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Perspectives on Carbon Capture and Sequestration in the United States

By

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in

Energy and Resources

in the

Graduate Division

of the

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## Abstract

### Perspectives on Carbon Capture and Sequestration in the United States

by

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Doctor of Philosophy in Energy and Resources

University of California, Berkeley

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Overall, this dissertation examines a sequence of important interconnected issues: the perspectives of potential and actual CCS host communities, the perspectives of the environmental community on the rationality of CCS as viable mitigation solution for the United States, and strategies for engaging with the public on CCS. Much of the research in this dissertation is original work addressing major interdisciplinary gaps in existing literature as well as in industry and government public engagement practice. Each of the chapters is a stand-alone paper that provides a unique contribution to a series of different types of carbon management technologies and academic disciplines. They are assembled together to provide a unique integrated evaluation of these related problems. Collectively, these chapters capture some of the major challenges facing mitigation technology engagement from the potentially time consuming need for careful social site characterization to the opportunities for using citizen-guided marketing methods to identify factors that may enhance effective public engagement.

Chapters 2 and 3 are essays on the perspectives of potential and actual CCS host communities. Chapter 2 finds that host communities in California's Central Valley are more concerned with the social risks of hosting a CCS project (e.g. fear of neglect should something go wrong) rather than with the technical risks of the technology. Chapter 3 finds that host communities across the US are more concerned with social risks, and want a say in how those risks should be mitigated. This Chapter concludes with a discussion of how a 'social site characterization' conducted along side a traditional site characterization when evaluating the potential for a CCS project may be a good way to both encourage positive relationships with community members and mitigate potential concerns.

Chapter 4 is an essay on the perspectives of the environmental community towards the potential of CCS as a viable mitigation solution in the US. This Chapter shows that environmental non-governmental organizations' position on CCS falls into one of four camps who believe: CCS should be developed and deployed in the near-term (Enthusiasts), CCS should be studied (Prudents), CCS will likely need to be deployed but only as a last resort (Reluctants), and CCS should not be deployed (Opponents). This Chapter finds that only Enthusiasts plan on educating the public about the technology in the near-term, however their ability to influence the public may be limited because they are more adept at targeting policymakers (not as experienced with the public) and receive much of their funding from industry (not seen as particularly trustworthy).

In this dissertation, Chapter 5 is an essay on using citizen-guided emotional messages about CCS as a way to effectively communicate with the energy veteran public. This Chapter finds that Wyoming citizens believe information about CCS presented within an emotionally self-referent framework is likely to be a more persuasive way to garner support for or rejection of the technology amongst the Wyoming public than just the presentation of the same information alone.

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INTRODUCTION

*The central task of science writing for a broad audience is, in consequence, how to make science human and enjoyable without betraying nature. – Edward O. Wilson*

Without substantial reductions in greenhouse gases (GHG) from the energy sector, the US recognizes that it will be impossible to avoid catastrophic climate change. One possible solution is carbon capture and sequestration (CCS), where carbon dioxide (CO<sub>2</sub>) emissions are captured from stationary sources and permanently stored deep underground. The solution is seen as promising because it will allow the US to continue using its vast fossil fuel resources and existing energy infrastructure. This technology, if successful, offers the additional benefit of enhancing national energy security through the use of CO<sub>2</sub> for enhanced oil recovery, where the use of domestic fuel supplies reduces the demand for foreign fuel.

Coal is the most important fuel used in the US energy sector today, and it will continue to be so into the foreseeable future. The US has the largest recoverable coal reserve in the world (27%),<sup>1</sup> and nearly half of all domestic electricity generation is produced from coal. The burning of coal for electricity is by far the US' largest source of CO<sub>2</sub> emissions (37% in 2005)<sup>2</sup> (Marland et al 2008). In response to increasing demands for cheap and secure electricity, 69 new coal-fired power plants are in various stages of completion (NRDC 2009). Furthermore, the electricity generated from coal is projected to increase by 21.1% between now and 2030 (Energy Information Administration 2011). Policymakers fear that a radical move away from coal to alternative sources of fuel for electricity generation would likely result in undesirable economic and political impacts, at least in the short-term. Although there appears to be growing support among policymakers and the energy industry for CCS as a viable bridging technology, it remains very controversial.

The first critique, argued largely by environmental activists, labels CCS as a 'dirty' climate change solution in the battle between 'dirty' and 'clean'. While CCS is a technology designed to mitigate climate change, environmentalists' argue that this dirty solution contributes to the continued use of the dirtiest of all fuels – coal (Wong-Parodi et al 2008, Anderson and Chiavari 2009, Ha-Duong and Loisel 2009). They cite reasons for why all coal use should cease from environmental reasons, e.g. mountain top removal, to human health impacts, e.g. the tons of smog contributing gases emitted annually from coal-fired power plants. Furthermore, they argue, technologies like CCS make it easier for the energy industry to justify the use of fuels like coal, and harder to justify the expense of developing alternative sources of energy. Therefore, CCS should not be a technology that the US should invest in when there are other, more appealing and more appropriate, solutions available.

The second, argued by social science academics and liberal activists<sup>3</sup>, view CCS as part of a US neoliberal agenda (Trainer 2008). Whatever the true intention of policymakers, and other proponents, CCS fits a little too comfortably within existing power and economic structures. It is

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<sup>1</sup> Followed by Russia (17.3%), China (12.6%), and India (10.2%) (Energy Information Administration 2003)

<sup>2</sup> Most coal plants in the US use pulverized coal technology, and typically deliver between 500- and 1000-MW of power. A 1000-MW pulverized coal-fired power plant emits between 6 and 8 million metric tons/year of CO<sub>2</sub> (Herzog and Golomb 2004).

<sup>3</sup> For examples, see [www.coal-is-dirty.com](http://www.coal-is-dirty.com) and [www.sourcewatch.org](http://www.sourcewatch.org).

therefore not only a symptom of the status quo, but also is a technology with agency that works to maintain existing structures of power. The danger is not just that those in power stay in power, but that those in power define the boundaries of the *possible* solutions to climate change (Demeritt 2006, Wynne 2002). In defining the boundaries of the possible, those in power implicitly define what is *impossible* – perhaps to the detriment of the climate, and to humanity. Thus solutions not seen as economically popular or politically popular, but that may be better solutions by a more appropriate set of criteria are underdeveloped or ignored completely.

