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Public Perceptions and Acceptance of Carbon Capture and Storage for Greenhouse Gas Mitigation

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Public Perceptions and Acceptance of Carbon Capture and Storage for Greenhouse Gas Mitigation: A Random Effects Model

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Abstract

The pressure to achieve net-zero CO_2 objectives has heightened the need to evaluate energy technologies in Canada, where the oil and gas industry remains essential to the economy. Carbon capture and storage (CCS) is a component of Canada's net-zero CO_2 strategies and can absorb up to 90 percent of the CO_2 emissions from major point emitters. However, public perception and support for CCS remain controversial. This study investigated the reasons for the heterogeneity in acceptance and support for CCS in Canada. Random effects model was applied to vignette experimental data to investigate the public's perceptions of CCS as a climate mitigation technology. Our findings indicate that cross-border import of CO_2 for storage has a strong effect on the acceptance of CCS plant scenarios. Consultation, compensation, proximity, knowledge, risks, and trust are critical drivers of CCS acceptance. The study concluded that communication efforts to improve public understanding and acceptance of CCS should focus on demystifying the risks of CCS instead of its technicalities and climate mitigation capacity.

Keywords: Public Perceptions, Carbon Capture and Storage, Cross-border Import of CO_2, Climate Change, Seismicity, vignette experiment

Introduction

According to the International Energy Agency (IEA), global energy-related carbon dioxide (CO_2) emissions experienced a notable increase in 2021, surpassing a total of 36 billion metric tonnes (IEA, 2021a). Over the last decade, the output of other heavy-point greenhouse gas (GHG) emitters, including steel, cement, and fertiliser, has also grown exponentially. Despite the continued need for these materials to keep our agricultural, construction, and transportation sectors afloat, continuing down this road is a potential recipe for global disasters. Rapid decarbonisation is crucial for the world's average temperature to rise by no more than two degrees Celsius above pre-industrial levels and to avert the worst effects of climate change (IPCC, 2022; Rockström et al., 2017).

Challenges caused by climate change have prompted a plethora of responses from a wide range of disciplines. In the technology industry, Rolnick et al. (2019) suggested leveraging machine learning to assess climate-related data collected through satellites. Economists have proposed a variety of measures to make the emission of CO_2 and other GHGs more expensive (David and Herzog, 2000; Nordhaus, 2019). In the biotechnology industry, Tylecote (2019) advocated the use of biomedicine and plant breeding to reduce global warming. Within the construction industry, Röck et al. (2020) conducted a large-scale analysis of more than 650 buildings to quantify the effect of embedded GHG emissions and advocated for shifts in building designs and operations. Other options to mitigate the impacts of climate change include leveraging wind and solar energy, planting more trees, adjusting food consumption patterns, and direct air capture of CO_2. However, while a variety of strategies may be implemented to lessen the severity of the effects of climate change, most of them are either inadequate, not ready, or too expensive. GHG removal and sequestration technologies are gaining interest as potential decarbonisation solutions that may be used in tandem with emission reductions (Pianta et al., 2021). Many of these decarbonisation solutions, aimed at reducing the effects of climate change and increasing people's ability to adapt to it, have received considerable research and development. However, several questions remain unanswered. To minimise emissions of GHGs, carbon dioxide capture and geological storage (CCS) is widely considered to be a viable, expedient, and secure option (Sun et al., 2021) and has become a vital component of national and international efforts to curb emissions of GHGs (Scott et al., 2013). CCS has emerged as a promising technique in the fight against climate change, with the potential to absorb up to 90 percent of the CO_2 emissions from fossil fuel power stations and other industrial heavy point-emitters (Kahlor et al., 2020).

Capturing CO_2 emissions at their sources, such as power plants or factories, and permanently storing them in underground reservoirs is known as CCS (Alphen et al., 2010). There are additional cases where the captured CO_2 is used in the production of other goods; in these cases, the process is known as "carbon capture and utilisation" (CCU) (Gough and Mander, 2019). Some studies suggest using the collected CO_2 for enhanced oil recovery (Whitmarsh et al., 2019), whereas others advocate the use of the collected CO_2 as a feedstock for industrial operations (Bruhn et al., 2016). Together, CCS and CCU are often referred to in the literature as carbon capture, utilisation, and storage (CCUS) (Osazuwa-Peters and Hurlbert, 2020; Pianta et al., 2021; Wang et al., 2021). More than 200 million metric tonnes of CO_2 have been removed from the atmosphere using this technology since the 1970s (Gibbins, 2019). Without CCS, mitigation costs are confirmed to increase by an average of 138 percent, according to reports (IEA, 2021b).

While interest in CCS has grown in the scientific community and gained attention from organisations and governments worldwide (Rosa et al., 2021), public perception and support for the technology remain controversial. Yet, it must be emphasised that public support is crucial to the ultimate success of CCS (Wang et al., 2021). Although the safety of CCS has been proven in several studies (Ringrose et al., 2017; Ringrose, 2018), according to Gabrielli et al. (2020), the primary barriers to realising the net-zero-CO_2 objective through CCS technology are the accessibility, availability, and acceptance of CO_2 storage facilities. CCS has been around for a while in the industrial world, yet most individuals are still unaware of what it is (Xenias and Whitmarsh, 2018). The absence of public support and the difficulties of implementing CCS in communities have both contributed to the postponement or outright cancellation of some CCS programmes (Witt, 2019).

Critics of CCS claim that it is only a lifeline that helps the oil and gas sector to keep running, and that if the goal is to reduce emissions, then we ought not to be discussing how to store CO_2 so much as we should be looking at ways to prevent it from occurring in the first place. Induced seismicity, dangers associated with CO_2 transport, and the potential for CO_2 leakage are other significant concerns about the CCS technology. Proponents of CCS, however, argue that decarbonisation through capture and storage is the safest, expedient, and secure approach since we do not have the luxury of time to progressively phase out high-emission industries without causing socio-economic instability. CCS has become an essential and integral component of the decarbonisation pathways of nations like Canada, the US, and the EU as they face increasing urgency to fulfil their net-zero CO_2 commitments.

Public opinion and assessment of CCS projects have been the subject of many studies (Boyd et al., 2017; Gough and Mander, 2019; Moon et al., 2020; Pianta et al., 2021; Upham and Roberts, 2011). When new technologies emerge with the potential to reduce GHG emissions, it is important to comprehend the public's acceptance of these innovations and the regulations that will either encourage or stifle their development (Moon et al., 2020). The public's opinion of CCS is as important as the technology's potential as a component of global plans to reduce GHG emissions and slow global warming (Arning et al., 2019). The rate at which this technology may be commercialised, and the overall cost of energy generation are also directly affected by CCS's implementation (Wilberforce et al., 2021).

As with other contemporary energy technologies (such as hydraulic fracturing), CCS has become a divisive topic due to several ongoing debates both in literature and policy. The increasing political obstacles associated with achieving emission reductions at a rate that is considered reasonable heighten the urgency of discussions on CCS as a means of achieving net-zero CO_2 targets (Carton et al., 2020). Initial efforts to implement CCS, spurred by the G8's 2008 decision to increase international collaboration on CCS and aim to start 10 large-scale CCS demonstration projects by 2010, did not materialise on the scale that was needed (Martin-Roberts et al., 2021). Owing to the complexity of the social, political, economic, and public aspects involved, the success of CCS cannot be reduced to engineering alone (Lima et al., 2021). For widespread adoption of CCS, a paradigm shift of unprecedented proportions is likely necessary. According to experts, society will eventually need to regard CO_2 as sewage waste and demand that companies pay taxes or levies for its capture and disposal (Lackner and Jospe, 2017). In Canada, this paradigm shift is still in the distant future, as public awareness, support, and acceptance of CCS remain rather low (Boyd et al., 2017; Seigo et al., 2014; Tcvetkov et al., 2019). There is also the possibility of induced seismicity, which has been shown to significantly influence people's willingness to adopt subsurface technologies (Evensen et al., 2022; Haemmerli and Stauffacher, 2020; Lokuge et al., 2023). However, the impact of induced seismicity, defined as seismic events caused by human activities, has not been well considered in discussions on CCS.

International studies have consistently revealed that the public is inexperienced with CCS technology compared to all other emission reduction technologies (Ashworth et al., 2019; Lima et al., 2021; Upham and Roberts, 2011). The energy economics literature often explores the evaluation of economic prospects, particularly in terms of local job creation and economic activities. These potentials are generally contrasted with the social (equity) and environmental concerns associated with these technologies (Liebe and Dobers, 2020; Parkins et al., 2021). Studies of opinions have also emphasised the need to consult with and compensate communities impacted by new energy projects (Brennan and Van Rensburg, 2016; Chewinski et al., 2023; García et al., 2016).

Surveys on public perceptions of CCS offer contradictory evidence regarding the impact of socio-demographic factors on acceptance of the technology. (Pianta et al., 2021; Tcvetkov et al., 2019). Regarding gender, a survey by Braun (2017) noted that the level of acceptability for CCS is 0.31 points higher among females compared to men. Pianta et al.’s (2021) research, however, found no statistically significant difference between male and female support for CCS. There are also conflicting findings in the literature on the correlation between income and education and CCS support (Ashworth et al., 2019; Braun, 2017; Moon et al., 2020; Pianta et al., 2021).

Despite the useful information that can be gleaned from these studies and the existing public perception literature, the inconsistencies that have been found empirically highlight the risks of relying on survey research for evaluating public preferences and concerns about a complex issue like CCS. There is a noticeable gap in our understanding of public preferences because the literature does not adequately address cross-border CO_2 trade potentials, local community engagement, compensations, information transparency, different monitoring regimes, or induced seismicity as major benefits and risk factors in individuals' evaluation of CCS projects. Using empirically designed vignette scenarios, this research conducts a quantitative examination of individuals' judgements of CCS project proposals in Canada, therefore filling a significant gap in the public perception literature on CCS by considering these factors. By employing a factorial survey (vignette) experiment (FSE), we are able to distinguish between the effects of a variety of complex decision factors that enter individuals' evaluation of CCS, including proximity, storage capacity, fairness of consultation and compensation schemes, transparency of CCS risk assessments, cross-border trade of CO_2, and different monitoring regimes (Auspurg and Hinz, 2015a). Inadequate public awareness of CCS, particularly in relation to its safety, effectiveness in mitigating climate change, and risks associated with seismic activity, implies that using a choice experiment may overwhelm participants and thus result in inaccuracies in measurement (Auspurg and Hinz, 2015a; Auspurg and Jäckle, 2017). By using a vignette experiment, we may get around these limitations and have people rate the pros and cons of various CCS scenarios on an ordinal scale, which reduces the likelihood of social-desirability bias (Liebe and Dobers, 2019, 2020).

Observable and unobserved individual heterogeneity may be investigated using a random intercept model. This offset the effects of unobserved heterogeneity across individuals in their ratings of hypothetical vignette scenarios. As noted by Mehdi et al. (2020), more advanced econometric assumptions, including random effects, may be better for studying potential variation in individuals beyond their reported characteristics. Due to the general public's limited familiarity with CCS (Ashworth et al., 2019; Lima et al., 2021), it is contested whether survey data can accurately gauge support or disapproval of a complex energy technology like CCS (Yang et al., 2016). Therefore, evaluating public perceptions within experimentally designed vignette scenarios may enhance our understanding of the intricate dynamics surrounding public support and acceptance of CCS.

The purpose of this paper, therefore, is to evaluate public perceptions and acceptance of CCS as a climate-mitigation strategy from a socio-psychological perspective using a vignette experimental technique. This distinguishes this paper from the wealth of public perception studies of CCS conducted in Canada and throughout the world. While stated preference techniques tend to focus on individuals' preferences, vignette experiments highlight the significance of societal norms and informal conventions when assessing conventional energy sources (Parkins et al., 2021). Thus, with the use of vignettes, people are able to contemplate alternative methods of building energy systems while keeping in mind the broader social, economic, and environmental settings.

Regardless of this novel aspect, and in line with growing efforts to diversify research on public involvement in the advancement of emerging technologies (Bellamy et al., 2019; Bellamy and Lezaun, 2017), it is critical that this paper be viewed within the existing larger ecology of investigations into the public licencing of unconventional decarbonisation alternatives. Public trust, knowledge, risk, and perception of CCS in relation to its unique impact on induced seismicity are currently understudied. This paper, therefore, seeks to examine individuals' perceptions of the seismic risks associated with CCS and the potential impacts of alternative monitoring strategies (technical and regulatory) on the public acceptability of CCS.

The specific objectives of this paper are fourfold: (1) to investigate public perceptions and acceptance of CCS projects, with a focus on the perceived fairness of CO_2 cross-border trading as part of the implementation of CCS; (2) to examine differences in CCS acceptance across respondent socio-demographic and other characteristics; (3) to analyse different governance and monitoring regimes that affect CCS project acceptance; and (4) to assess the impact of perceived CCS induced seismic/earthquake risks on CCS project acceptance. The consensuses that may be reached from answering these questions will serve as a cornerstone for future discussions in both policy and the literature. The remainder of the paper is structured as follows: The second section examines data and techniques. The third section contains the findings and discussions. The fourth section wraps up the study and offers policy recommendations.

Data and Methods

Study Approach

For this research, a factorial experimental survey was conducted in a national online survey administered in October 2022 throughout Canada. The study received ethics approval from the University of Alberta Research Ethics Board (Pro00123473). The 1,002 respondents who filled out the online survey were all part of the same access panel provided by Survey Engine – survey software designed for academic research (SurveyEngine, 2023). The individuals were sent an invitation to participate in the survey by means of a hyperlink leading to the survey and vignette experiment. Age, gender, level of education, and household income quotas were established to provide a balanced representation of the Canadian population.

The objective of the survey was to gain a comprehensive understanding of the factors that influence individuals' acceptance of CCS plant scenarios. This includes examining the respondent characteristics that contribute to the acceptance of CCS, as well as their knowledge, trust, perceptions of the risks and benefits associated with CCS, and other relevant environmental factors. This enabled us to assess the public's acceptance of CCS and the extent of its societal approval. The survey included seven (7) sections, presenting each respondent with approximately 30 questions. The sections covered themes and questions relating to the environment, knowledge of different low-carbon technologies, perceptions of different risk factors, trust in different institutions, socio-demographic characteristics, and vignette scenarios.

