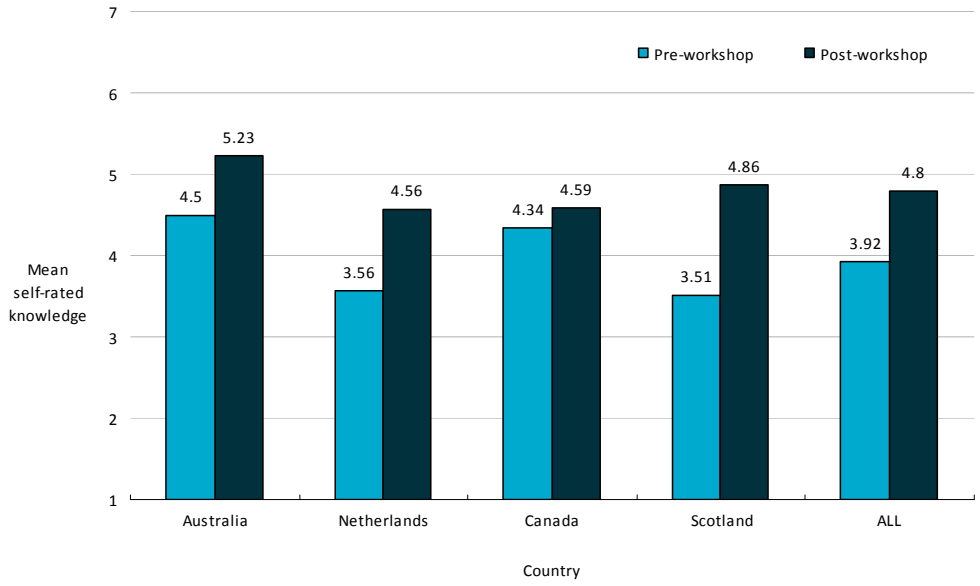

Fig. 1. Change in mean self-rated knowledge for all energy sources and related technologies in each country

The greatest increase in the average self-rated knowledge score for any source or technology was in relation to CCS. CCS was a particular focus of the workshop and it is also one of the least well known technologies. As such, unlike some of the more conventional energy sources and technologies, it does not suffer from a ceiling effect that seems apparent for those such as solar and wind. The mean increases in knowledge for CCS for each country are shown in Table 2.

Table 2. Change in self-rated knowledge of carbon capture and storage

Country	Mean Pre-Test Score (S.E.)	Mean Post-Test Score (S.E.)	Mean Diff. (S.E.)
Australia	3.64(.17)	5.04(.14)	1.40(.16)***
Netherlands	2.92(.13)	4.80(.11)	1.88(.13)***
Canada	2.92(.18)	4.89(.14)	1.97(.21)***
Scotland	2.13(.13)	5.09(.14)	2.96(.19)***
ALL	2.88(.08)	4.95(.07)	2.07(.09)***

Note: Paired t-tests of mean difference; knowledge ranges from 1-7; ***p < .01 (two-tailed tests).

4.3. Attitudes toward energy sources and related technologies, in particular CCS

Participants were generally more supportive of renewable energy technologies than fossil fuels, such as coal. This remained true for all countries at all time points. Attitudes toward renewable energy technologies did however vary in how they changed: decreasing significantly in both the Netherlands (Mean difference = -0.2, p<.01) and Canada (Mean difference = -0.31, p<.01), increasing significantly in Scotland (Mean difference = 0.45, p<.01), and remaining relatively unmoved in Australia. Contrastingly, attitudes toward fossil fuels became uniformly more *positive* across the different country workshops (and

significantly so everywhere but Australia), with support for the use of fossil fuels increasing significantly in the Netherlands (Mean difference = 0.21, p<.05), Canada (Mean difference = 0.23, p<.05), and Scotland (Mean difference = 0.35, p<.01). So while participants are more supportive of renewables than fossil fuels, the *relative* preference for renewable technologies over fossil fuels actually diminished for everyone except Scotland (who became more supportive of everything), and significantly so for the Dutch and Canadians.

The attitudinal changes regarding CCS differed between each country. Initially, many participants were unsure of their opinion towards CCS. During the workshop, the proportion of *unsure* participants considerably reduced, however the direction of this shift differed across countries. Participants in both Australia (Mean difference = 0.66, p<.01) and Canada (Mean difference = 0.88, p<.01) significantly increased their support for CCS, evidencing moderate agreement with the use of CCS by the end of the workshop. However, the attitude change evident in the Netherlands (Mean difference = -0.49, p<.01) and Scotland (Mean difference = -0.38, p<.05) was to the contrary, with participants becoming significantly less supportive of CCS following the workshop. The mean changes in attitude toward CCS are shown in Table 3.