CCS proponents, self-proclaimed ‘pragmatists,’ counter the critiques of these ‘idealists’ by arguing that coal is here to stay, period. Proponents argue that, despite some of CCS’ shortcomings, the US will continue to use its cheapest source of energy, which is coal (Drake 2008). This technology offers the US a way to meet mitigation goals while at the same time allows power producers to continue to offer cheap and reliable electricity to their consumers. The use of CCS, they argue, does not preclude the development of alternate sources of energy (Wong-Parodi et al 2008). Rather, the use of CCS will allow for a smoother transition to alternatives than dropping fossil fuel based electricity all at once (Herzog 2001).

As a greater number of policymakers come forward in support of carbon management technologies like CCS, the public remains largely ignorant of the technology. Some experts and policymakers see the absence, or downright exclusion, of the public in the discussion of how the nation should move forward with respect to climate change as justified (Rayner 2003, Lahsen 2005). They argue that the public elects policymakers to make the ‘right’ and ‘best’ decisions. Furthermore, the public does not possess the technical know-how to sufficiently understand proposed solutions and they do not understand how each solution may impact the nation. Despite these arguments, there is a growing, if somewhat grudging, acknowledgement that what the public thinks about potentially risky technologies matters, a lot (NETL 2009, O’Hare 1983).

Accidents and missteps in the production of fossil fuel resources, e.g. Deep Horizon oil spill in 2010, and in the generation of electricity, e.g. Fukushima reactor leak in 2011, has cast a negative light on the energy industry. The latest Gallup polls show that the public believes that oil companies are not doing enough to ensure the safe operation of their rigs, and that when accidents do occur companies do not react quickly enough to mitigate damage (Newport 2010). These polls also suggest that the ongoing nuclear crisis in Japan is related to heightened fears of a nuclear-related accident in the US, and that the public is less supportive of new nuclear construction than they were before the crisis (Jones 2011). Events like these have resulted in an overall poor view of the energy industry that includes nearly all energy-related technologies, from nuclear power to coal mining (Rosa and Dunlap 1994, Firestone and Kempton 2006, Montrie 2003).

Based on experience, opinion polls, and research with the public on energy-related technologies, CCS proponents are well aware that public support or, at the very least, no active resistance, may be important to the future success of the technology (Hess 2005, BD Solomon et al 2009, Van der Horst 2007, Walsh et al 1993). When the public learns about the technology, their initial views are neutral to slightly negative (Palmgren et al 2004). In addition, the public views CCS as similar in both scale and risk to nuclear power with respect to catastrophic leaks and waste storage, even though the public knew that these two technologies are not the same (Reiner et al 2009). This view is arguably the most troubling for CCS proponents, who probably prefer that CCS was not associated with a technology that is nearly universally viewed by the public as the most dangerous and risky way to generate electricity (Slovic 1987).

Seizing an opportunity to address public concerns as they may arise, research on the public perceptions of CCS has risen over the past several years. For some researchers, the aim of understanding perceptions is to develop ways to effectively educate the public about the technology (Morgan et al 2002, Atman et al 1994, Bostrom et al 1994). Education, they believe, is important for

two reasons. First, an informed public is a powerful public. For example, an educated public will have the information necessary to competently join the debate, now dominated by policymakers and technocrats, on how the US should proceed with respect to climate change solutions. Second, an educated public will be able to make more informed decisions in their personal life. For example, an informed person will be better equipped to decide whether or not she wants to purchase a home near a CO<sub>2</sub> sequestration site. As a group, these researchers are neither proponents nor opponents of technology but rather are interested in understanding ways to effectively educate the public.

Other researchers, by and large, are interested in promoting CCS as a rational climate change solution for the US (Parfomak 2008). These researchers are interested in understanding the public's perceptions of CCS so that they can develop strategies for promoting CCS to the public (Ha-Duong et al 2007, Miller et al 2007). Goals for engagement range from learning how to allay fears and concerns about the technology to developing techniques for persuading the public that the technology is the best way to proceed with national climate change mitigation goals.

Most of this research on public views of CCS, has thus far, been with the general public<sup>4</sup> rather than with the public most likely to be the first to encounter the technology. If the nation decides to go forward with CCS, the public who will be first exposed to the technology are those who live in places with existing fossil fuel operations and with an established energy infrastructure (NETL 2010). These places will be favored over others not only because the technology needs to be located near fossil fuel power plants, but it will also be located at places where costs and technical risks can be minimized, i.e. well-characterized geology and potential for enhanced oil recovery. The public living near these potential locations is familiar with the energy industry or may be very familiar because their livelihoods are heavily dependent on the local energy industry (Wong-Parodi et al 2009, Wong-Parodi et al in review)<sup>5</sup>. Collectively, these people are the 'energy public' (also referred to as 'host communities' or 'energy veteran' throughout this dissertation).<sup>6</sup>

To date, research on public perceptions and effective engagement has not clearly articulated "which *forms, features, and conditions* of public engagement about CCS are optimal for *what* purposes, and *why*?" (underlined words added by author, PytlikZillig and Tomkins 2011, p 2) This dissertation takes the first steps towards answering these questions and in so doing makes an important contribution both to the practice of public engagement about CCS, and also to the theoretical understanding of perceptions of carbon management technologies that will be useful beyond the energy policy arena. My dissertation is a collection of four essays on the perceptions of CCS. The first two center on understanding the perceptions of the energy public living near actual or potential CCS projects, and the last two focus on the factors that influence the perceptions of this public.

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<sup>4</sup> For examples, see Palmgren et al 2004, Sharp 2000, and Reiner 2008.

<sup>5</sup> In chapters 2 and 3, I refer to the energy public as 'host communities' because they are located near actual or potential CCS pilot projects. These publics had varying degrees of knowledge and experience with the local energy industry. In chapter 5, I refer to the energy public in Wyoming as 'energy dependent' because their livelihoods depend directly or indirectly on the local energy industry. While I found nearly all in the energy dependent public were extremely knowledgeable about their local energy industry, I found a wider range of knowledge about the inner-workings of the local industry amongst the host community public. It is likely that the wider range of knowledge about the energy industry in the host communities is due to a more diverse local economy.

<sup>6</sup> It is important to note, that if CCS should go to scale then it will be cited in places that don't have an existing energy public but rather a public that is unfamiliar and inexperienced with the energy industry. Therefore, study of the demands on existing infrastructure in places where CO<sub>2</sub> may be sequestered is necessary. For example, if CCS were to go to scale then it could be located in locations with deep saline aquifers where there is no existing infrastructure, no experienced workers, and no existing regulatory or enforcement mechanisms. Much, I believe, can be learned from an examination from Rural Sociology, which has well documented the experience of the growing pains associated with new economies and new technologies.