Participants were shown hypothetical scenarios in which a CCS project was proposed to be built within a certain radius of the participant's home. Seven attributes (factors) were used to define this CCS project and its features, with attribute levels varying across vignettes. Similar to prior qualitative research in this field and political and social debates regarding energy development, the selection of these attributes was driven by theories relevant to distributional and procedural fairness in the energy economics literature (Cox et al., 2020; Liebe et al., 2017; Moon et al., 2020; Parkins et al., 2021). Finally, the research drew on the expertise of people in the CCS and energy industries to build the attributes so that they would accurately represent the most common worries people have about projects of this kind.

Study Design

When evaluating CCS projects, several factors outside of the attributes of choice experiments (CE) are likely to come into play, including fairness, information transparency, distributive justice, etc. (Cox et al., 2020; Liebe et al., 2017; Parkins et al., 2021). This makes choice experiments less ideal for inferring causal preferences from structurally more extensive social factors (Liebe et al., 2017). As a result, most multifactorial survey studies separate questions concerning social elements, such as people's sense of fairness or justice, their attitudes, or their own social standards, from the actual elicitation of preferences (Parkins et al., 2021).

Factorial Survey Experiment (FSE) (also known as vignettes) is an alternative research design that takes into account these societal aspects in condensed and detailed scenarios grounded in important decision-making considerations. In FSE, participants are presented with a series of hypothetical scenarios (called "vignettes") that vary from one another according to a predetermined set of characteristics. After reading each scenario, participants are asked to rate it based on how acceptable, supportive, or fair they find it to be. An FSE is a controlled experiment in which the variables or scenario features given in the circumstances are systematically varied, allowing for the isolation of the effects of individual factors that make up the scenario (Liebe et al., 2017). Hence, relevant vignette characteristics and their causal effects may be identified. In addition, theory-led experimental designs and researcher-generated contextual variables allow for the uncovering of causal qualities via the randomization of discrete and interrelated traits, which are assumed to be major predictors of respondents' decision making (Auspurg and Hinz, 2015a). The rating is the dependent variable, and the factors or attributes are the independent variables in multivariate regression analysis.

The following are necessary for any FSE to be conducted successfully: attribute levels and the total number of attributes in each scenario. The so-called complete factorial, or the total number of scenarios that may be evaluated, is calculated by adding up all conceivable combinations of attributes. Often, the number of scenarios in vignette research will be too high to show to all respondents. Thus, if this is the case, an experimental design is employed to cut down on the sample size of vignettes given to respondents, but it should still be feasible to isolate the influence of individual variables. Researchers must decide on a scale for capturing respondents' ratings (e.g., 5, 7, or 11-point scales are often used). See (Auspurg and Hinz, 2015b, 2015a; Auspurg and Jäckle, 2017) for details.

For the seven different vignette attributes selected, five attributes had three levels and two had six levels (Table 1). First, there has been a substantial discussion in the literature on the possible advantages and discomforts associated with living close to energy plants. More economic activity, employment, and demand for local products and services may result from closer proximity, but this may also lead to more traffic, noise, and rivalry for farmland. People's openness to CCS plants in their communities may be influenced by these nuanced trade-offs.

Table 1: FSE Attributes and Attribute Levels.

Attribute	Levels	Attribute Level
Proximity	1	Less than 50 km from the home
	2	Between 50 km and 100 km from the home
	3	More than 100 km from the home
Implementation	1	Group of companies
	2	Government and industry partnership
	3	Federal government
Risk Assessment Information	1	Public will not have access to information
	2	Information available online at the approval stage
	3	Information available as long as the CCS plant is running
Consultation	1	Individuals will not be consulted
	2	Individuals will not be consulted except relevant NGOs
	3	Residents of directly affected communities will be consulted
	4	Residents of directly affected and surrounding communities will be consulted
	5	All residents in the province will be consulted
	6	A national consultation will take place
Benefits	1	No financial benefits
	2	Contract preferences for local businesses in host community
	3	Direct financial compensation to individuals in host community
Storage Capacity	1	5% of total household emissions
	2	10% of total household emissions
	3	20% of total household emissions
Cross-border import of CO_2	1	Only domestic
	2	Domestic and from the Netherlands
	3	Domestic and from the UK
	4	Domestic and from Norway
	5	Domestic and from the USA
	6	Domestic and from Germany

People exhibit a NIMBY (not in my backyard) effect when they demonstrate a free-rider preference by being in favour of a project conceptually but opposed to it when it is located in close proximity to their own property (Wolsink, 2006). A survey by Krause et al. (2014) found that many Americans were in favour of CCS facility operations as long as they were situated elsewhere in the country but changed their minds when they learned that one would be constructed in close proximity to their homes. However, a national survey in Canada conducted by Boyd et al. (2017) revealed that those who live closer to a CCS facility are more likely to be in favour of such initiatives. In an experimentally constructed situation, these variations increase the possibility of a different outcome. Therefore, the study investigated CCS plant locations and proximity to communities and homes to explore the relationship between proximity and acceptance of CCS project facilities. The proximity of CCS plant locations was modelled, ranging from “less than 50 km from the home”, to “between 50 km and 100km from the home”, and “more than 100 km from the home”.

Second, the extent to which the public has trust and confidence in those who will make and supervise critical decisions at a CCS plant may be correlated with their willingness to support the project (Ashworth et al., 2019). This directly translates to the trust the public has in those entities. Publicly administered facilities may be seen quite differently by different people (Cvetković et al., 2021). Some may have a lot of faith in them, while others may consider them inefficient and bureaucratic. In contrast, privately managed institutions may be effective, but their business motives and social benefits are up for debate. Many energy providers are for-profit businesses, so they must be closely monitored and regulated if the public is to get any benefit from their services (Strielkowski et al., 2020). In order to address regulatory concerns with respect to the execution of CCS projects in Alberta, the province has established a government-industry CCS Development Council (IEA, 2008). These connections were modelled into the implementation attribute as “group of companies”, “government-industry partnership”, and “federal government”.

Third, when it comes to siting CCS projects, it's important that the public feels that they have been included, that they have access to relevant information, and that they have a say in the final decision. Having the public feel that they were included fairly in the planning process is a key part of what is known as “procedural justice”. According to a survey by Xenias & Whitmarsh (2018), experts who involve the public in discussions about CCS are more likely to see its benefits and rank it higher than those who do not. Hasan et al. (2018), however, pointed out that the act of public engagement in a project that has already been decided may be better understood as a "rhetoric" activity than as a way to improve the system.

Aitken (2010) reveals that people's perceptions of procedural justice and, by extension, the fairness of the result, are boosted when they are given a greater role in making decisions and shaping plans. The study adapts this factor to model public engagement as “individuals will not be consulted”, “individuals will not be consulted except relevant NGOs”, “residents of directly affected communities will be consulted”, “residents of directly affected and surrounding communities will be consulted”, “all residents in the province will be consulted”, and “a national consultation will take place”.

Fourth, the public's acceptability of CCS plants in their communities may heavily hinge on how well officials manage and communicate information about the plants' risks assessment. It is important to stress that the confidence people have in the project's stakeholders has a direct bearing on how well information is disseminated to the local population (Ter Mors et al., 2010).

Many studies have shown that people in a community are more likely to support the development of energy technology when they have access to relevant information and procedures are talked about openly (Firestone & Kirk, 2019; Musall & Kuik, 2011).
According to research by Brennan & Van Rensburg (2016), two-thirds of respondents would rather have complete transparency, even if it means accepting a reduction in pay. It was also discovered that having community representation in decision-making reduced the amount of money that needed to be paid as compensation to community members. This study takes this idea and models its effects on openness and information sharing at various stages as "public will not have access to information", or "information available online at the approval stage" and "information available as long as the CCS plant is running".
Fifth, remuneration is a significant component influencing local acceptability of energy technologies (Jacquet, 2012; Lienhoop, 2018; Parkins et al., 2021). Monetary incentives dispersed throughout the community, rather than just to the afflicted people, may outweigh concerns about closeness (Hoen et al., 2019; Jacquet, 2012). But nevertheless, localised monetary incentives might be seen as bribery; therefore, it is not unquestionable that compensation programmes can overcome community hostility (Aitken, 2010; Kerr et al., 2017). Several different types of remuneration have been proposed in the literature, including cash payments to residents, payments depending on how close a home is to the affected area, and community infrastructure investments (García et al., 2016; Lienhoop, 2018). In light of these findings, the research builds a model of compensation that takes into account several measures of distributive justice ranging from "no financial benefits", to "contract preferences for local businesses in host community", and "direct financial compensation to individuals in host community".
Sixth, several of the major emitting areas and nations have been actively working to improve their CCS technology in order to lower costs and better understand their storage potential (Wennersten et al., 2015). Concerns about CCS stem from its supposedly limited storage capacity, which is seen by some as a major drawback to the technology (Oltra et al., 2010). Various aspects of CCS have been the subject of intensive engineering and feasibility research, including its capture, transit safety, and cutting-edge monitoring technologies (Bertram & Merk, 2020; Gonzalez et al., 2021; Løvseth et al., 2021; Merk et al., 2022). However, as CCS is not very familiar to the general public, information on individuals' understanding of CCS plants' storage capacities is scarce. The storage capacity of CCS can be categorised into three components: the geological storage capacity or potential of a given country, the storage capacity of individual CCS plants, and the annual injection capacity per CCS plant. In this paper, storage capacity refers to individual CCS plant storage capacity. Therefore, experts' advice was used to model the storage capacity attribute of CCS scenario plants relative to a percentage of total household emissions in a given province as "5% of total household emissions", "10% of total household emissions", and "20% of total household emissions".
Finally, the spatial complexity of climate mitigation strategies requires a cooperative approach, and various nations have distinct comparative advantages that may be used to address this

problem. Various countries and regions have enacted treaties and procedures to prevent the illegal dumping of garbage on their territories. Protecting the marine environment from pollution due to the dumping of wastes at sea has been a top priority for many years, and two separate global treaties have been at the forefront of this effort: the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (London Convention) and the Protocol to the Convention, 1996 (London Protocol) (Bergesen et al., 2019). With a few exceptions, such as dredging debris, fish waste, inert, and inorganic geological material, the Protocol prohibits the disposal of all wastes or other substances. It was later proposed in 2006 by the UK, Norway, and others that the London Protocol be amended to include “CCS processes for sequestration” among the wastes that may be considered for dumping (Dixon & Birchenough, 2021).

This establishes a legal framework within the realm of international environmental law for the purpose of regulating the process of CCS. Nevertheless, it has been acknowledged that there might be a potential need for cross-border exportation in situations when a participating country lacks enough appropriate geological storage capabilities but still wants to use CCS to mitigate emissions (Bergesen et al., 2019; Dixon & Birchenough, 2021; Role et al., 2012). Countries, including those that are part of this regulatory framework, need public consent to authorise or prohibit the cross-border importation of CO_2. Despite Canada's relatively low contribution to global emissions, it has a significant share of around 15% in the current global capacity for CCS/CCUS. This provides a comparative edge for the nation in international CO_2 trade. While its economic advantages are undeniable, there may be a price to pay for accepting CO_2 since it is considered a waste product and may cause seismic activities. This idea was used to model the sources of CO_2 (cross-border import) for the proposed CCS plants as “only domestic”, “domestic and from the Netherlands”, “domestic and from the UK”, “domestic and from Norway”, “domestic and from the USA”, and “domestic and from Germany”.

*A **government-industry partnership** has been tasked to build a carbon capture and storage (CCS) plant **more than 100km** from your home. The plant can store emissions equivalent to **20% of the emissions** generated by households in your province. It will store **CO_2 from domestic sources and CO_2 imported from the Netherlands**. **People like yourself will not be consulted but relevant NGOs will be involved** in the regulatory approval process. **At the regulatory approval stage**, the public will be informed about the CCS plant’s earthquake risk assessment. **The CCS plant operator does not provide any financial compensation to the host community**.*

Given the assumptions stated above, **how acceptable** is this CCS development scenario to you?

-5	-4	-3	-2	-1	0	1	2	3	4	5

Completely unacceptable

neither acceptable nor unacceptable

Completely acceptable

Figure 1: Example of a Vignette Scenario used in the Experiment

The full factorial design generated from the seven attributes resulted in 8748 unique vignettes. NGene (ChoiceMetrics, 2014) was used to make a fractional factorial design, which cut down on the number of sets even more. The study chose an orthogonal design with two-way interactions because the attributes can change in different ways within and between vignettes (Auspurg and Hinz, 2015a). The fold-over method was used to produce the two-way interactions, and then a sample was systematically taken (Auspurg and Hinz, 2015b). There was a total of 72 individual vignettes used in the final design.

To control for potential learning and order effects in vignette evaluations, the study randomly (without replacement) assigned each respondent six vignettes from the pool (Auspurg and Jäckle, 2017). Each respondent was only asked to rate six vignettes (on an 11-point scale) in an effort to reduce mental weariness (see Figure 1 for an example). The vignette structure asked for ratings from -5 to +5, with the extremes being described in text as "completely unacceptable" to "completely acceptable", providing a range of judgements large enough to mitigate the risks of censored responses and outliers (Kübler et al., 2018).

Econometric Approach

Vignette data may be analysed using a variety of statistical methods. In most studies, including this one, participants react to many vignettes, and it is likely that their individual evaluations of each scenario are not independent but rather connected with one another (Auspurg and Hinz, 2015). Several approaches, such as clustered standard errors, random effects, and mixed effects regression models exist to consider such dependencies (Liebe et al., 2017). Taking into consideration the nested nature of the data (each respondent rated 6 vignettes) and individual variations across participants, random effects regression models were employed for this analysis (Atzmüller and Steiner, 2010). Employing a simple least squares regression and neglecting the fact that respondents rate many vignettes would result in biased standard errors of the model coefficients (Bosker, 2012).

All participants read a short script at the start of the experiment (based on the stated preference literature). The script educated responders about the hypothetical nature of the vignette scenarios and created a baseline of comprehension. Consequently, the study presumes that the respondents' interpretations of the acceptance responses were consistent. Therefore, there was no need to account for differences in response scales, also known as "differential item functioning," or DIF, during the model estimation phase (Greene et al., 2021), as it was assumed that all respondents would rate a given CCS plant scenario as "completely acceptable" if it fully satisfied their preferences.