Table 3. Change in attitude toward carbon capture and storage

Country	Mean Pre-Test Score (S.E.)	Mean Post-Test Score (S.E.)	Mean Diff. (S.E.)
Australia	4.40(.17)	5.06(.17)	.66(.17)***
Netherlands	4.24(.14)	3.75(.15)	-.49(.10)***
Canada	4.52(.15)	5.40(.16)	-.88(.20)***
Scotland	4.48(.13)	4.10(.17)	-.38(.19)**
ALL	4.40(.07)	4.48(.09)	.08(.09)

Note: Paired t-tests of mean difference; knowledge ranges from 1-7; ***p < .01, ** p < .05 (two-tailed tests).

Not surprisingly, a significant proportion of the table based discussions at each of the workshops centred on individual reactions to CCS. CCS invoked a mix of views among workshop participants. General concerns about CCS included whether it would remain safe in the storage areas, that it would not contaminate water supplies, and the effectiveness of monitoring the storage sites. There were also discussions about whether CCS was an appropriate bridging technology. Some individuals who were sceptical wanted to know who was behind its development and who would benefit from its existence. Other remarks appear more positive, suggesting CCS constitutes a practical solution to reduce emissions while fossil fuels continue to be used. Some examples of comments made by participants are included below.

> *"If CO_2 underground, there is a chance that they start drilling in the future at that same place which would release the CO_2 into the atmosphere. That would be a big problem!"* The Netherlands, [5], p. 32

> *"We're not going to transfer to whether it's wind power or nuclear, we're not going to have that as a total source of energy. We're still going to have to use fossil fuels, so if you can take the carbon away from that, well, it's a short-term fix which is probably good."* Scotland, [7], p. 27

Many participants' expressed concerns that any investment in CCS would be detrimental to the ongoing development of renewable energy, best reflected in the quote below.

> *"Solar, wind and geothermal are preferred technologies to use. CCS makes it possible to reach targets on the short term. But CCS is probably an expensive solution that demands money that could be spent better to solar, wind and geothermal."* The Netherlands [5] p. 45

5. Discussion and Conclusion

While the overall shifts in attitude towards renewable energy technologies are surprising, the results from the four countries reinforce previous observations that strong support for renewable energy technologies exists around the globe. Accordingly, this support for renewable energy needs to be a major consideration for any government aiming to invest large sums of public money in new energy technologies. It was deemed particularly important by many participants that investments into renewable energy technologies should not suffer because of investment in CCS. That is, there was little tolerance in trading off between CCS and renewables – there was an expectation that they should continue in parallel. As has been highlighted in previous research – acknowledgment of the portfolio of options is helpful in allaying concerns that CCS may take precedence in investment over renewable energy forms [19].

Awareness of CCS as an energy technology was moderate in the Netherlands, Australia and Canada, but lower in Scotland. Similar to the Eurobarometer results [13], it is likely the higher awareness in the Netherlands was because of the controversy associated with the failed Barendrecht project and the resulting ruling by the Dutch government that no CCS projects would take place on shore in the Netherlands. The Australian sample was also made up of representatives from the Southwest Hub CCS flagship project local community, which was more likely to be aware of the project and hence CCS. Similarly Calgary, with its heavy reliance on oil extraction, already has an interest in CCS.

As the focus of the workshop information was on CCS, a significant proportion of table discussions at each of the workshops centred on individual reactions to the technology. Initially, many participants were unsure of their opinion towards CCS, reflecting the low level of knowledge. While the proportion of participants that responded "unsure" reduced considerably during the workshop, participants' still tended to focus their perceptions of CCS on the perceived risks and uncertainties associated with the technology. Participants in all countries raised questions around its safety, the likelihood for unplanned leaks of CO_2, and questions about its ability to allow CO_2 to remain stored for long periods of time. These are examples of frequently asked questions that consistently arise whenever individuals are first presented with information about CCS and this is unlikely to change until there are large scale projects commercially deployed for some period of time. Therefore, independent information needs to be made readily available to stakeholders about concerns that constantly arise. This could be achieved by developing a series of fact sheets that are peer reviewed by a diverse set of stakeholders that may have opposing views around the potential of CCS to improve the credibility of the information being presented.

One of the major aims of the large group process was to provide background information on climate change and energy technologies, and to enable peer to peer discussion around what they have heard as part of the process. While every effort was made to present consistent information, the variations experienced between countries, could perhaps be associated with the style of presentation by the different experts. Despite this, the results indicate that the workshop was successful at informing participants about the range of energy technologies as well as providing them with a safe environment to openly discuss their views about the range of low carbon energy options. However, such a process will never produce the deep deliberations that can arise from conducting a longer citizen panel or similar process that takes place over a series of workshops. The length of time that participants are involved in such a process may also

impact on their overall impressions of the technologies being presented. The risk communication literature suggests that new technologies with associated uncertainties are more likely to be successfully deployed when an early engagement process with a broad spectrum of stakeholders is employed. This becomes even more critical when the deployment of the technology is dependent on the investment of large sums of public monies. Although engagement around CCS does not necessarily guarantee acceptance and deployment of the technology, it certainly assists to evaluate the public's understanding and what may constitute it being accepted.

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