## The story of CCS, in brief

### *The reinvention of old technologies*

The birth of CCS cannot be attributed to one inspired individual. Rather, it was born out of the uncoordinated collective efforts of many individuals, with often quite different objectives. It wasn't until the 1960s and 1970s, when climate change science provided compelling evidence linking rising CO<sub>2</sub> emissions with fossil fuel use, that seemingly unrelated technologies would come together to form a new technology – CCS. For the purposes of this dissertation, the story of CCS begins at the turn of the 20<sup>th</sup> Century.

In the early 1910s and 1920s, petrochemical companies were looking for ways to reduce production costs. One avenue of research was the use of pure streams of CO<sub>2</sub> for petrochemical production processes (Gunardson 1998). This research would prove quite lucrative for the energy industry, and would later provide the foundation for the development of carbon management technologies. Pure CO<sub>2</sub> proved to be useful in the production processes of many industries<sup>7</sup>, from the chemicals industry, e.g. raw material for the production of methanol and urea, to the food and beverages industry, e.g. refrigerant additive for the storage and transport of foods. By the 1960s, industrial CO<sub>2</sub> was formulated almost exclusively from fossil fuel feedstocks (Yang 1986).

By this time, Keeling had published his Mauna Kea Observatory findings that showed a positive relationship between atmospheric levels of CO<sub>2</sub> and temperature (Keeling 1960)<sup>8</sup>. Furthermore, other researchers observed that increasing levels of CO<sub>2</sub> was strongly positively correlated with increasing rates of anthropogenic emissions of the gas largely due to the combustion of fossil fuels (Bottinga and Craig 1968, Shaw and Donn 1968, McCormick and Ludwig 1967, Landsberg 1970). This evidence, coupled with findings that atmospheric CO<sub>2</sub> acts like a 'greenhouse gas' that may lead to irreversible and potentially catastrophic climate change, provided the impetus for scientists to seek ways to mitigate or prevent the release of anthropogenic CO<sub>2</sub>.

At the same time, scientists at Brookhaven National Laboratory, searching for ways to produce hydrogen at low-cost, came across the work conducted in the early 20<sup>th</sup> Century by the petrochemical industry on the purification of CO<sub>2</sub> from fossil fuel feedstocks. Inspired by this research, a team at Brookhaven, lead by Meyer Steinberg, began to investigate the possibility of removing and concentrating CO<sub>2</sub> from the atmosphere (Steinberg 1976, 1977, 1978). They even went so far as to look into ways of extracting CO<sub>2</sub> from the ocean, in hopes that they would be able to produce fuels for nuclear powered vessels (Steinberg and Baron 1977). It was during this exciting time that Steinberger and his team learned about the findings of Keeling and other climate change scientists.

By the end of the 1960s, there was a growing consensus within the scientific community that climate change was occurring and would prove more expensive to solve over time. At this time, scientists and engineers felt fairly confident that solutions were at hand, and that climate change would be resolved in a reasonable manner (Nordhaus 1975). The next decade saw the rise of an increasingly globalized effort to not only understand the science of climate change but to also develop technical solutions to address climate change.

By the mid-1970s, the evidence for anthropogenic climate change had moved out of the scientific community to the public arena. Fred Baes at Oak Ridge National Laboratory published a report on the possible effects from burning fossil fuels on the atmospheric level of CO<sub>2</sub> (Baes et al 1976). His work was so well received by the scientific community, that he was urged by colleagues to publish a

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<sup>7</sup> See Appendix A.3 for an overview of industrial uses of CO<sub>2</sub>.

<sup>8</sup> See Appendix A.1 for a brief summary of climate change science.

condensed version for the public entitled “Carbon Dioxide and the Climate: the uncontrolled experiment” in *American Scientist* (Baes et al 1977).

Parallel to the important work on anthropogenic sources of CO<sub>2</sub> and the studies modeling potential impacts of climate change, researchers began to investigate potential solutions in earnest. During this heady time, technologies considered by the scientific community ranged from energy efficiency to the stratospheric disposal of CO<sub>2</sub>. In 1977, Cesare Marchetti, of the International Energy Agency (IEA), was the first to propose the permanent disposal of CO<sub>2</sub> in his publication entitled “On Geoengineering and the CO<sub>2</sub> problem” (Marchetti 1977). In his paper, Marchetti proposed pumping liquid CO<sub>2</sub> into the Atlantic Ocean off the Straights of Gibraltar, where ocean currents would move the CO<sub>2</sub> away from the western coasts of Spain and Morocco. This concept, later called CO<sub>2</sub> capture with ocean sequestration, gave life to the notion that, not only is disposal possible, but that CO<sub>2</sub> could be extracted directly from the source of emissions – a fossil fuel power plant.

At the same time, CO<sub>2</sub> researchers at the Department of Energy (DOE)<sup>9</sup> were well positioned to start testing some of the solutions related to the fossil fuel industry (Steinberg 1992). In many ways, this group of researchers was uniquely situated to test possible solutions. They possessed a deep knowledge of CO<sub>2</sub> capture technologies, and had experience testing injection technologies for acid gas disposal and enhanced oil recovery in their collaborative work with the energy industry (see [www.cdiac.ornl.gov](http://www.cdiac.ornl.gov)). One branch of their research team was devoted to investigating ways to economically remove and recover CO<sub>2</sub> from industrial processes. Another branch focused on permanent storage options for CO<sub>2</sub> such disposal into the ocean, oil and gas fields, and coal seams. The findings from these studies somewhat dampened the optimism for the commercialization of these technologies. In short, the researchers discovered that the management of carbon in the energy industry would be an expensive endeavor, one that would likely double the cost of electricity.

Despite this, a growing number of researchers believed that to avoid catastrophic climate change, carbon reductions in the energy sector would be absolutely necessary. By the 1990s, the technologies developed and tested by the CO<sub>2</sub> researchers at DOE became known as ‘carbon capture and storage’ technologies (Steinberg 1992). In the late 1980s, recognizing that only a global effort could effectively solve climate change, scientists in the US and around the world formed the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2007). Comprised of prominent scientists, this organization offered the latest assessments on the state-of-the art science on climate change. In response to the call that a global effort would be needed to combat climate change, the CCS community began to establish research programs around the world<sup>10</sup>.