The linear random intercept model is specified as:

$$y_{ij} = \beta' x_{ij} + \mu_j + e_{ij} \quad (1)$$

Where y_{ij} is the rating variable for the ith respondent of the jth vignette scenario, x_{ij} is a vector of CCS project attributes, e_{ij} are respondent level errors, and μ_j are vignette level errors or random effects. The vector β collect the coefficients of the attributes, also called fixed effects. The respondent level and vignette errors are assumed independent, with respondent level errors following a normal distribution with variance $\sigma_{e.}^2$ The distribution of the random effects μ_j is assumed to be:

$$\mu_j \overset{iid}{\sim} N(0, \sigma_u^2) \quad (2)$$

Where σ_u^2 is the vignette level variance. In other words, a normal distribution is assumed for the random effects, which is consistent with the common assumption that they are independent and identically distributed (therefore homoscedastic) across vignette levels.

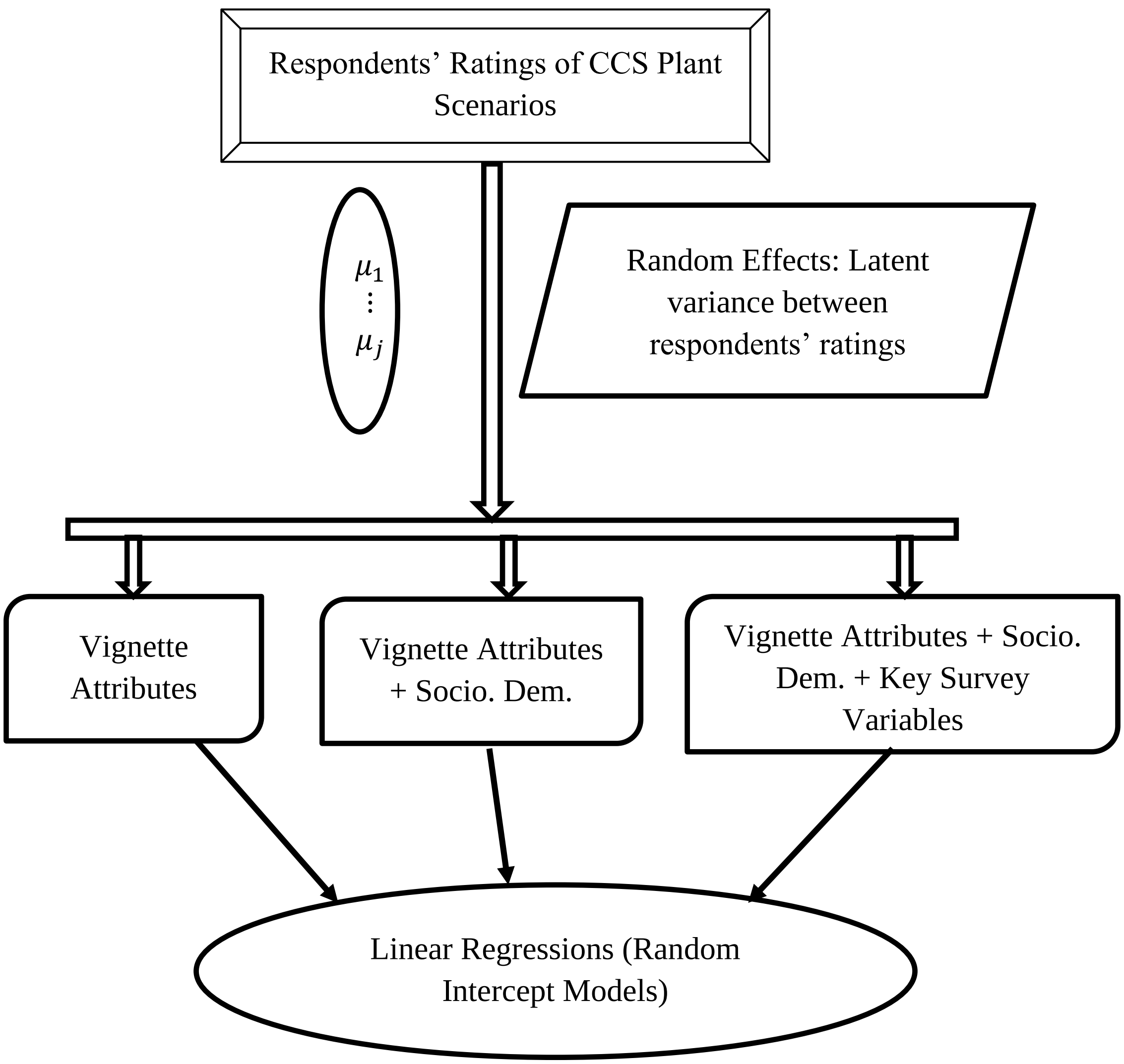

Figure 1: Flowchart of Random Effects Model Analysis

Another assumption is made, which is not often stated explicitly: that the random effects on the covariates are independent on average. This is known as the exogeneity of the covariates, and it is stated as follows:

$$E(\mu_j | x_{1j}, x_{2j}, \ldots, x_{nj}, z_i, v_i) = 0 \qquad (3)$$

Exogeneity ensures the unbiasedness of the estimates (Ebbes et al., 2004; Grilli & Rampichini, 2011, 2015; Kim & Frees, 2007).

The base model (model with only attributes – equation 1) was extended to include respondents' socio-demographic variables.

$$y_{ij} = \beta' x_{ij} + \gamma' z_i + \mu_j + e_{ij} \qquad (4)$$

Where z_i is a vector of respondents' socio-demographic variables. The vector γ collect the coefficients of the respondents' socio-demographic variables. Finally, equation 4 was then extended to include other key survey variables.

$$y_{ij} = \beta' x_{ij} + \gamma' z_i + \delta' v_i + \mu_j + e_{ij} \qquad (5)$$

Where v_i is a vector of other survey variables and the vector δ collect the coefficients of those survey variables.

$$x = \begin{bmatrix} proximity \\ implementation \\ risk\ info \\ consultation \\ benefits \\ storage\ capacity \\ cross-border\ import \end{bmatrix}; z = \begin{bmatrix} age \\ gender \\ household\ income \\ education \\ household\ size \end{bmatrix}; and\ v = \begin{bmatrix} CCS\ knowledge \\ CCS\ benefits \\ CCS\ risks \\ environmental\ risks \\ institutional\ trust \\ CCS\ support \\ induce\ seismisity \end{bmatrix}$$

Stata 17.0 was used to estimate the random intercept models based on the idea that participants' acceptance benchmarks would change between vignettes with different levels of attributes (Auspurg & Hinz, 2015a). The likelihood ratio test demonstrates that this model specification performs better in the analysis when compared to an ordinary least squares regression model.

Results

Sample and Descriptive Data Analysis

Table 2 below presents the summary statistics of the respondents' characteristics. From the results, most respondents (67.97%) are in their prime working lives (between the ages of 19 and 59). In this sample, about 17.76% are young adults (ages 19–29), 33.14% are adults (ages 30-49), 17.07% are late adults (ages 50–59), and 32.04% are seniors (ages 60 and more). This estimate is quite similar to the official data from Statistics Canada, which puts the median age at 41 years old (Statistics Canada, 2021b).

In terms of gender, the results show that males represented 47.5%, females 51.0%, and non-binary, transgender, and non-identified people 1.10%. Since women constitute 50.7% of the Canadian population over the age of 20 (Statistics Canada, 2021b), and around 51.40% of those who completed the survey fall into this demographic, it appears that this sample accurately represents the country as a whole. Considering the stereotype that only men are interested in the energy sector, it's encouraging to see that women make up more than half of the respondents.

Participants' levels of education varied greatly, from advanced degrees to certificates in technical fields. The results (Table 2) indicate that 26.35% of the respondents are college graduates, 10.28% completed trade or technical school, 21.16% hold an undergraduate degree, 10.98% hold a graduate degree, and 1.2% did not specify their level of education. When compared to the average of Canada, where only around 65% of the workforce has some kind of post-secondary education, this is an above-average figure (Statistics Canada, 2019). The fact that it was conducted online and included non-working adults (such as retirees) makes this inevitable.

Table 2: Summary Statistics of Respondents' Socio-demographics and Survey Variables

Variable	**Description**	**Sample (n = 1,002) (Percentages)**	**Census Benchmark (2021)**
Age (years)	19 – 29	17.76	19.99
	30 – 39	17.17	14.46
	40 – 49	15.97	12.81
	50 – 59	17.07	13.43
	60 +	32.04	25.33
Gender	Male	47.50	49.30
	Female	51.40	50.70
	Other	0.80	-
	Prefer not to say	0.30	-
Level of Education	College	26.35	21.80
	Graduate	10.98	8.40
	High School	30.04	26.70
	Technical or trade	10.28	8.70
	certificate	21.16	17.50
	Undergraduate	1.20	-
	Prefer not to say		
Willingness to take	Completely	8.48	-
Risks	unwilling	23.35	-
	Unwilling	31.54	-
	Neutral	29.14	-
	Willing	7.19	-
	Very willing	0.30	-
	Prefer not to say		

Place of Residence	Rural	13.27	17.80
	Urban	86.73	82.20
Political Orientation	Green	47.01	-
	Left	22.85	-
	Right	29.44	-
	Centrist	0.70	-

	No. of obs	***Mean***	***Median***	***Min***	***Max***	***SD***
Income	921	129,061.80	54,000	2,000	50,000,000	1,648,342
Household size	1,000	2.50	2	1	14	1.48

Different people will react differently to the same risk because optimists will concentrate on the prospective benefits and pessimists will dwell on the potential drawbacks of any given option (Dohmen et al., 2018). Frey et al. (2021) argue that self-reported propensity measures are more likely to capture individual variations in risk preferences linked to sociodemographic characteristics like sex and age, hence, this is what was done. Respondents were asked about their willingness to take risks. The results (Table 2) show that 8.48% of the respondents were completely unwilling to take risks, 23.35% were unwilling to take risks, 29.14% were willing to take risks, 7.19% were very willing to take risks, and 31.54% were risk neutral. This implies that more than a third of the respondents (36.33%) are risk lovers, about a third are risk averse (31.83%), and about a third are risk neutral (31.54%). The sample was also representative of both rural and urban inhabitants. More than three-quarters (86.73%) of the survey respondents said they were in metropolitan cities, while 13.27% said they were in a rural place. Using Stephanie & Graham (1989) study as a guide, respondents were presented with a triangle to indicate which vertex best describes their political orientation (with the vertices corresponding to left, right, and green). The results in Table 2 above show that the majority of the respondents (47.01%) were green-oriented, 22.85% are left-wing, 29.44% were right-wing, and 0.70% were centrists (they did not lean toward any of the political orientations).

The income variable was measured as both continuous and categorical, and the majority of the respondents provided their approximated income figures. The few respondents who provided the income interval were then extrapolated to get an approximate figure. The data shows that the incomes of the respondents are distributed quite unevenly. Incomes range from $2,000 to $50,000,000, with a median of $54,000 and a mean of $129,062. According to a Statistics Canada (2022) report from 2020, the median after-tax income for Canadian families and single people was $66,800. Our sample may not be statistically representative of the Canadian public at large (a potential selection bias), but it does give insight into a subset of the population that may contribute a wide variety of viewpoints to the question of whether or not the public would approve a CCS project. The household sizes of the respondents likewise ranged widely, from one to fourteen members, with a mean of 2.5 and a median of 2. The typical Canadian household, according to Statistics Canada (2021), has 3.2 people. This reveals some dynamics in the socio-demographics of the respondents.

Summary Statistics of Selected Survey Variables

Respondents' objective knowledge about CCS-induced seismicity was assessed. The results (Table 3) show that about two-third of the respondents (65.97%) responded true to the question, "CCS will always cause earthquakes, which will always be felt by humans on the surface of the earth". According to the science, it is extremely unlikely for an earthquake of this magnitude to be caused by CCS activities. Consequently, an affirmation of the veracity of this assertion indicates a deficiency in one's comprehension of the technology. This suggests that a significant portion of the population lacks familiarity with the scientific principles underlying the technology. Respondents were also asked to indicate their general level of support for the CCS technology. The results in Table 3 below show that a significant number of the respondents either support (31.30%) or strongly support (11.57) the technology. While about 12.50% oppose or strongly oppose (9.71%) the technology. 34.92%, however, neither support nor oppose the technology.

Table 3: Summary Statistics of Survey Variables

Variable	**Description**	**Sample (n = 1,002) (Percentages)**
CCS Induces Seismicity	True	65.97
	False	34.03
CCS General Support	Strongly oppose	9.71
	Somewhat oppose	12.50
	Neither support nor oppose	34.92
	Somewhat support	31.30
	Strongly support	11.57
CCS Knowledge	Never heard about it	22.85
	Heard about it	24.55
	Know just a little	35.43
	Know a fair amount	12.57
	Know a great deal	4.59
Climate change risks	None existing	6.19
	Low	15.97
	Moderate	34.93
	High	41.82
	Prefer not to say	1.10

Trust in fed gov't energy regulator	Not at all	24.45
	A little	51.20
	A lot	17.76
	Prefer not to say	6.59
CCS will increase economic growth	Not at all	13.57
	Somewhat	36.23
	Very little	31.24
	Very much	10.78
	Prefer not to say	8.18
CCS will lower the drive to cut CO_2 emissions	Not at all	10.38
	Somewhat	40.82
	Very little	27.15
	Very much	14.47
	Prefer not to say	7.19

Respondents' subjective knowledge about CCS was assessed in the survey. The summary statistics in Table 3 above show that about 22.85% of respondents said they never heard about CCS while about 24.55% of the respondents reported to have heard about it. About 35.43% know just a little and about 12.57% know a fair amount. However, only about 4.59% reported to know a lot about the CCS technology. Despite its existence for decades, the literature has consistently reported low levels of knowledge and awareness about the technology (Ashworth et al., 2019; Lima et al., 2021; Wang et al., 2019). Although some studies have reported relatively high levels of CCS knowledge in Canada (Boyd et al., 2017; Zhang et al., 2022), the lack of proper understanding of the technology has led to questions about the validity of using only surveys to assess public support for the technology.

The survey also included an assessment of people's perceptions of the risks associated with climate change. The results indicate that a significant proportion (41.83%) of the participants hold the belief that the risks associated with climate change are of a very high magnitude, while around 34.93% of the respondents perceive these risks to be of a moderate level. However, around 15.97% of individuals hold the belief that risks associated with climate change are minimal, and approximately 6.19% maintain the opinion that climate change risks do not exist. The acceptability and support for various mitigation techniques are significantly influenced by individuals' beliefs on the risks associated with climate change (Evensen et al., 2023; Kácha et al., 2022; Spence et al., 2010). Acceptance of CCS, however, may be driven by more prominent motivations, given the numerous facets of CCS, including economic development, distributive fairness and justice, induced seismicity, and climate mitigation.