From the beginning, Japan was perhaps the most active country in developing and testing CCS technologies. In 1990, Japan established the first CCS research program, which remains, to this day, the largest and longest running program in the world (Research Institute for Innovative Technologies for the Earth, [www.rite.or.jp](http://www.rite.or.jp)). In 1991, the IEA launched its Greenhouse Gas Research and Development Programme (see [www.icaghg.org](http://www.icaghg.org)). The following year, the organization hosted its first International Greenhouse Gas Technologies (GHG-T) conference. This conference would later become the premiere forum for CCS researchers around the world where they could meet and discuss the latest technological and policy developments.

Over the last two decades, interest in CCS as a viable solution for climate change has risen and fallen with changing political tides and as CCS development has encountered technological barriers. In the past, what was meant by ‘capture’ and by ‘sequestration’ was more broadly defined than it is

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<sup>9</sup> The Carbon Dioxide Research Division at the Office of Energy Research at the Department of Energy.

<sup>10</sup> For examples, see Global CCS Institute ([www.globalccsinstitute.com](http://www.globalccsinstitute.com)), Mizuho Information and Research Institute ([www.mizuho-ir.co.jp](http://www.mizuho-ir.co.jp)), and The Cooperative Research Centre for Greenhouse Gas Technologies ([www.co2crc.com.au](http://www.co2crc.com.au)).

today. For example, capture technologies included the promotion of CO<sub>2</sub> uptake during naturally occurring processes on land (C4 crops) and in the oceans (iron fertilization to promote the growth of phytoplankton) (Litynski et al 2006, Ametistova et al 2002). Sequestration technologies included the disposal of CO<sub>2</sub> into the deep ocean to the burial of woody and plant materials. In some cases, CCS meant the prevention of the release of CO<sub>2</sub> to the atmosphere from the soil through low-till agriculture. Today, CCS means the capture of CO<sub>2</sub> through chemical processes from stationary sources of emissions and underground disposal in geologic reservoirs such as gas/oil fields, unmineable coal seams, and basalt (saline aquifers) formations<sup>11</sup>.

### *Policy perfect*

By the end of the 1960s, growing public concern over the environment made issues like climate change worthy of political attention, and the scientific community responded to this growing attention. By the time Nordhaus (1975) presented his work entitled “Can we control carbon dioxide?” to the International Institute for Applied Systems Analysis, policymakers were paying attention to the climate change solutions proposed by scientists (Nordhaus 1975). One broad category of technologies that would come to include CCS, were those called ‘clean up ex-post’ technologies. While this category was seen as promising by policymakers, it did not get full political support at the time because political attention was focused on the category of ‘reduced emissions’ technologies (e.g. energy efficiency). Reduced emissions technologies were a political favorite because they promised to result in both reduced GHG emissions and increased national energy and financial savings. By the 1990s, however, it became clear that reduced emissions technologies, while necessary, would not be sufficient for effectively combating climate change. The reality was that the US relied heavily on fossil fuels in the energy sector and therefore major reductions in the energy industry would be necessary (Princen and Finger 1994). Thus, an important question for policymakers was: “How can the US continue to use coal and other fossil fuels, while at the same time reduce CO<sub>2</sub> emissions in the energy sector?”

To this day, policymakers make three arguments in defense of their support of CCS. First, alternative technologies are not mature “despite great efforts and investments...by many nations to increase the share of energy to satisfy the primary energy demand and to foster conservation and efficiency improvements of fossil fuel energy usage” (Herzog and Golomb 2004, p 1). Second, transitioning away from fossil fuels will be difficult because of large private and public investments, on the order of trillions of dollars, in the US’ existing energy infrastructure (Herzog 2001). Finally, high volume mature sectors of the economy are very resistant to radical technical change.<sup>12, 13</sup> CCS allows the energy sector to make incremental changes using technologies they are already experienced with.<sup>14, 15</sup> Despite all of CCS’ favorable characteristics, policymakers acknowledge that all stakeholders do not share the same position on CCS.

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<sup>11</sup> For an overview of the technology, see Appendix A.4.

<sup>12</sup> Abernathy-Utterback product life cycle model: during the lifetime of a product, a section becomes rigid, especially those sectors that are capital intensive (Kemp 2001).

<sup>13</sup> Such sectors are powerful and able to fight off regulations that require major change in their process technologies (Kemp 2001).

<sup>14</sup> Presently, all commercial CO<sub>2</sub> capture plants use processes based on chemical absorption with monoethanolamine (MEA) solvent. MEA was developed more than 60 years ago as a general, nonselective solvent to remove acid gas, such as CO<sub>2</sub> and H<sub>2</sub>S from natural gas streams” (Herzog 2001).

<sup>15</sup> “Years of technological innovation and experience have given use the tools and expertise to handle and control CO<sub>2</sub> in the operational subsystem with adequate certainty and safety; however, that same level of expertise and understanding is largely absent once the CO<sub>2</sub> enters the storage reservoir” (Herzog and Golomb 2004, p 6).

The first challenge facing CCS is cost and regulatory uncertainty. CCS is very expensive, and especially risky for early adopters in the energy sector given the uncertain state of federal climate change legislation. Most energy and economic models suggest that commercialization will occur, in a carbon market scenario, only when the price of CO<sub>2</sub> reaches at least 30 US\$/ton of CO<sub>2</sub> (IPCC 2005). Federal policymakers have tried to reduce costs by investing millions of dollars in a Carbon Research Program through DOE, which is tasked with CCS-related research on technology and infrastructure development, as well as fostering international collaboration. While federal policymakers have only promised to reduce regulatory uncertainty, motivated by the prospect of DOE project funding, state policymakers have made great strides in developing CCS-related state legislation. For example, Texas passed House Bill 149 in 2006 that provides liability protection to fossil fuel-based power plants that sequester CO<sub>2</sub>, by transferring the ownership of the CO<sub>2</sub> to the state (McDonald 2007).<sup>16</sup>

The second challenge facing CCS is the public. The US government cannot (and should not) pursue forceful initiatives i.e. commercial CCS without the public supporting such action (Kraft and Vig 2003). There are a number of reasons why the general public might not be supportive of the technology. First, the price of electricity from coal-fired power plants would increase. Capturing 90% of CO<sub>2</sub> from a power plant, for example, would add 2¢ per kilowatt,<sup>17</sup> with 75-80% of this cost attributable to capture and compression processes (Herzog and Golomb 2004).<sup>18</sup> Second, while capture, compression, and transportation of CO<sub>2</sub> involve relatively mature technologies, the long-term sequestration of CO<sub>2</sub> is a novel process. Since the formations targeted for CO<sub>2</sub> storage may be located near populated areas, the technology will require an unprecedented level of long-term stewardship. This will require a long-lasting relationship between the energy sector, monitoring organization, and the energy public. Third, while CO<sub>2</sub> is not toxic or flammable, it is heavier than air and can cause suffocation if present in high enough concentrations (Herzog 2001). Finally, CCS has been linked in the minds of the public with fossil fuels, and with coal in particular (Wong-Parodi 2009). The technology has also been linked to nuclear power, and to the storage of nuclear waste in particular (Reiner et al 2010). Thus, some of the public may believe the technology plays a role in the perpetuation of the use of dirty and dangerous fuels for electricity production (NRDC 2009).

These challenges are daunting. The challenge of overcoming the high cost and regulatory uncertainty of CCS will take an enormous amount of dedication by policymakers and researchers alike, as well as a properly incentivized energy sector. However, unlike the public, the energy sectors' motivations are, in general, purely economic. This sector will develop and deploy CCS if mandated to do so, given sufficient technical and financial support, even if the industry, as a whole, believes climate change is bogus. The receptivity of the public to CCS depends on characteristics not only of the technology itself, but also on other characteristics that may prove to be more influential with some segments of the US population than simple expert designed cost/benefit analyses of the technology.

While policymakers and CCS developers know that public (active or inactive) support for CCS may play an important role in the successful commercialization of the technology, little federal funding has gone to social science research. Indeed, most federal funding is funneled through DOE's Carbon Sequestration Program and has been classified as 'outreach and education' (see [www.fossil.energy.gov/sequestration](http://www.fossil.energy.gov/sequestration)). Most work on understanding what the public thinks about

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<sup>16</sup> See Appendix A.5 for a full description of CCS projects in the US.

<sup>17</sup> A noticeable difference to residential consumers who are used to paying on 9.63 cents/kWh (December 2008 in the East South Central) (Energy Information Administration 2009).

<sup>18</sup> However, the price of electricity is likely to increase (between 3 cents/kWh and 22 cents/kWh) for all mitigation technologies except for energy efficiency and conservation (National Renewable Energy Laboratory 2002).



CCS, to date, has been conducted by social scientists interested in risk perceptions and communications. Furthermore, nearly all of this work has been conducted with general publics and not the energy public. My work builds upon, and contributes, to this fledging area of investigation.

## **Effective ways of engaging with the public on CCS**

### *Public perceptions of CCS*

The first studies on the public and CCS centered on the public's perceptions of the technology (Curry 2004, de Best-Waldhober et al 2008, Ha-Duong et al 2007, Shackley et al 2004, Sharp 2000). Researchers found that most of the public had never heard of CCS and, without learning details of the technology, they had no idea what the technology was used for. In order to assess public perceptions – generally understood as the thoughts and feelings that a person has toward a person, event, object, or issue (Broadbent 1958) – researchers found that they had to inform their participants about the technology. Typically, the information presented to participants was technical in nature and included the rationale for using the technology, how it works, cost estimates, and technical risks. Thus, the participants expressed their views of the technology with respect to the expert factual information about the technology.

The CCS information used in these studies was taken from scientific papers and reports<sup>19</sup> and did not include information on how the technology may impact and affect the lives of the public where the technology will be deployed. Sociological studies argue that people evaluate technologies in light of their life histories, and perspectives are tied to broader worldviews and beliefs as they are to factual information (Freudenberg and Pastor 1992). In addition, social psychology studies found that lay peoples' views of technological risk are *qualitatively* different than those of experts (Slovic 1987, Glickman and Gough 1990, Krinsky and Golding 1992). Thus, the factual CCS information presented to the participants may not be what participants would find most useful when evaluating the technology. While these studies provided important information with respect to how the general public may view the technology, participants had no reason to imagine how *they* may be affected by the technology and their responses reflected this. Therefore, these studies provide little insight into how the public who are directly affected, the 'host community,' perceives the technology.

A second set of studies on the public and CCS focused on developing strategies for effectively engaging with the public about the technology. Several examined the "social acceptance" of CCS (Huijts et al 2007, Uno et al 2004), while others investigated the factors that influence acceptance (Miller et al 2007). In some studies "effective engagement" meant devising ways to educate the public to promote a more democratic exchange between decision-makers and citizens, and in others it meant developing ways to minimize the Not In My Backyard (NIMBY) reaction to the technology (Heiman 1990, Piller 1991, Takahashi 1998). By asking their participants to describe if CCS was, or could be made, acceptable to them, these researchers forced participants to imagine that they were part of the public directly affected by the technology. While these studies provide some insight into how the public directly affected by a project might view the technology, the participants are members of the general public and, therefore, the findings provide only limited guidance when developing CCS engagement strategies for host communities.

It wasn't until US DOE began developing and deploying small-scale CCS pilot projects around the US by the mid-to-late 2000s (DOE 2006, DOE 2007a, 2007b, 2008c) that the opportunity to assess 'real' host community perceptions arose. These projects usually had an 'education and outreach' component, in addition to experiments conducted at these sites, that typically involved a

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<sup>19</sup> Such as from the DOE's website, [www.fossilenergy.doe.gov/sequestration](http://www.fossilenergy.doe.gov/sequestration).



one-way exchange of factual information about CCS and of the project (Wilson 2006), which was the type of communication commonly used for many of the initial CCS perceptions studies. Little study was conducted at these sites to understand host community perceptions of the technology, let alone study of effective engagement strategies.

### *Host community perceptions of CCS*

In this dissertation, the main objective of Chapters 2 and 3 is to understand and explain the views of host communities located near actual or potential CCS sites. These chapters are motivated by three theoretical arguments. First, public acceptance of large-scale infrastructures, and their attendant costs, benefits, and risks, could be considered intrinsically important in a democratic nation (Thiabaut and Walker 1975, Lind and Tyler 1988, Chess and Purcell 1999). Second, public participation is a way to promote the inclusion of multiple viewpoints that may result in the development of ‘non-expert’ knowledge (Beierle 1999, Chess and Purcell 1999, Johnson 1987, Senier et al 2008). Third, psychological studies<sup>20</sup> suggest there is a strong connection between attitude/perception and behavior (LaPiere 1934), which is moderated by attitude strength (Cook and Sheeran 2004, Holland et al 2002). These findings are supported by case studies that suggest negative views towards large-scale infrastructure projects with potentially negative environmental impacts such as CCS can lead to social resistance and public protest of the particular project, and of the technology used for the project in general (Beierle 1999, Shively 2007, Endres 2009).