The survey also assessed respondents' perceptions about CCS impact on economic growth and the need to reduce emissions. The summary statistics in Table 3 show that about 10.78% of the respondents believe that CCS will increase economic growth very much, while about 31.24%

believe it will increase economic growth just a little. 36.23% believe it will increase economic growth somewhat, while about 13.57% believe it will not increase economic growth at all. Regarding the need to transition to lower carbon economies, about 14.47% believe it will very much lower the drive to cut down on emissions, while about 27.17% believe that the risk of lowering the drive to cut down on emissions is very little. The majority (40.82%), however, believe it will somewhat lower the drive to cut down on emissions, while only about 10.38% believe it will not lower the drive to reduce emissions. There are several opinions on the importance of the CCS technology. Some contend that CCS only serves as a lifeline for the oil and gas sector to sustain its operations (Gonzalez et al., 2021), while others advocate for its substantial contribution to climate change mitigation (Longa et al., 2020).

The survey also explored individuals trust in institutions, particularly federal government energy-regulating institutions. Table 3 above shows that about 17.76% of the respondents have a lot of trust in federal government energy regulators, while the majority (51.20%) have just a little trust in government energy regulators. However, about one quarter (24.45%) of the respondents do not have any trust in federal government energy regulators. The level of trust placed in government energy organisations is indicative of the degree of confidence individuals have in their ability to effectively manage energy-related matters (Stretesky et al., 2023; Truong et al., 2019; Yang et al., 2016). The delegation of monitoring and regulating responsibilities for a complex energy technology like CCS may be limited to organisations that have a high level of public confidence.

Summary of Vignette Ratings

Regarding CCS project vignette ratings, respondents provided their acceptance ratings to the vignette scenarios presented to them. Figure 3 shows a bell-shaped rating distribution (excluding the two extremes), with a mean acceptance rating of -0.33 and a standard deviation of 2.93. The figure depicts that about 13.29% of the respondents view the proposed CCS plants as completely unacceptable, 14.95% view them as neither acceptable nor unacceptable, and about 4.66% view them as completely acceptable.

It is also interesting to note that after excluding the middle ratings, there appears to be a balance between the opposers and supporters of the proposed CCS plants (43.45% opposers and 41.61% supporters). This indicates that unique CCS plant features have the potential to tip the neutral ratings to either side of the balanced scale. This observation is consistent with that of Whitmarsh et al.’s (2019) cross-national survey, which also shows a relatively lower level of support for CCS in Canada when compared to the United States, the United Kingdom, and Norway.

However, according to Wang et al. (2021) findings, participants in a randomised control experiment conducted among undergraduate students in China exhibited a noteworthy level of support for CCS that was much higher than the average level. This increase in support was shown after the participants were exposed to social norm information. This suggests that respondents' values and norms influenced their assessments of CCS plant scenarios.

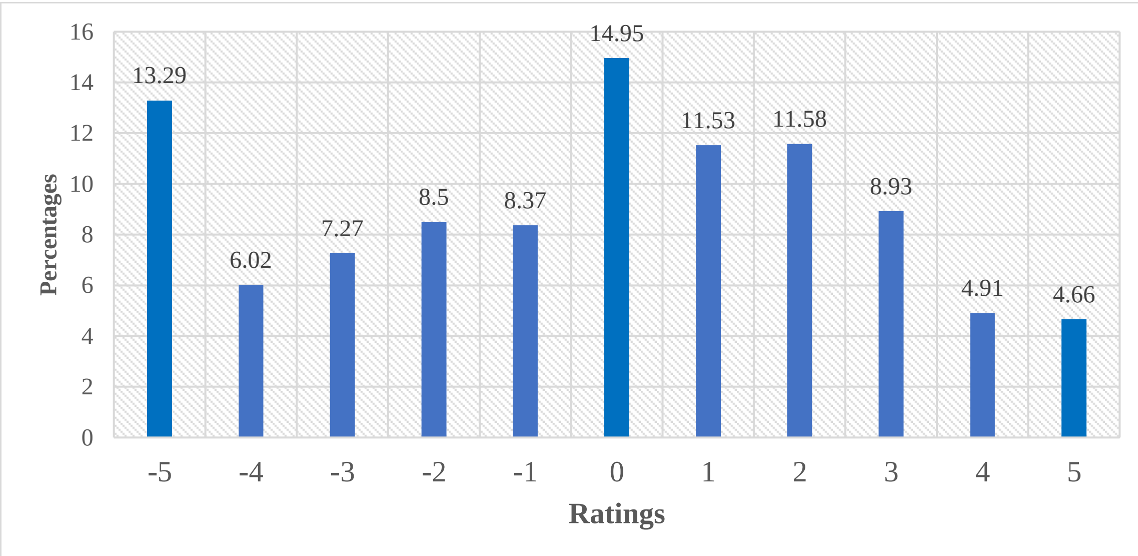

Figure 2: Acceptance vignette ratings

Governance and Monitoring of CCS Projects

Shale gas reservoirs are proposed to be the storage wells for captured CO_2, and induced seismicity monitoring is an essential component of those reservoirs as well as managing and mitigating the latent risks related to induce earthquakes. CCS plants may be particularly susceptible to monitoring on a regional and global scale because of the distinct signature of climate change and the localised nature of CCS plant risks (Keeling et al., 2011). The science of the CCS technology guarantees its safety. However, Lackner & Brennan (2009) noted that the public is generally worried about technical solutions that lead to situations that might spin out of control (as can be seen in the discussions around the use and development of artificial intelligence). The social licencing of CCS might be improved by exposing its monitoring and administration to public scrutiny and by entrusting several organisations with the building of a decision tree capable of handling improbable situations.

Respondents were asked about who should be responsible for the evaluation of site-specific conditions of CCS projects (Figure 4). 23.05% of the respondents indicated that the federal government should be entrusted with that responsibility; 18.46% indicated that an independent body should be set up to handle that; 17.27% indicated it should be handled by CCS operators; and 16.47% indicated that it should be the responsibility of an environmental organisation. Next to those institutions are the provincial government (8.88%), research institutions and universities (8.48%), taxpayers (5.79%), and specialised politicians (1.6%).

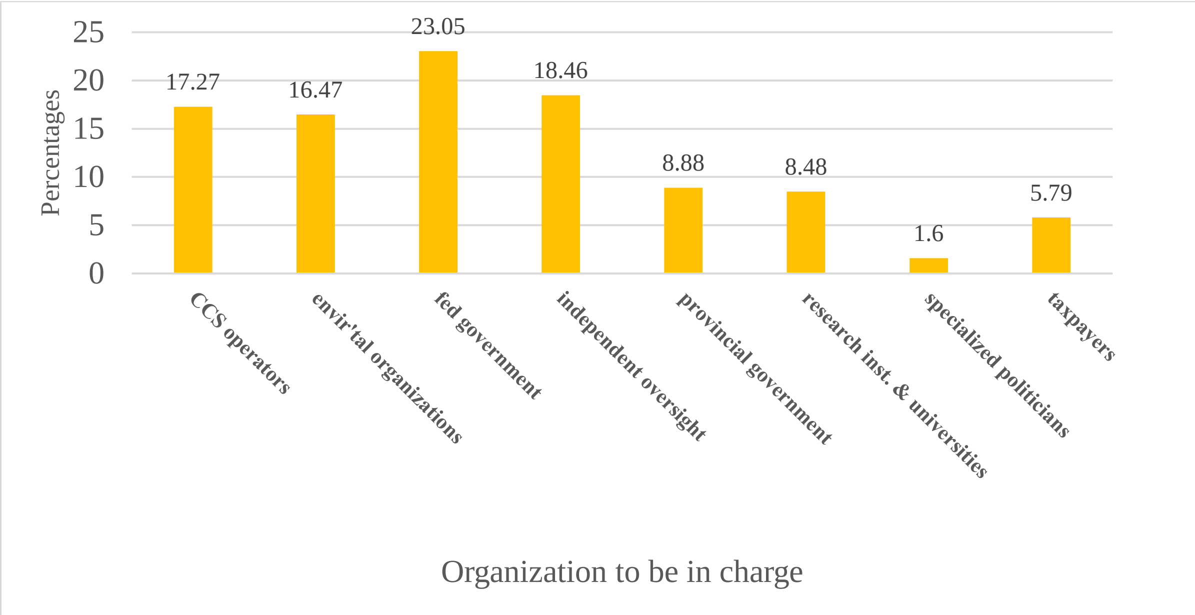

Figure 4: Organisation that should be responsible for evaluating CCS site-specific conditions

(In your opinion, which organisation should be responsible for the evaluation of site-specific underground conditions for storing CO_2 long term?)

A significant site-specific factor that raises concern among stakeholders is the potential for CO_2 leakage from CCS facilities (Tcvetkov et al., 2019). The leakage of CO_2 can result in significant ramifications for the surrounding ecosystems, including acidification and pollution caused by the mobilisation of heavy metals (Elzahabi & Yong, 2001). It is anticipated that the oversight of such a significant matter will be delegated to institutions possessing a high degree of proficiency in the field and deemed trustworthy by the general populace.

The participants were asked in a targeted manner regarding the entities that ought to assume the responsibility of monitoring the potential leakage of CO_2 (Figure 5). The majority of the respondents (27.15%) indicated that CCS project operators should monitor potential CO_2 leakages. The federal government (18.16%), independent organisations (16.97%), and environmental agencies (16.57%) were the other top four institutions respondents indicated should handle the monitoring of CO_2 leakages. Provincial governments (9.28%), research institutions/universities (5.89%), taxpayers (3.89%), and specialised politicians (2.1%) were the least preferred institutions for the monitoring of CO_2 leakages.

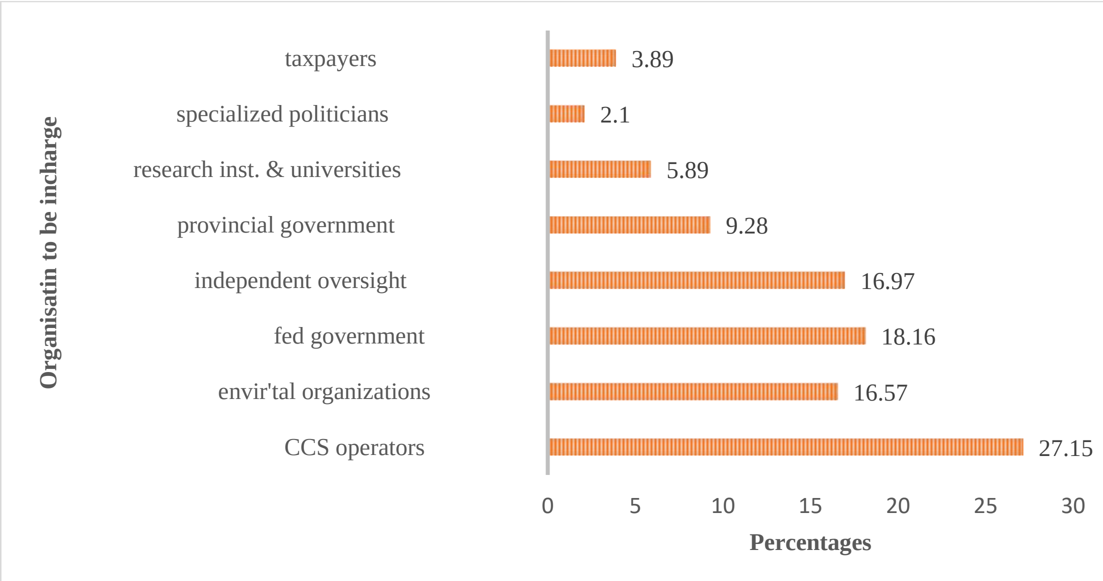

Figure 5: Organisation that should be responsible for monitoring CO_2 leakage during operations

(In your opinion, which organisation should be responsible for monitoring CO_2 leakage during operations?)

A key site-specific concern about CCS wells is the possibility of induced seismicity. Even though the chances of CCS-induced seismicity are slim in many regions, the dissemination of information pertaining to seismic monitoring endeavours has been observed to elicit heightened concerns regarding potential hazards (Seigo et al., 2011). In fact, it is the primary determinant of support or resistance towards subsurface energy technologies, making it the most crucial risk factor (Evensen et al., 2022; Haemmerli & Stauffacher, 2020; Lokuge et al., 2023). Nevertheless, the topic of induced seismicity has not received much attention in recent conversations around CCS. Given the significance of this matter, it is very likely that individuals would delegate the task of monitoring to institutions that they not only have faith in but also possess a strong belief in their competence.

Participants were asked about which institutions should be responsible for monitoring CCS-induced seismic risks (Figure 6). The results show that the majority of the respondents (21.46%) noted that the CCS operators should be in charge of monitoring seismic risks. The federal government (20.16%), independent (17.56%), and environmental organizations (16.77%) were the other top four institutions that respondents indicated should be responsible for monitoring induced seismic activities. These findings suggest that a combined effort has a better chance of influencing public opinion. Similar results from a study performed by Boroumand, (2015) revealed that respondents favoured a team-based strategy for seismicity education.

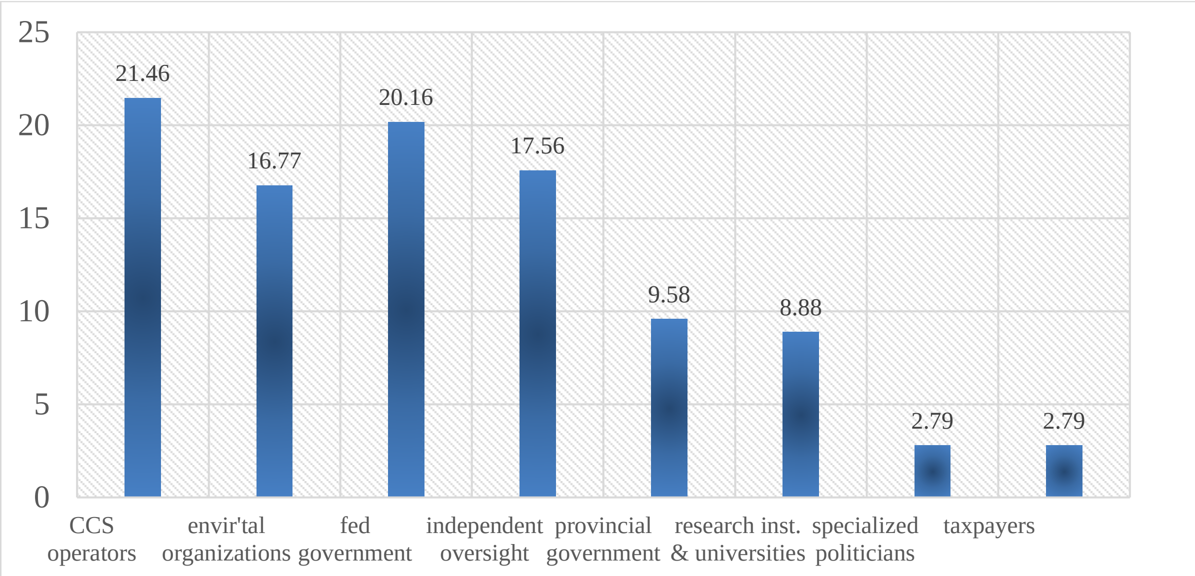

Figure 6: Organisation that should be responsible for monitoring CCS seismic risks

(In your opinion, which organisation should be responsible for monitoring CCS seismic risks during operations?)