In Fall 2005, I was invited to join a team of researchers at UC Berkeley to work as part of DOE’s carbon sequestration network to assess the CCS perceptions of several pilot project host communities. The team of researchers chose to develop a series of focus groups to assess perceptions for two reasons: this was a new area of research and the focus group allows multiple dimensions important to participants emerge through discussion, and this is an excellent way to pilot and refine surveys for any subsequent larger studies (Richards and Morse 2007). Chapter 2 is an essay on host community perspectives of two communities in California’s Central Valley. Chapter 3 is an essay where the perspectives of several host communities, including those described in Chapter 2, from across the US are aggregated and analyzed.

Again, what sets the findings in these essays apart from all other previous CCS perceptions research is that the participants are members of host communities. For these communities, unlike the general public, the prospect of CCS is not an abstract technology but it is rather an actual or potential reality. The general public are primarily concerned with the technical risks of CCS deployment e.g., asphyxiation due to a catastrophic leak (Curry 2004, de Coninck et al 2008, Ha-Duong et al 2007, Huijts et al 2007, Shackley et al 2004, Sharp 2000). I found that the energy public, like the general public, is concerned with technical risks however they are also concerned with a whole host of risks not previously found in the CCS perceptions literature.

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<sup>20</sup> However, it should be noted that this is very much a social psychological perspective. For example, sociologists may view CCS perceptions as resulting from real objective facts (objective/realist approach) or see views as resulted from social artifacts that are fabricated by social groups or institutions (constructivist approach) (Krimsky and Golding 1992). It should also be noted that while a causal relationship between attitude and behavior is generally accepted in social psychology, there are different theories about the relationship between attitude and behavior. For example, the Theory of Planned Behavior argues that behaviors follow from intent and perceived control (Fazio and Towles-Schwen 1999). Some argue that intentions are influenced by social norms in that only attitudes supported by the ingroup are strengthened (Terry et al 2000, White et al 2002, Smith and Terry 2003). Others have found that intention predicts only 28% of behavior (Sheeran 2002), and that strong attitudes but not weak ones predict behavior (Sheeran and Abraham 2003, Sheeran and Orbell 2000).

The main contribution from these essays to the CCS perceptions literature is that host communities are more concerned about risks that are social in nature, rather than those that are technical in nature. Therefore, attempts for effective engagement with host communities, whether it is for education purposes or to encourage acceptance of CCS, may be less successful if the information presented is only expert-approved facts about the technology. The social risks that most concerned the host communities was that they would have no voice if something should go wrong with the project, and that just procedures would not be followed for project selection and implementation. The character of these risks was moderated by a community's history with the local energy industry, environmental problems, socioeconomic status, and the belief in the trustworthiness of private and public institutions.

The main theoretical contributions from these essays are to two bodies of literature. The first are literatures that are concerned with technology and democracy. The communities want a voice in defining the risks to be mitigated as well as the justice of the procedures by which CCS is implemented. These findings support theories posited by political scientists that suggest democracy can be promoted through more participation (Rowe and Frewer 2000), and that identifying social goals can be an effective way to encourage participation (Beirele 1999, Chess and Purcell 1999, Senier et al 2008). In addition, these findings contribute to the procedural justice literature where the fairness of the process is central to its legitimacy (Lind and Tyler 1988, Thubaut and Walker 1975). The second contribution is to sociocultural understandings of risk and technology. The findings are consistent with sociological studies that argue that risk perceptions are tied to broader worldviews and beliefs as they are to actual risks (Freudenberg and Pastor 1992).

#### *Non-government organizational perceptions of CCS*

Historically, non-governmental organizations (NGOs) have been influential in shaping the public's perceptions of environmental problems, their causes and their potential solutions. Evidence suggests that the public tends to trust environmental information presented by non-governmental organizations (NGOs) (Jepson 2005), far more than similar information presented by government agencies or larger corporations (Rousseau et al 1988, Siegrist and Cvetovich 2000). Therefore, any CCS-related information presented by NGOs is likely to be more credible to the public than the information that is presented by DOE or by companies in the energy industry.

Around the time that DOE established its Carbon Sequestration Research Program in 2000, environmental NGOs began to view CCS as a climate change solution with real potential. The growing interest in CCS is due to "the fact that nothing else seems to have been able to address the problem (of climate change)" (Wong-Parodi et al 2008, p 4). As interest in CCS as a potential solution rose, NGOs began to put forth their official position on whether or not CCS is a rational solution for climate change in the US. Given that the public tends to turn to NGOs for information and solutions to environmental problems like climate change, the position that trusted NGOs assume on CCS may play an influential role in the way the general public views the technology. Furthermore, NGOs are becoming increasingly more directly involved in the policymaking process and therefore may be an important part of the process of creating CCS policy (Cohen 1995, Jepson 2005).

In this dissertation the main objectives of Chapter 4 is to understand and explain environmental NGO perceptions' of CCS, as well as to understand how NGOs plan to educate the public about the technology. The motivation for this chapter draws largely from three theoretical arguments. First, sociological studies suggest that the public tend trust NGOs more than corporations and governments (Jonas 1973, Siegrist and Cvetovich 2000, Rousseau et al 1998), because they are seen as having integrity (e.g. unbiased with respect to solutions), ability (e.g. possess analytical skills to

assess solutions), and benevolence (e.g. care about people and the environment) (Mayer et al 1995). Second, studies find that when people are unable to seek out information about emerging technologies because they possess, for example, little time, experience, or knowledge, they rely on the information presented by trusted sources (Miller et al 2007, Lang and Hallman 2005). Third, political scientists find that US NGOs are increasingly present and influential in national and international environmental policymaking (Fisher 1997, Fox and Brown 2000, Princen and Finger 1994).

The study of environmental NGO perceptions of CCS was conducted in parallel to the study of host community perceptions of the technology. While working with the research team at UC Berkeley on the focus group protocol for the host communities, we learned that members of one of our host communities had expressed anger and outrage by the way in which members of the DOE education and outreach program had conducted a local town hall meeting about the project (Wilson 2006). According to the article, members of the community did not appreciate or understand the scientific jargon used during the presentation and felt that their concerns was not adequately heard by the project team members.<sup>21</sup> It became clear to us that not only may the way in which the technology was presented to host communities shaped perceptions (likely applies to the general public as well), but also from *whom* the public learned about CCS. The literature clearly suggested that NGOs are trusted sources of information about technologies like CCS.

In Winter 2006, I conducted a series of open-ended interviews with climate change experts at national and regional environmental NGOs. The team decided that interviews was appropriate for the exploratory nature of the study where we wanted to both explain the perspectives of the NGOs and we wanted to understand how the NGOs planned to educate their constituents (Bewley 2002).

The main contribution from this essay to the CCS perceptions literature is that NGOs may have only a limited impact on the public's view of the technology, for only those most enthusiastic ('Enthusiasts') about the technology plan to educate the public in the near-term. Those most enthusiastic about CCS are also those that are supported by the energy industry, and therefore may not be considered as impartial as the traditional public interest NGOs (Siegrist and Cvetovich 2000). Furthermore the history of Enthusiasts activism suggest that they target policymakers more than the public, therefore it is unclear how influential they will be in shaping CCS public perceptions.

The main theoretical contributions from this essay are to organizational studies. Douglas and Wildavsky (1982) proposed a sociocultural understanding of environmental organizations in which NGOs are classified as either hierarchical or sectarian. They argue that hierarchical organizations that tend to be centrally-organized with clear chains of authority, value social stability and would collaborate with mainstream institutions to avoid environmental harm. They argue that sectarian organizations that tend to be flexibly-organized and significantly volunteer dependent, would have less faith in established institutions and would favor extra-institutional strategies such as direct action to achieve their environmental goals. Despite the limitations of their analysis of the environmental movement (Winner 1982, Abel 1985, Tulloch and Lupton 2003), Wildavsky and Douglas' sociocultural perspective remains influential (see e.g., Rayner 1992, Thompson et al 1999). The findings in this essay loosely corroborate the relationship between NGO social structure and strategy. Overall, NGOs that appear more open and supportive of CCS, a technology favored by industry and policymakers, are more centrally organized than NGOs less supportive of CCS.<sup>22</sup>

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<sup>21</sup> This is in parallel to other DOE-public interactions around other technologies. See Dietz, T. and Stern, P.C. Public participation in environmental decision making. National Research Council of the National Academies, 2008, ISBN: 0-309-12399-2, 322 pages.

<sup>22</sup> There are benefits and drawbacks for both types of organizational styles with respect to environmental policies and goals. In a more centralized top-down style, the organization may be able to achieve their desired goals through

By the end of the 2000s, it was clear that the engagement strategies that relied on fact-based information about CCS such as those used at the DOE at the pilot project sites (Bradbury et al 2009) did little to garner host community support for CCS projects (Wade 2010, Greenburgh and Hund 2010). Rather than generating positive views of the technology, these strategies deepened feelings of suspicion and ire among members of the host communities. Events at CCS projects outside of the US echoed these findings, where several small-scale projects were terminated due to local protest (Brown 2007, Bradbury and Wade, 2010, Voosen 2010). By 2010 it seemed clear that the US government wanted to include CCS as possible solution in its climate change policy ‘toolbox’ (NETL 2010), however the balance of public opinion, especially by host communities (Bradbury et al 2009), towards CCS was negative. At this time, the CCS social science community was becoming interested in understanding factors that influenced public support, either in favor of or against, for CCS as a possible climate change solution. The view was that this could lead to strategies that would be useful to enhance CCS engagement efforts to not only encourage acceptance, but could also be an avenue for developing more effective ways to educate the public about the technology.

The main objectives Chapter 5 is to understand the perceptions of the public who are members of host communities where the technology will likely be first deployed (‘energy veteran’), and to evaluate the factors that influence the support or opposition to the technology. The motivation for this chapter comes from two theoretical arguments. First, experiments by psychologists in media studies suggest that well designed messages are those that are not only informational and logical, but those that trigger an emotional response in recipients (Dillard & Peck, 2000, 2001; Pechmann & Reibling, 2006). ‘Emotionally self-referent’ (ESR) messages – that trigger thoughts about identity (Escalas, 2004; Dunlop, Melanie Wakefield, & Kashima, 2008) – are better remembered, and viewed as more persuasive than those that do not arouse such a response. Second, research suggests that ESR messages may have the additional benefit of being talked about with recipients’ friends and families. Exposure to these messages encourages discussion where information flows through social networks, potentially influencing those not exposed to the original message (David, Cappella, & Fishbein, 2006; Luke & Harris, 2007; Maibach, Abrams, & Marosits, 2007). Third, persuasion studies several factors mediate the degree to which a recipient is persuaded by a message. Some factors center on the recipient herself, examples are the level of motivation to understand the message (Block and Keller 1995, Shiv et al 2004), degree to which message reflects existing attitudes and attitudes of peers (Aaker and Maheswaran 1997, Shiv et al 2004), the congruence of the message to personal experience (Shiv et al 2004), and if the message is delivered by a trusted source (Priester and Petty 2003). Other factors center on the message such as if it is presented in narrative rather than list form (Adaval and Wyer 1998) and if it encourages elaboration by the recipient (Bohner et al 2003)<sup>23</sup>.

By Fall 2010, in many conversations I had with CCS researchers about where the technology would be first deployed that Wyoming came up again and again as an excellent place to find an energy public. The state’s economy is largely based on the extraction of fossil based resources and in the face perceived growing animosity towards coal, CCS has been embraced by state leaders as a

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collaborative incremental steps but may also foster an environment that favors expert knowledge and discourages the questioning of authority. In a more decentralized bottom-up style, the organization may be able to achieve their desired goals by original and dramatic strategies but may be hindered by an outsider status.

<sup>23</sup> It should be noted that some experiments have found that elaboration is discouraged if the task is too cognitively taxing (Keller and Block 1997), if there aren’t enough cognitive resources (Peracchio and Meyers-Levy 1997), and too much elaboration can lead to counter-arguments (Keller and Block 1997).

way to keep the state's economy afloat. The state has taken many steps to foster the development of CCS from passing CCS-friendly legislation to submitting a proposal for DOE's FutureGen competition (Joint Judiciary Interim Committee, 2008a, 2008b; Bleizeffer, 2009, 2010a, 2010b). In Summer 2010 I conducted a series of interviews in two of the most energy veteran communities in the state, Gillette and Rock Springs, where the participants developed a persuasive pro- or anti-CCS campaign based on ESR messages designed to generate statewide support or opposition to the technology.