Finally, when respondents were asked about the minimum acceptable level of monitoring to allow for the operation of a CCS plant (Figure 7), 40.92% indicated that it should be able to detect and mitigate earthquake risks. 21.96% indicated that monitoring should be able to assess the likelihood and severity of earthquakes. 20.46% indicated that monitoring to observe seismic risks will be sufficient, while only about 16.67% indicated that the monitoring should be able to forecast the likelihood of earthquakes.

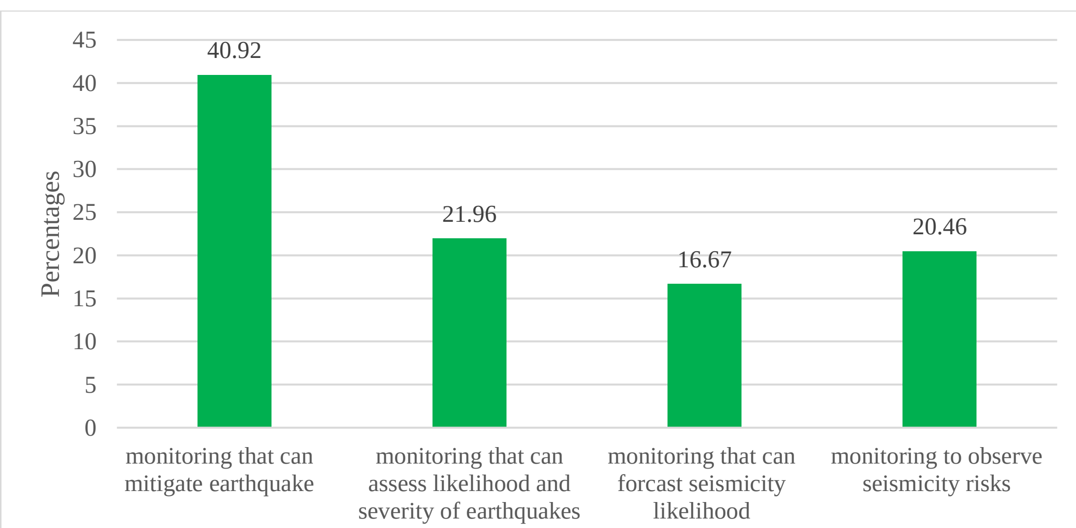

Figure 7: Minimum acceptable level of monitoring of CCS projects

(In your opinion, what should be the minimum acceptable level of monitoring of CO_2 storage facilities to assure their safe operations?)

Results of Random Effect Models

Table 4 presents the results of the random effects regression models, i.e., random intercept models of CCS acceptance. Models 1 include only vignette attributes as independent variables and CCS acceptance rating as the dependent variable. Models 3 and 4 add respondents' characteristics and principal components of heterogeneity survey variables to the model 1. The Breusch and Pagan Lagrangian multiplier test for random effects show that the random intercept model specification is preferred over an ordinary least squares regression model *(prob > chibar2 = 0.0000).* The intra-class correlations for the base model is 0.6334, and indicate a moderately high correlation of the six responses per respondent. Further, to test whether respondent ratings were independent of the vignette attributes included in the vignette scenarios, respondents who rated all six scenarios as completely unacceptable (-5) or completely acceptable (+5) regardless of the attribute levels were excluded for two additional separate models. Comparing the results of these two models without the extreme ratings to the base model, we do not find any significant differences. This suggests that the estimates are robust and that the vignette attributes and their levels influence respondents' ratings. The coefficient estimates for each attribute are presented relative to the benchmark level of that attribute (called status quo in CE literature) in the context of CCS development in Canada.

Cross-border import of CO_2 for storage across models has the strongest effect on CCS plant scenario acceptance. Measured against storing only domestically emitted CO_2, the least preferred scenario involves importing CO_2 from Germany (-0.739) to be stored in CCS plants in Canada. This negative effect on acceptance from the cross-border importation of CO_2 is not only in relation to Germany but also to other countries such as the Netherlands (-0.728), the UK (-0.674), the US (-0.588), and Norway (-0.580).

Table 4: Results of Random Effects Regression Models

Variables	Acceptance	Socio-dem.	Full model
Implementation			
gov't-industry partnership	0.119*	0.132**	0.160**
	(0.062)	(0.066)	(0.074)
fed gov't	0.103*	0.105	0.100
	(0.061)	(0.065)	(0.072)
Proximity			
between 50 km and 100 km	0.136**	0.175***	0.171**
	(0.060)	(0.062)	(0.071)
more than 100 km	0.241***	0.265***	0.250***
	(0.062)	(0.065)	(0.071)
Capacity			
10% of hh emissions	-0.024	-0.031	-0.005
	(0.060)	(0.064)	(0.073)

20% of hh emissions	0.014	0.040	0.110
	(0.061)	(0.064)	(0.073)
Cross-border import of CO_2			
domestic and the Netherlands	-0.728***	-0.718***	-0.701***
	(0.096)	(0.101)	(0.111)
domestic and the UK	-0.674***	-0.685***	-0.684***
	(0.093)	(0.100)	(0.110)
domestic and Norway	-0.580***	-0.588***	-0.588***
	(0.086)	(0.092)	(0.100)
domestic and the US	-0.588***	-0.581***	-0.634***
	(0.096)	(0.100)	(0.107)
domestic and Germany	-0.739***	-0.773***	-0.762***
	(0.0959)	(0.102)	(0.104)
Consultation			
only relevant NGOs	0.101	0.107	0.103
	(0.085)	(0.090)	(0.100)
only residents of directly affected communities	0.280***	0.306***	0.364***
	(0.083)	(0.088)	(0.100)
residents of surrounding communities	0.239***	0.262**	0.247**
	(0.083)	(0.088)	(0.100)
all residents in the province	0.354***	0.391***	0.379***
	(0.086)	(0.090)	(0.100)
a national consultation	0.327***	0.346***	0.386***
	(0.082)	(0.086)	(0.100)
Information			
only at regulatory approval stage	0.519***	0.553***	0.571***
	(0.062)	(0.066)	(0.072)
throughout the plant's lifespan	0.567***	0.582***	0.577***
	(0.0633)	(0.068)	(0.075)
Benefits			
contract preference for local businesses	0.421***	0.443***	0.473***
	(0.060)	(0.063)	(0.071)
direct financial compensation to individuals affected	0.627***	0.655***	0.645***
	(0.066)	(0.070)	(0.077)

Table 5: Continuation of Table 4

Variables	Acceptance	Socio-dem.	Full model
Gender		0.735***	0.451***
		(0.155)	(0.149)
Age		-0.330***	-0.197***
		(0.051)	(0.050)
Log household income		0.131	0.012
		(0.095)	(0.084)
Education		0.004	-0.016
		(0.063)	(0.060)
Household size		0.002***	0.002***
		(0.000)	(0.000)
CCS knowledge			0.296***

			(0.070)
Perception of CCS benefits			0.019
			(0.069)
Perception of environmental risks			-0.163***
			(0.052)
Trust in federal gov't energy regulator			-0.420***
			(0.111)
Perception of CCS risks			-0.285***
			(0.067)
CCS general support			0.894***
			(0.091)
CCS induced seismicity			0.413***
			(0.161)
Constant	-0.896***	-1.340	-2.633**
	(0.131)	(1.059)	(1.038)
Number of vignettes ratings	6,012	5,430	4,218
Number of respondents	1002	904	703
Std. dev. random effect (*sigma_u*)	2.2926	2.2208	1.7807
Std. dev. error (*sigma_e*)	1.7442	1.7521	1.7351
Intra-class correlation (*rho*)	0.6334	0.6164	0.5130
Wald chi^2	283.75	1468.68	2570.03

*Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1*

Notice that for the US and Norway, even though the effect is still negative, the magnitude in terms of acceptance is lower. Considering the global impacts of climate change and the localised risks of CCS plants, this result reveals a lower preference for CO_2 trading between countries. This is because CO_2 may be regarded as sewage (and it is) (Lackner and Jospe, 2017), and countries might not want to be on the receiving end. Despite the 2009 amendment to Article 6 of the London Protocol in the EU, which permits countries to consent to the export and import of CO_2 for offshore geological storage, thereby eliminating a major international legal obstacle to CCS and enabling the transportation of CO_2 across national boundaries for offshore storage (Bergesen et al., 2019; Dixon et al., 2015; Dixon and Birchenough, 2021; Role et al., 2012), our results show that there exists a prevalent negative public perception towards cross-border importation of CO_2. This finding also relates to the literature on the transnational transportation of waste (Kellenberg, 2015; Liddick, 2010; Pellow, 2007). This suggests that if the correct disposal costs, environmental rules, compensation, monitoring, and compliance framework are in place, people can be persuaded to support the international trading of CO_2.

CCS plant acceptability is also significantly impacted by compensation. Against no financial compensation at all, the most preferred attribute scenario involves financial compensation (0.627) to individuals directly affected by the siting and operation of the CCS plant. This effect is stronger than the option for contract preference for local businesses and services (0.421). Prioritising local firms and services in contracts and providing compensation directly to impacted persons over no financial compensation at all represent a desire for fairness in a proximity-based compensation system revealed by earlier research (Mills et al., 2019; Parkins et al., 2021; Walker and Baxter, 2017). This suggests that people might be willing to tolerate some degree of risk associated with CCS plants in exchange for their fair share of the pie.

How effectively and transparently authorities manage and distribute information regarding the risk assessment of CCS facilities is also crucial to the plants' acceptance. Relative to not sharing information about the risk assessment of the CCS plant, public acceptance hinges not only on making information available online throughout the plant’s lifespan (0.567), but also on making the information available at the regulatory approval stage (0.519). This positive relationship between acceptance and access to information was also observed by Firestone and Kirk (2019) and Musall and Kuik (2011). Some individuals might even be willing to accept lower compensation in return for access to information (Brennan and Van Rensburg, 2016). This implies that prioritising communication, information sharing, and transparency in the design of CCS plants is essential to enhancing their public acceptance.

Likewise, the concept of procedural justice has been observed to have a significant and robust impact on acceptance. Relative to no consultation at all, conducting a national consultation (0.327) as an integral part of the planning process for a CCS plant's construction increases its public acceptance. Similarly, consulting the residents of the host province (0.354), residents of the directly affected communities (0.280), or residents of the directly affected and surrounding communities (0.239) has a positive effect on the acceptance of proposed CCS plant scenarios. However, consulting relevant NGOs about proposed CCS plants, relative to the option of no consultation at all, has no statistically significant impact on public acceptance of CCS plants. This result is in line with the findings of Aitken (2010), Liebe and Dobers (2019), and Xenias and Whitmarsh (2018). This suggests that involving the public in the decision-making process has the capacity to enhance the level of acceptance of CCS facilities.

Another significant and robust determinant of public acceptance of CCS scenario plants is proximity. Against the option of having a CCS plant located less than 50 km from the place of residence, respondents not only prefer a distance of between 50 km and 100 km (0.136) but also have a greater preference for a farther distance of more than 100 km (0.241). This finding is in line with the NIMBY description given by Krause et al. (2014) and dismisses the assertion of Boyd et al. (2017) that living close to such facilities is positively associated with acceptance. However, as noted by Wolsink (2006), labelling this as NIMBY behaviour may obscure our understanding of the real motives, as this relates more to the issue of fairness and justice in the site selection. Therefore, in modelling a potential CCS plant scenario, it may be essential to look at proximity with the lens of fairness instead of the label of NIMBY.

Furthermore, the effect of the system of administration and how the CCS plant is put into use on public opinion is revealing. Relative to the option of a CCS plant scenario being implemented by an industry consortium, government-industry partnership (0.119) or only by the federal government (0.103) is preferred. This makes sense because many energy technologies are often regarded as only for-profit ventures (Strielkowski et al., 2020), and as such, a government partnership may be reassuring that public interest will be prioritised. As per our prior analysis, it is noticeable that the federal government is deemed more suitable for assuming responsibility for specific types of CCS projects monitoring.

After controlling for economic, transparency, and fairness-related factors, it has been observed that the impact of storage capacity on the acceptance of CCS plant scenarios is relatively low and statistically insignificant. This indicates that deliberations regarding CCS are focused more on the social (fairness and justice) and economic (compensation) elements of the technology than on its place in the battle against climate change. This implies that communication efforts to improve public understanding and acceptance should focus on the socio-economic aspects of the technology instead of its technicalities and climate mitigation capacity.

Effects of Respondent Socio-demographics on CCS Acceptance

Public opinion and perceptions matter tremendously in how people see issues and technologies like CCS, according to the research on CCS and related energy technologies (Howell et al., 2019; Moon et al., 2020; Pianta et al., 2021), which suggests that respondent characteristics may possibly alter their judgement of CCS plant scenarios. As such, Model 2 incorporates a set of covariates pertaining to sociodemographic factors that have been highlighted in the literature as having effects on individuals' perceptions of energy technologies. The findings confirm the relevance of respondent socio-demographic characteristics as drivers of public acceptability of CCS based on these control variables in Model 2. Table 5 findings indicate that male gender significantly influences the acceptance levels of CCS plants, as reflected in vignette scenario ratings that are 0.735 scale points higher. The observed positive coefficient among males could potentially signify the prevalence of male-oriented focus in the energy sector, a matter of significant prominence in the western part of Canada. These findings align with the observations made by Yang et al. (2016), which indicate that males exhibit a higher likelihood of accepting CCS compared to women. Nevertheless, according to Arning et al. (2019) study, no statistically significant difference was noted in the acceptability levels of CCS between men and women. This contradictory finding might perhaps be attributed to the varying degrees of participation of men and women within the public debate on energy issues across different countries. It is also important to acknowledge that there is a higher likelihood for males to recognise emerging technologies and engage in public discourse around them, as shown by several studies (Miller et al., 2007).

It's evident that various individuals of different ages think differently, and that different strategies are needed to persuade them (Stephens et al., 2009). The relevance of age in predicting the acceptance of CCS plants among respondents is noteworthy. The findings indicate that there is a statistically significant negative correlation between age and acceptance, with a decrease of 0.330 scale points per decade of age increase. This finding could potentially be attributed to the notion that the discourse surrounding CCS is primarily situated within the socio-economic realm rather than its capacity for climate mitigation. Consequently, it is plausible that younger individuals are more inclined to endorse the technology in comparison to their older counterparts. Yang et al. (2016) also observed a negative relationship between age and acceptance of CCS. The common belief that people become more conservative as they age provides a possible rationale.

The predictive power of household size in relation to CCS acceptance is negligible. The acceptance ratings of CCS plant scenarios among respondents are positively correlated with an increase in household size. This is evidenced by an increase of 0.002 scale points. A similar analysis by Dütschke et al. (2016) confirms that there exists a positive correlation between the number of individuals within a household and the acceptance of CCS, particularly in cases where the source of CO_2 emissions comes from coal combustion. Finally, the results in Table 5 above indicate that there is no statistically significant impact on the acceptance of CCS scenario plants in relation to the education level and household income of respondents. This result align with the findings of Yang et al. (2016).

Effects of other Respondent Characteristics on CCS Acceptance

In addition to the socio-demographic model, knowledge about the technology, perceptions of its benefits and risks, and trust in institutions are also potential drivers of acceptance of CCS plants, as has been shown in related literature (Chewinski et al., 2023; Howell et al., 2019; Liebe & Dobers, 2020; Mooney et al., 2022). The socio-demographic model (model 2) was therefore extended to include these variables to get the final model specification (model 3). In order to comprehensively assess the respondents' knowledge, trust, and attitudes towards CCS, as well as various environmental variables, a series of questions were incorporated into the survey for each of the aforementioned factors. The inclusion of numerous highly correlated variables in the model poses the challenge of multi-collinearity and overfitting. To address this issue of multi-collinearity (and overfitting) and attain parsimony in the model specification, the study utilised a widely recognised method of dimensionality reduction known as principal component analysis (PCA). Principal components (PCs) are a linear combination of the original variables. As such, all the original variables are still utilised instead of a subset of them. PCs with the highest eigenvalues (greater than unity) were included in the regression. The Kaiser-Meyer-Olkin test for sampling adequacy shows values above 0.60. This statistic measures the proportion of variance among the variables that might be common variance and, hence, implies that the samplings are adequate and satisfactory for the PCA.

As shown in Table 5 above, the coefficient of self-reported support for CCS is highly significant and robust in influencing acceptance of CCS plant scenarios. An increase in self-reported support for CCS leads to a 0.894 scale point increase in CCS plant scenario acceptance. Initially, this may appear as two facets of an identical coin, thereby appearing insignificant in the analysis. However, situating it within the debates surrounding CCS exposes significant insights. By disentangling the economic incentives associated with the technology from its potential to mitigate climate change, one can discern distinctions between the factors that motivate support for the technology and those that drive its acceptance, particularly when considering its siting within an individual's locality. Examining the relationship between the perceptions of benefits and risks associated with CCS among respondents and their acceptance of CCS plant scenarios may provide clarity on this matter.

The acceptance of CCS scenarios is significantly influenced by the objective knowledge of respondents regarding the risks associated with seismicity caused by CCS. On average, respondents who possess insufficient objective knowledge regarding the risks of CCS-induced seismic activity tend to rate CCS plant scenarios 0.163 scale points higher than those who possess accurate knowledge. The significance of this matter lies in the discrepancy between the general public's perception of induced seismicity resulting from CCS and the scientific reality. Based on scientific evidence, the likelihood of CCS inducing seismic activity that is felt on the earth's surface is extremely low (Larkin et al., 2019). However, the mere reference to seismic activity elicits a sense of anxiety. In the same vein, perceptions about the general risks of CCS (such as CO_2 leakage, seismicity, promoting CO_2 emissions, and profit interest) are also negatively correlated with acceptance of CCS plant scenarios. Specifically, an increase in individuals' perceptions about the risks of CCS decreases their average rating of CCS plant scenarios by 0.285 scale points. This result is in line with the findings of Wallquist et al. (2010) and Wennersten et al. (2015). Intriguingly, the perception of benefits associated with CCS (e.g., decreasing CO_2, promoting economic growth, benefiting the environment, and being a cheaper option) is statistically insignificant in predicting the level of public acceptability of CCS plant scenarios.

Furthermore, there exists a positive correlation between possessing a thorough understanding of CCS and the degree to which it is embraced as a viable technology for mitigating climate change. To holistically capture respondents' knowledge of the technology, several questions were asked, such as the possibility of groundwater contamination, CO_2 leakage, induced seismicity, storage capacity, viability of the technology, and the place where CO_2 will be stored underground. The results indicate that an increase in individuals understanding of the technology on average increases their acceptance of CCS plant scenarios by 0.296 scale points. In their analysis, Pianta et al. (2021) demonstrate that individuals who possess knowledge of CCS tend to have the perception that it's societal and climate change-related benefits are greater. However, it is important to note that this does not necessarily result in a corresponding increase in acceptance, as previously mentioned. It is plausible that a higher understanding of the technology may lead to a reduction in perceived risks, thereby resulting in greater levels of acceptance of the technology.

Moreover, the perception of individuals regarding the risks associated with environmental issues (such as glyphosate usage, mobile towers, wind turbines, antibiotics, pests/parasites, crime/violence, drugs, ozone depletion, climate change, and induced seismicity) tends to adversely affect their acceptance of CCS. Individuals with higher perceived risks associated with these environmental phenomena, on average, tend to rate CCS scenario plants 0.163 scale points lower. These findings reiterate the argument that an individual's perception of risks significantly impacts their willingness to embrace CCS as a technology for mitigating climate change (Peridas et al., 2021).

Finally, the acceptance of CCS is found to have a negative correlation with trust in federal government energy regulatory and monitoring institutions. Specifically, an increase in respondents' trust in federal government energy regulators decreases their acceptance rating of CCS scenario plants by 0.420 scale points. At first glance, this phenomenon may seem counterintuitive. However, upon closer examination, it becomes evident that the underlying cause is primarily rooted in the level of confidence individuals have in the federal and provincial governments. The extent to which people trust government energy organisations serves as an indicator of their faith in these entities' capacity to proficiently handle energy-related issues (Stretesky et al., 2023; Truong et al., 2019; Yang et al., 2016). Due to the complexity of CCS as an energy technology, it may only be appropriate to delegate monitoring and regulatory obligations to institutions that have a high level of public trust. However, the negative relationship between trust in government energy regulators and acceptance of proposed scenarios for CCS plants can be attributed to the overwhelming influence of multinational corporations in the oil and gas sector and the prevailing public perceptions regarding the industry's involvement in promoting the CCS technology.

Conclusion and Policy Implications

The results of CCS research and development have shown that the technology is not only ready but essential for reducing the worst effects of climate change. The public and the economy are putting more pressure on leaders to follow through on their promises to take measures to slow climate change. However, public opinions of the technology are cause for concern since they demonstrate that the execution of CCS projects has been delayed and that considerable challenges persist in linking the promise of CCS to the investment and deployment of CCS facilities. It is still painfully obvious that CCS implementation is falling short of expectations (Martin-Roberts et al., 2021).

A recent analysis of CCS/CCUS policy by the International CCS Knowledge Centre showed that the Government of Canada's 2023 budget has measures to promote large-scale CCS/CCUS projects. However, the analysis noted that Canada's policy framework is missing important details that are needed to encourage private-sector investment (International CCS Knowledge Centre, 2023). The risk assessment and risk management of CCS in Canada centre on three key areas: government and industry factors, environmental risk factors, and socio-economic factors. The socio-economic considerations include several elements, such as the public's opinions of the risks and benefits associated with CCS, the economic costs involved, the availability of information, effective communication strategies, the engagement of stakeholders, and the social and public acceptance of CCS, including the use of decision support tools to facilitate the decision-making process (Larkin et al., 2019). Our experiment explored CCS plant attributes that influence individuals' acceptance of the technology. The paper documents that cross-border imports of CO_2 for storage have the strongest effect on CCS plant scenario acceptance, indicating a lower preference for CO_2 trading between countries. Canada currently holds a share of approximately 15 percent in the global capacity for CCS/CCUS, which amounts to roughly seven million tonnes of CO_2 annually. It is worth noting that this contribution is significant considering that Canada's CO_2 emissions constitute less than two percent of the global total emissions (IEA, 2022).

Our analysis shows that the level of acceptance of CCS plants is contingent upon the provision of compensation, as those affected by such facilities are willing to tolerate a certain level of risk in return for fair remuneration. A proper incorporation of compensation, communication, information sharing, and transparency into the design of CCS plants will be imperative for augmenting public acceptance in Canada. The significant impact of procedural justice on the degree of societal approval of CCS facilities is also worth mentioning. Our empirical evidence suggests that engaging in national and provincial consultation, as well as seeking input from residents of communities directly impacted by CCS plants, can yield favourable outcomes in terms of fostering acceptance.

Individuals regard climate change as a significant concern because they are aware of the repercussions of global warming and are afraid of the harm it brings to their life, as was discovered by Arlota & de Medeiros Costa (2021), CCA (2019), NAS (2021), and Nordhaus (2019). However, this is not sufficient to encourage people to pay for measures that reduce global warming (Lima et al., 2021). Our results validate the significance of the socio-economic and socio-demographic characteristics of respondents (such as age, gender, and household size) as determinants of their acceptance of CCS as a climate mitigation strategy. Knowledge about the technology, perceptions of its benefits and risks, induced seismicity, and trust in institutions are key drivers of acceptance of CCS plants.

The results of this research have three main policy implications for Canada. First, the results reveal a lower preference for CO_2 cross-border trading due to the global impacts of climate change and localised risks of CCS plants. However, if the correct disposal costs, environmental rules, compensation, monitoring, and compliance framework are in place, people can be persuaded to support the international transport (trading) of CO_2. Second, prioritising local firms and services in contracts and providing compensation directly to impacted persons represents a desire for fairness in a proximity-based compensation system, suggesting that people may be willing to tolerate some risk in exchange for their fair share of the pie. Similarly, prioritising communication, information sharing, and transparency in the design of CCS plants is essential to enhancing public acceptance, as some individuals may be willing to accept lower compensation for full access to information. Third, the acceptance of CCS scenarios is significantly influenced by the objective knowledge of respondents regarding the risks associated with seismic activity caused by CCS. Also, perceptions about the general risks of CCS are negatively correlated with acceptance of CCS plant scenarios, while perceptions of the benefits associated with CCS are statistically insignificant in predicting the level of public acceptability of CCS plant scenarios. This implies that possessing a thorough understanding of CCS can lead to a reduction in perceived risks, resulting in greater levels of acceptance. Hence, communication efforts to improve public understanding and acceptance should focus on demystifying the risks of the technology instead of its technicalities and climate mitigation capacity.

There are two limitations inherent in this study that give rise to considerations for future research. First, a series of hypothetical scenarios pertaining to CCS plants were offered to the public, but with the caveat that these scenarios do not include the whole spectrum of potential CCS implementations and associated ramifications. In the context of this research, several elements that might have a significant impact on acceptability, such as the public's perception of the financial implications of energy use and the accompanying cost (Volken et al., 2019), were not comprehensively examined. Moreover, the scenarios presented exhibit a certain level of abstraction and are hypothetical in nature. Hence, the survey results reflect the public's reaction, although potentially divergent from actuality. In addition, it should be noted that the survey findings provide a momentary depiction of the present sentiments held by the general population and should not be extrapolated to predict future trends (Renn, 2015).

Second, the scope of this research was restricted to Canada, limiting the applicability of the findings to a broader context. The significance of norms and values and the perceived salience of the climate change problem exhibit variation across countries and cultures. This means that our results cannot be generalised across countries. Given the broad spectrum of opinions on CCS that have been expressed, it is reasonable to presume that various subsets of the population will have varied perspectives on the topic. Therefore, future studies should concentrate on subgrouping the population to provide more specific policy recommendations. Also, to fully comprehend the potential of cross-border CO_2 storage trade, a cross-national study is required.

References

Aitken, M. (2010). Wind power and community benefits: Challenges and opportunities. *Energy Policy*, *38*(10), 6066–6075. https://doi.org/10.1016/j.enpol.2010.05.062

Arlota, C., & de Medeiros Costa, H. K. (2021). Climate change, Carbon Capture and Storage (CCS), energy transition, and justice: Where we are now, and where are (should be) we headed? In *Carbon Capture and Storage in International Energy Policy and Law*. INC. https://doi.org/10.1016/B978-0-323-85250-0.00019-0

Arning, K., Offermann-van Heek, J., Linzenich, A., Kaetelhoen, A., Sternberg, A., Bardow, A., & Ziefle, M. (2019). Same or different? Insights on public perception and acceptance of carbon capture and storage or utilization in Germany. *Energy Policy*, *125*(November 2018), 235–249. https://doi.org/10.1016/j.enpol.2018.10.039

Ashworth, P., Boughen, N., Mayhew, M., & Millar, F. (2010). From research to action: Now we have to move on CCS communication. *International Journal of Greenhouse Gas Control*, *4*(2), 426–433. https://doi.org/10.1016/j.ijggc.2009.10.012

Ashworth, P., Sun, Y., Ferguson, M., Witt, K., & She, S. (2019). Comparing how the public perceive CCS across Australia and China. *International Journal of Greenhouse Gas Control*, *86*(May), 125–133. https://doi.org/10.1016/j.ijggc.2019.04.008

Atzmüller, C., & Steiner, P. M. (2010). Experimental vignette studies n survey research. *Methodology*, *6*(3), 128–138. https://doi.org/10.1027/1614-2241/a000014

Auspurg, K., & Hinz, T. (2015a). Multifactorial Experiments in Surveys : Conjoint Analysis, Choice Experiments, and Factorial Surveys. *Experimente in Den Sozialwissenschaften*, *1*(ISBN 978-3-8487-1916-7), 291–315.

Auspurg, K., & Hinz, T. (2015b). Setting Up the Survey. *Factorial Survey Experiments*, 60–84. https://doi.org/10.4135/9781483398075.n4

Auspurg, K., & Jäckle, A. (2017). First Equals Most Important? Order Effects in Vignette-Based Measurement. *Sociological Methods and Research*, *46*(3), 490–539. https://doi.org/10.1177/0049124115591016

Bergesen, H. O., Parmann, G., & Thommessen, O. B. (2019). Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972). In *Yearbook of International Cooperation on Environment and Development 1998–99*. https://doi.org/10.4324/9781315066547-20

Bertram, C., & Merk, C. (2020). Public Perceptions of Ocean-Based Carbon Dioxide Removal: The Nature-Engineering Divide? *Frontiers in Climate*, *2*. https://doi.org/10.3389/fclim.2020.594194

Boroumand, N. (2015). Survey Responses on the Public Perception of Induced Seismicity. *CSEG Recorder*, *40 No. 5*(May 2015), 36–41. https://csegrecorder.com/articles/view/survey-responses-on-the-public-perception-of-induced-seismicity

Bosker, R. S. T. A. B. (2012). Multilevel Analysis: An Introduction to Basic and Applied Multilevel Analysis. *Department of Statistics University of Oxford*. http://www.stats.ox.ac.uk/~snijders/mlbook.htm

Boyd, A. D., Hmielowski, J. D., & David, P. (2017). Public perceptions of carbon capture and storage in Canada: Results of a national survey. *International Journal of Greenhouse Gas Control*, *67*(August), 1–9. https://doi.org/10.1016/j.ijggc.2017.10.010

Braun, C. (2017). Not in My Backyard: CCS Sites and Public Perception of CCS. *Risk Analysis*, *37*(12), 2264–2275. https://doi.org/10.1111/risa.12793

Brennan, N., & Van Rensburg, T. M. (2016). Wind farm externalities and public preferences for community consultation in Ireland: A discrete choice experiments approach. *Energy Policy*, *94*, 355–365. https://doi.org/10.1016/j.enpol.2016.04.031

Bruhn, T., Naims, H., & Olfe-Kräutlein, B. (2016). Separating the debate on CO2 utilisation from carbon capture and storage. *Environmental Science and Policy*, *60*, 38–43. https://doi.org/10.1016/j.envsci.2016.03.001

Carton, W., Asiyanbi, A., Beck, S., Buck, H. J., & Lund, J. F. (2020). Negative emissions and the long history of carbon removal. *Wiley Interdisciplinary Reviews: Climate Change*, *11*(6), 1–25. https://doi.org/10.1002/wcc.671

CCA. (2019). *Canada's top climate change risks: the expert panel on climate change risks and adaptation potential*. https://cca-reports.ca/wp-content/uploads/2019/07/Report-Canada-top-climate-change-risks.pdf

Chewinski, M., Anders, S., & Parkins, J. R. (2023). Agricultural landowner perspectives on wind energy development in Alberta, Canada: insights from the lens of energy justice and democracy. *Environmental Sociology*, *00*(00), 1–13. https://doi.org/10.1080/23251042.2023.2247627

ChoiceMetrics. (2014). *NGENE 1.1. 2 User Manual and Reference Guide: the cutting edge in experimental design*. Choice Metrics.

Cox, E., Spence, E., & Pidgeon, N. (2020). Public perceptions of carbon dioxide removal in the United States and the United Kingdom. *Nature Climate Change*, *10*(8), 744–749. https://doi.org/10.1038/s41558-020-0823-z

Cvetković, V. M., Öcal, A., Lyamzina, Y., Noji, E. K., Nikolić, N., & Milošević, G. (2021). Nuclear power risk perception in serbia: Fear of exposure to radiation vs. social benefits. *Energies*, *14*(9). https://doi.org/10.3390/en14092464

David, J., & Herzog, H. (2000). The Cost of Carbon Capture. *Energy*, 13–16. http://sequestration.mit.edu/pdf/David_and_Herzog.pdf

David, J. L., & Andrew, J. W. (2006). SOCIAL ATOMISM, HOLISM, AND TRUST. *Academy of Management Review*, *31*(2), 386–408.

Dixon, T., & Birchenough, A. (2021). *Exporting CO2 for Offshore Storage -The London Protocol's Export Amendment*. *March*.

Dixon, T., McCoy, S. T., & Havercroft, I. (2015). Legal and Regulatory Developments on CCS. *International Journal of Greenhouse Gas Control*, *40*, 431–448. https://doi.org/10.1016/j.ijggc.2015.05.024

Dohmen, T., Willrodt, J., & Willrodt, J. (2018). *Willingness to Take Risk : The Role of Risk Conception and Optimism Willingness to Take Risk : The Role of Risk Conception and Optimism*. *DISCUSSION PAPER SERIES 11642*.

Ebbes, P., Böckenholt, U., & Wedel, M. (2004). Regressor and random-effects dependencies in multilevel models. *Statistica Neerlandica*, *58*(2), 161–178. https://doi.org/10.1046/j.0039-0402.2003.00254.x

Elzahabi, M., & Yong, R. N. (2001). pH influence on sorption characteristics of heavy metal in the vadose zone. *Engineering Geology*, *60*(1–4), 61–68. https://doi.org/10.1016/S0013-

7952(00)00089-2
Evensen, D., Varley, A., Whitmarsh, L., Devine-Wright, P., Dickie, J., Bartie, P., Napier, H., Mosca, I., Foad, C., & Ryder, S. (2022). Effect of linguistic framing and information provision on attitudes towards induced seismicity and seismicity regulation. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-15448-4
Evensen, D., Whitmarsh, L., Devine-Wright, P., Dickie, J., Bartie, P., Foad, C., Bradshaw, M., Ryder, S., Mayer, A., & Varley, A. (2023). Growing importance of climate change beliefs for attitudes towards gas. *Nature Climate Change*, *13*(3), 240–243. https://doi.org/10.1038/s41558-023-01622-7
Firestone, J., & Kirk, H. (2019). A strong relative preference for wind turbines in the United States among those who live near them. *Nature Energy*, *4*(4), 311–320. https://doi.org/10.1038/s41560-019-0347-9
Frey, R., Richter, D., Hertwig, R., & Mata, R. (2021). Identifying robust correlates of risk preference : A systematic approach using specification curve analysis. *Personality and Social Psychology*, *120*, 538–557.
Gabrielli, P., Gazzani, M., & Mazzotti, M. (2020). The Role of Carbon Capture and Utilization, Carbon Capture and Storage, and Biomass to Enable a Net-Zero-CO2 Emissions Chemical Industry. *Industrial and Engineering Chemistry Research*, *59*(15), 7033–7045. https://doi.org/10.1021/acs.iecr.9b06579
Gibbins, J. O. N. (2019). *CCS – From an Oil Crisis to a Climate Crisis Response*. *26*, 559–562.
Gonzalez, A., Mabon, L., & Agarwal, A. (2021). Who wants North Sea CCS, and why? Assessing differences in opinion between oil and gas industry respondents and wider energy and environmental stakeholders. *International Journal of Greenhouse Gas Control*, *106*(February), 103288. https://doi.org/10.1016/j.ijggc.2021.103288
Gough, C., & Mander, S. (2019). Beyond Social Acceptability: Applying Lessons from CCS Social Science to Support Deployment of BECCS. *Current Sustainable/Renewable Energy Reports*, *6*(4), 116–123. https://doi.org/10.1007/s40518-019-00137-0
Greene, W. H., Harris, M. N., Knott, R. J., & Rice, N. (2021). Specification and testing of hierarchical ordered response models with anchoring vignettes. *Journal of the Royal Statistical Society. Series A: Statistics in Society*, *184*(1), 31–64. https://doi.org/10.1111/rssa.12612
Grilli, L., & Rampichini, C. (2011). The role of sample cluster means in multilevel models a view on endogeneity and measurement error issues. *Methodology*, *7*(4), 121–133. https://doi.org/10.1027/1614-2241/a000030
Grilli, L., & Rampichini, C. (2015). Specification of random effects in multilevel models: a review. *Quality and Quantity*, *49*(3), 967–976. https://doi.org/10.1007/s11135-014-0060-5
Haemmerli, L., & Stauffacher, M. (2020). The Neglected Role of Risk Mitigation Perception in the Risk Governance of Underground Technologies— The Example of Induced Seismicity. *International Journal of Disaster Risk Science*, *11*(5), 630–639. https://doi.org/10.1007/s13753-020-00298-3
Hasan, M. A., Nahiduzzaman, K. M., & Aldosary, A. S. (2018). Public participation in EIA: A comparative study of the projects run by government and non-governmental organizations.

Environmental Impact Assessment Review, *72*(November 2017), 12–24. https://doi.org/10.1016/j.eiar.2018.05.001

Hoen, B., Firestone, J., Rand, J., Elliot, D., Hübner, G., Pohl, J., Wiser, R., Lantz, E., Haac, T. R., & Kaliski, K. (2019). Attitudes of U.S. Wind Turbine Neighbors: Analysis of a Nationwide Survey. *Energy Policy*, *134*(August), 110981. https://doi.org/10.1016/j.enpol.2019.110981

Howell, E. L., Wirz, C. D., Brossard, D., Scheufele, D. A., & Xenos, M. A. (2019). Seeing through risk-colored glasses: Risk and benefit perceptions, knowledge, and the politics of fracking in the United States. *Energy Research and Social Science*, *55*(May), 168–178. https://doi.org/10.1016/j.erss.2019.05.020

IEA. (2008). CO2 Capture and Storage: A key carbon abatement option. In *Energy Technology Analysis* (Vol. 9789264041). https://doi.org/10.1787/9789264041417-en

IEA. (2021a). Global Energy Review 2021 – Analysis - IEA. *International Energy Agency*.

IEA. (2021b). Global Energy Review 2021: Assessing the effects of economic recoveries on global energy demand and CO2 emissions in 2021. *Global Energy Review*. https://doi.org/10.1787/90c8c125-en

IEA. (2022). CO2 Emissions in 2022. Retrieved September 02, 2023, from https://www.iea.org/reports/co2-emissions-in-2022.

International CCS Knowledge Centre. (2023). Canadian CCUS policy requires further detail to support advancing projects. Retrieved August 19, 2023, from https://ccsknowledge.com/news/canadian-ccus-policy-requires-further-detail-to-support-advancingprojects#:~:text=Canada%20has%20pledged%20to%20cut,tonnes%20per%20year%20by%202030.

IPCC. (2022). An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development,. In *Cambridge University Press* (Vol. 4, Issue 1). https://doi.org/10.1017/9781009157940

Jacquet, J. B. (2012). Landowner attitudes toward natural gas and wind farm development in northern Pennsylvania. *Energy Policy*, *50*, 677–688. https://doi.org/10.1016/j.enpol.2012.08.011

Kahlor, L. A., Yang, J., Li, X., Wang, W., Olson, H. C., & Atkinson, L. (2020). Environmental Risk (and Benefit) Information Seeking Intentions: The Case of Carbon Capture and Storage in Southeast Texas. *Environmental Communication*, *14*(4), 555–572. https://doi.org/10.1080/17524032.2019.1699136

Keeling, R. F., Manning, A. C., & Dubey, M. K. (2011). The atmospheric signature of carbon capture and storage. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1943), 2113–2132. https://doi.org/10.1098/rsta.2011.0016

Kellenberg, D. (2015). The economics of the international trade of waste. *Annual Review of Resource Economics*, *7*(1), 109–125. https://doi.org/10.1146/annurev-resource-100913-012639

Kerr, S., Johnson, K., & Weir, S. (2017). Understanding community benefit payments from renewable energy development. *Energy Policy*, *105*(February), 202–211.

https://doi.org/10.1016/j.enpol.2017.02.034
Kim, J. S., & Frees, E. W. (2007). Multilevel modeling with correlated effects. *Psychometrika*, *72*(4), 505–533. https://doi.org/10.1007/s11336-007-9008-1
Lackner, K., & Jospe, C. (2017). Climate Change is a Waste Management Problem | Issues in Science and Technology. *ISSUES in Science and Technology*, 83–89. https://issues.org/climate-change-waste-management-problem/
Lackner, K. S., & Brennan, S. (2009). Envisioning carbon capture and storage: Expanded possibilities due to air capture, leakage insurance, and C-14 monitoring. *Climatic Change*, *96*(3), 357–378. https://doi.org/10.1007/s10584-009-9632-0
Larkin, P., Leiss, W., Arvai, J., Dusseault, M., Fall, M., Gracie, R., Heyes, A., & Krewski, D. (2019). An integrated risk assessment and management framework for carbon capture and storage: A Canadian perspective. *International Journal of Risk Assessment and Management*, *22*(3–4). https://doi.org/10.1504/IJRAM.2019.103336
Liddick, D. (2010). The traffic in garbage and hazardous wastes: An overview. *Trends in Organized Crime*, *13*(2–3), 134–146. https://doi.org/10.1007/s12117-009-9089-6
Liebe, U., Bartczak, A., & Meyerhoff, J. (2017). A turbine is not only a turbine: The role of social context and fairness characteristics for the local acceptance of wind power. *Energy Policy*, *107*(May), 300–308. https://doi.org/10.1016/j.enpol.2017.04.043
Liebe, U., & Dobers, G. M. (2019). Decomposing public support for energy policy: What drives acceptance of and intentions to protest against renewable energy expansion in Germany? *Energy Research and Social Science*, *47* (August 2018), 247–260. https://doi.org/10.1016/j.erss.2018.09.004
Liebe, U., & Dobers, G. M. (2020). Measurement of fairness perceptions in energy transition research: A factorial survey approach. *Sustainability (Switzerland)*, *12*(19), 1–14. https://doi.org/10.3390/su12198084
Lienhoop, N. (2018). Acceptance of wind energy and the role of financial and procedural participation: An investigation with focus groups and choice experiments. *Energy Policy*, *118*(April), 97–105. https://doi.org/10.1016/j.enpol.2018.03.063
Lima, P. R., Pereira, A. A. M., Chaves, G. de L. D., & Meneguelo, A. P. (2021). Environmental awareness and public perception on carbon capture and storage (CCS) in Brazil. *International Journal of Greenhouse Gas Control*, *111*(August). https://doi.org/10.1016/j.ijggc.2021.103467
Lokuge, N., Phillips, J., Anders, S., & van der Baan, M. (2023). Human-induced seismicity and the public acceptance of hydraulic fracturing: A vignette experiment. *Extractive Industries and Society*, *15*(August), 101335. https://doi.org/10.1016/j.exis.2023.101335
L'Orange Seigo, S., Dohle, S., & Siegrist, M. (2014). Public perception of carbon capture and storage (CCS): A review. *Renewable and Sustainable Energy Reviews*, *38*, 848–863. https://doi.org/10.1016/j.rser.2014.07.017
L'Orange Seigo, S., Wallquist, L., Dohle, S., & Siegrist, M. (2011). Communication of CCS monitoring activities may not have a reassuring effect on the public. *International Journal of Greenhouse Gas Control*, *5*(6), 1674–1679. https://doi.org/10.1016/j.ijggc.2011.05.040

Martin-Roberts, E., Scott, V., Flude, S., Johnson, G., Haszeldine, R. S., & Gilfillan, S. (2021). Carbon capture and storage at the end of a lost decade. *One Earth*, *4*(11), 1569–1584. https://doi.org/10.1016/j.oneear.2021.10.002

Mehdi, F., Aurelio, F., & Massimo, F. (2020). Economies of Scale and Scope in Multi-Utilities. *International Association for Energy*, *29*(4), 123–143.

Merk, C., Nordø, Å. D., Andersen, G., Lægreid, O. M., & Tvinnereim, E. (2022). Don't send us your waste gases: Public attitudes toward international carbon dioxide transportation and storage in Europe. *Energy Research and Social Science*, *87*(May 2021). https://doi.org/10.1016/j.erss.2021.102450

Miller, E., Bell, L., & Buys, L. (2007). Public understanding of carbon sequestration in Australia: socio-demographic predictors of knowledge, engagement and trust. *Australian Journal of Emerging Technologies and Society*, *5*(1).

Mills, S. B., Bessette, D., & Smith, H. (2019). Exploring landowners' post-construction changes in perceptions of wind energy in Michigan. *Land Use Policy*, *82*(May 2018), 754–762. https://doi.org/10.1016/j.landusepol.2019.01.010

Moon, W. K., Kahlor, L. A., & Olson, H. C. (2020). Understanding public support for carbon capture and storage policy: The roles of social capital, stakeholder perceptions, and perceived risk/benefit of technology. *Energy Policy*, *139*(May 2019), 111312. https://doi.org/10.1016/j.enpol.2020.111312

Mooney, R., Boudet, H. S., & Hazboun, S. O. (2022). Risk-benefit perceptions of natural gas export in Oregon. *Local Environment*, *27*(3), 342–356. https://doi.org/10.1080/13549839.2022.2040470

Musall, F. D., & Kuik, O. (2011). Local acceptance of renewable energy-A case study from southeast Germany. *Energy Policy*, *39*(6), 3252–3260. https://doi.org/10.1016/j.enpol.2011.03.017

NAS. (2021). Climate change and global warming: Impacts on crop production. *Genetically Modified Plants*, 283–296. https://doi.org/10.1016/b978-0-12-818564-3.09991-1

Nordhaus, W. (2019). Climate change: The ultimate challenge for economics. *American Economic Review*, *109*(6), 1991–2014. https://doi.org/10.1257/aer.109.6.1991

Oltra, C., Sala, R., Solà, R., Di Masso, M., & Rowe, G. (2010). Lay perceptions of carbon capture and storage technology. *International Journal of Greenhouse Gas Control*, *4*(4), 698–706. https://doi.org/10.1016/j.ijggc.2010.02.001

Osazuwa-Peters, M., & Hurlbert, M. (2020). Analyzing Regulatory Framework for Carbon Capture and Storage (CCS) Technology Development: A case study approach. *The Central European Review of Economics and Management*, *4*(1), 107–148. https://doi.org/10.29015/cerem.834

Parkins, J. R., Anders, S., Meyerhoff, J., & Holowach, M. (2021). Landowner acceptance of wind turbines on their land: Insights from a factorial survey experiment. *Land Economics*, 012521-0008R1. https://doi.org/10.3368/le.98.4.012521-0008r1

Pellow, D. (2007). *Resisting Global Toxics: Transnational Movements for Environmental Justice*. 10.7551/mitpress/7479.001.0001

Peridas, G., & Mordick Schmidt, B. (2021). The role of carbon capture and storage in the race to carbon neutrality. *Electricity Journal*, *34*(7), 106996. https://doi.org/10.1016/j.tej.2021.106996

Pianta, S., Rinscheid, A., & Weber, E. U. (2021). Carbon Capture and Storage in the United States: Perceptions, preferences, and lessons for policy. *Energy Policy*, *151*, 112149. https://doi.org/10.1016/j.enpol.2021.112149

Ringrose, P., Greenberg, S., Whittaker, S., Nazarian, B., & Oye, V. (2017). Building Confidence in CO2 Storage Using Reference Datasets from Demonstration Projects. *Energy Procedia*, *114*(November 2016), 3547–3557. https://doi.org/10.1016/j.egypro.2017.03.1484

Ringrose, P. S. (2018). The CCS hub in Norway: Some insights from 22 years of saline aquifer storage. *Energy Procedia*, *146*, 166–172. https://doi.org/10.1016/j.egypro.2018.07.021

Rockström, J., Gaffney, O., Rogelj, J., Meinshausen, M., Nakicenovic, N., & Schellnhuber, H. J. (2017). A roadmap for rapid decarbonization. *Science*, *355*(6331), 1269–1271. https://doi.org/10.1126/science.aah3443

Role, T., To, C., Of, P., & Marine, T. H. E. (2012). THE LONDON CONVENTION AND PROTOCOL : LONDON CONVENTION What is the London Convention and its Protocol ? *Office*.

Rolnick, D., Donti, P. L., Kaack, L. H., Kochanski, K., Lacoste, A., Sankaran, K., Ross, A. S., Milojevic-Dupont, N., Jaques, N., Waldman-Brown, A., Luccioni, A., Maharaj, T., Sherwin, E. D., Mukkavilli, S. K., Kording, K. P., Gomes, C., Ng, A. Y., Hassabis, D., Platt, J. C., … Bengio, Y. (2019). *Tackling Climate Change with Machine Learning*. http://arxiv.org/abs/1906.05433

Rosa, L., Sanchez, D. L., Realmonte, G., Baldocchi, D., & D'Odorico, P. (2021). The water footprint of carbon capture and storage technologies. *Renewable and Sustainable Energy Reviews*, *138*(April 2020), 110511. https://doi.org/10.1016/j.rser.2020.110511

Rossi, P. H. (1979). 14. Vignette analysis: uncovering the normative structure of complex judgments. *Qualitative and Quantitative Social Research: Papers in Honor of Paul F. Lazarsfeld*, *176*.

Scott, V., Gilfillan, S., Markusson, N., Chalmers, H., & Haszeldine, R. S. (2013). Last chance for carbon capture and storage. *Nature Climate Change*, *3*(2), 105–111. https://doi.org/10.1038/nclimate1695

Shackley, S., McLachlan, C., & Gough, C. (2004). The public perception of carbon dioxide capture and storage in the UK: Results from focus groups and a survey. *Climate Policy*, *4*(4), 377–398. https://doi.org/10.1080/14693062.2004.9685532

Slovic, P., Flynn, J. H., & Layman, M. (1991). *Perceived Risk, Trust, and the Politics of Nuclear Waste*. 1603–1608.

Spence, A., Poortinga, W., Pidgeon, N., & Lorenzoni, I. (2010). Public perceptions of energy choices: The influence of beliefs about climate change and the environment. *Energy and Environment*, *21*(5), 385–407. https://doi.org/10.1260/0958-305X.21.5.385

Statistics Canada. (2019). *Canada at a Glance 2019: Education*. https://www150.statcan.gc.ca/n1/pub/12-581-x/2019001/edu-eng.htm

Statistics Canada. (2021a). Census Profile, 2021 Census of Population. *Government of Canada*, 3–5.https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/index.cfm?Lang=E%0Ahttps://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/search-recherche/lst/results-resultats.cfm?Lang=E&GeoCode=35&Letter=L#letL

Statistics Canada. (2021b). *Population estimates on July 1st, by age and sex*.

https://doi.org/https://doi.org/10.25318/1710000501-eng
Statistics Canada. (2022). *Canadian Income Survey*. *400*(March 2020), 1–11. https://www150.statcan.gc.ca/n1/daily-quotidien/220323/dq220323a-eng.htm
Stephanie, S., & Graham, U. (1989). Triangles and Triads. *Operational Research Society*, *42*(8), 673–683.
Stephens, J. C., Bielicki, J., & Rand, G. M. (2009). Learning about carbon capture and storage: Changing stakeholder perceptions with expert information. *Energy Procedia*, *1*(1). https://doi.org/10.1016/j.egypro.2009.02.288
Stretesky, P. B., Short, D., & Stamford, L. (2023). The Role of Institutional Trust in Industry, Government, and Regulators in Shaping Perceptions of Risk Associated with Hydraulic Fracturing in the United Kingdom. *Sociological Perspectives*, *66*(3), 496–522. https://doi.org/10.1177/07311214221125803
Strielkowski, W., Veinbender, T., Tvaronavičienė, M., & Lace, N. (2020). Economic efficiency and energy security of smart cities. *Economic Research-Ekonomska Istrazivanja* , *33*(1), 788–803. https://doi.org/10.1080/1331677X.2020.1734854
Sun, X., Alcalde, J., Bakhtbidar, M., Elío, J., Vilarrasa, V., Canal, J., Ballesteros, J., Heinemann, N., Haszeldine, S., Cavanagh, A., Vega-Maza, D., Rubiera, F., Martínez-Orio, R., Johnson, G., Carbonell, R., Marzan, I., Travé, A., & Gomez-Rivas, E. (2021). Hubs and clusters approach to unlock the development of carbon capture and storage – Case study in Spain. *Applied Energy*, *300*(June). https://doi.org/10.1016/j.apenergy.2021.117418
SurveyEngine. (2023). *Academic-Grade Research Software & Management*. Survey Engine. Accessed September 09, 2022, < https://surveyengine.com/>
Tcvetkov, P., Cherepovitsyn, A., & Fedoseev, S. (2019). Public perception of carbon capture and storage: A state-of-the-art overview. *Heliyon*, *5*(12), e02845. https://doi.org/10.1016/j.heliyon.2019.e02845
Ter Mors, E., Weenig, M. W. H., Ellemers, N., & Daamen, D. D. L. (2010). Effective communication about complex environmental issues: Perceived quality of information about carbon dioxide capture and storage (CCS) depends on stakeholder collaboration. *Journal of Environmental Psychology*, *30*(4), 347–357. https://doi.org/10.1016/j.jenvp.2010.06.001
Truong, D., Davidson, D. J., & Parkins, J. R. (2019). Context matters: Fracking attitudes, knowledge and trust in three communities in Alberta, Canada. *Extractive Industries and Society*, *6*(4), 1325–1332. https://doi.org/10.1016/j.exis.2019.09.004
Tylecote, A. (2019). Biotechnology as a new techno-economic paradigm that will help drive the world economy and mitigate climate change. *Research Policy*, *48*(4), 858–868. https://doi.org/10.1016/j.respol.2018.10.001
Upham, P., & Roberts, T. (2011). Public perceptions of CCS: Emergent themes in pan-European focus groups and implications for communications. *International Journal of Greenhouse Gas Control*, *5*(5), 1359–1367. https://doi.org/10.1016/j.ijggc.2011.06.005
Volken, S., Wong-Parodi, G., & Trutnevyte, E. (2019). Public awareness and perception of environmental, health and safety risks to electricity generation: an explorative interview study in

Switzerland. *Journal of Risk Research*, *22*(4). https://doi.org/10.1080/13669877.2017.1391320
Walker, C., & Baxter, J. (2017). Procedural justice in Canadian wind energy development: A comparison of community-based and technocratic siting processes. *Energy Research and Social Science*, *29*(February), 160–169. https://doi.org/10.1016/j.erss.2017.05.016
Wang, M., Gong, Y., Wang, S., Li, Y., & Sun, Y. (2021). Promoting support for carbon capture and storage with social norms: Evidence from a randomized controlled trial in China. *Energy Research and Social Science*, *74*(February), 101979. https://doi.org/10.1016/j.erss.2021.101979
Wang, M., Wang, S., Sun, Y., & Li, Y. (2019). Improving Public Acceptance of Carbon Capture and Storage(CCS) in China. *IOP Conference Series: Earth and Environmental Science*, *371*(3). https://doi.org/10.1088/1755-1315/371/3/032071
Wennersten, R., Sun, Q., & Li, H. (2015). The future potential for Carbon Capture and Storage in climate change mitigation - An overview from perspectives of technology, economy and risk. *Journal of Cleaner Production*, *103*, 724–736. https://doi.org/10.1016/j.jclepro.2014.09.023
Whitmarsh, L., Xenias, D., & Jones, C. R. (2019). Framing effects on public support for carbon capture and storage. *Palgrave Communications*, *5*(1). https://doi.org/10.1057/s41599-019-0217-x
Wilberforce, T., Olabi, A. G., Sayed, E. T., Elsaid, K., & Abdelkareem, M. A. (2021). Progress in carbon capture technologies. *Science of the Total Environment*, *761*, 143203. https://doi.org/10.1016/j.scitotenv.2020.143203
Witt, K. (2019). *The University of Queensland Surat Deep Aquifer Appraisal Project (UQ-SDAAP) Scoping study for material carbon abatement via carbon capture and storage Supplementary Detailed Report Effects of message framing on the support for carbon capture and* (Issue April).
Wolsink, M. (2006). Invalid theory impedes our understanding: A critique on the persistence of the language of NIMBY. *Transactions of the Institute of British Geographers*, *31*(1), 85–91. https://doi.org/10.1111/j.1475-5661.2006.00191.x
Xenias, D., & Whitmarsh, L. (2018). Carbon Capture & Storage (CCS) and public engagement: expert and public views. *Geophysical Research Abstracts*, *20*, 2018–10076.
Yang, L., Zhang, X., & McAlinden, K. J. (2016). The effect of trust on people's acceptance of CCS (carbon capture and storage) technologies: Evidence from a survey in the People's Republic of China. *Energy*, *96*, 69–79. https://doi.org/10.1016/j.energy.2015.12.044
Zhang, K., Lau, H. C., & Chen, Z. (2022). Regional carbon capture and storage opportunities in Alberta, Canada. *Fuel*, *322*(December 2021), 124224. https://doi.org/10.1016/j.fuel.2022.124224