This essay makes several contributions to the CCS perceptions literature. First, ESR messages may be at least as important as scientific based CCS messages when trying to influence the perceptions of the energy veteran public. Second, this essay outlines a citizen-guided social marketing method to identify specific emotional triggers that elicit thoughts about self, and to use these in a CCS outreach program. These findings complement those described in previous essays that host communities are more concerned about risks that are social in nature rather than those that are about technological risks per se (Wong-Parodi et al 2008, Bradbury et al 2008). Finally, these findings support findings described in Chapter 3 that past history with the energy industry may influence a host community's sense of social *and* technological risk.

The main theoretical contribution from this essay is to the sociological and psychological studies of persuasion, which could be useful in a wide range of domains including energy policy, environmental policy, and public health. One of the main contributions is to the study of social identity, where this essay demonstrates the centrality of identity in what a person finds persuasive and unpersuasive. Social identity theory posits that people derive their identity from their group membership, and that this social identity has emotional significance (Tajfel and Turner, 1979; Ellemers, 1993; Ellemers et al., 1999). At one level the participants saw the demand of their out-of-state customers (outsiders) for low-carbon fuels is not only a threat to Wyoming's economy, but is also an aggressively direct attack on the participants' identity as a Wyomingite. Thus, participants expressed animosity towards outsiders ('outgroup') and strongly defended the Wyomingite (the 'ingroup') way of life (see e.g. Hornsey et al 2002). At another level, the participants saw that appeal to a Wyomingites' sense of self as a route that would be an effective way of engaging them on ways to make coal low-carbon. Thus, identity is a leverage point that can be used as a springboard for opening a dialogue about topics that may otherwise be sensitive or difficult to broach creating an opportunity to develop persuasive or educational CCS message.

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In summary, the main research objectives of this dissertation are:

- The main objective of chapters 2 and 3 are to understand and explain the views of host communities located near actual or potential CCS sites.
- The main objectives of chapter 4 are to understand and explain environmental NGO perceptions' of CCS, as well as to identify how NGOs plan to educate the public about the technology.
- The main objective of chapter 5 are to understand the perceptions of the public who are members of host communities where CCS will likely be first deployed ("energy veteran"), and to evaluate the factors that influence the support or opposition to the technology.

## HOST COMMUNITY PERSPECTIVES

Over the last decade, many energy experts have supported carbon sequestration as a viable technological response to climate change. Given the potential importance of sequestration in US energy policy, what might explain the views of communities that may be directly impacted by the siting of this technology? To answer this question, we conducted focus groups in two communities who were potentially pilot project sites for California's DOE-funded West Coast Regional Partnership (WESTCARB). We find that communities want a voice in defining the risks to be mitigated as well as the justice of the procedures by which the technology is implemented. We argue that a community's sense of empowerment is key to understanding its range of carbon sequestration opinions, where 'empowerment' includes the ability to mitigate community-defined risks of the technology. This sense of empowerment protects the community against the downside risk of government or corporate neglect, a risk that is rarely identified in risk assessments but that should be factored into assessment and communication strategies.

This Chapter was published in *Environmental Research Letters* in 2009 and appears in this dissertation with the permission of the journal and my co-author (Isha Ray). I developed the research, study design, and research instruments in collaboration with my co-authors, trained research assistants to assist in the collection and data entry necessary for the study, recruited participants, moderated the focus groups and conducted the interviews, performed data analysis, and wrote the first complete draft of the manuscript.

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### Host community perceptions of carbon capture and sequestration risk

Burning fossil fuels is the largest source of energy for electricity generation in the US, and is projected to remain so until at least 2030 (EIA 2008). However, this large-scale combustion of fossil fuels presents a large-scale problem for global climate change mitigation. The US electricity sector contributes nearly one-quarter of all greenhouse gas emissions (EIA 2009). Given the growing political and social impetus for US action on climate change (NETL 2006, WESTCARB 2008), how does the US deal with the environmental challenge of fossil fuels, and in particular with coal?

The answer put forth by many policymakers, both in the USA and internationally, is 'clean coal technologies' (e.g., Parson and Keith 1998, IPCC 2005, DOE 2008b). These technologies, which include integrated gasification combined cycle, circulating fluidized bed coal combustors, and carbon sequestration, are being promoted as 'one of the most promising ways for reducing the buildup of greenhouse gases in the atmosphere' (DOE 2008a). Since 2000, the US DOE has invested heavily in the research and development of these and other energy-related technologies. As part of this effort, DOE developed seven regional research partnerships to develop technology, infrastructure, and regulations through pilot tests, including community outreach and education efforts, to implement large-scale carbon sequestration projects in different regions and geologies in the US (DOE 2006, 2007a, 2007b, 2008c).

The successful deployment of carbon sequestration will be a major endeavor that requires technical know-how, innovative regulations, financial incentives, and public acceptance. Many professionals argue that public acceptance remains one of the most challenging barriers to this

technology, at least in the US (e.g. Parfomak 2008). Research shows that public opinion so far varies from slightly in favor of CCS to opposition to it, and that carbon sequestration is sometimes seen as a stalling tactic compared to addressing the ‘real’ issue of fossil fuel use (Palmgren et al 2004).

It can be argued that public opinions, and eventually acceptance, matter for two reasons. First, public acceptance of large-scale infrastructures, and their attendant costs, benefits and risks, could be considered intrinsically important in a democratic nation. Second, public acceptance could be of instrumental importance in that organized protests could slow down, increase the transactions costs of, or even block, sequestration projects. The latter is a real possibility; past projects with potentially negative environmental impacts, such as hazardous waste disposal facilities, have faced social resistance and public protest (Beierle 1999, Shively 2007, Endres 2009). Thus far, most of the research on public perceptions of carbon sequestration has focused on how the general public views the risks of this technology and on how to garner acceptance of it (de Coninck et al 2008, Ha-Duong et al 2007, Huijts et al 2007, Miller et al 2007, Palmgren et al 2004, Shackley et al 2004, Sharp 2000). However, actual deployment of carbon sequestration will directly impact not ‘the public’ but specific communities.

How host communities themselves understand and define the risks of being host sites remains an understudied question. Host community opinions may differ from those of the public at large because their perceptions are based on the concrete rather than the abstract, particularly when the benefits of hosting are widespread but the risks are locally concentrated. If carbon sequestration needs public acceptance, the directly impacted public is arguably the most important segment to understand and accommodate<sup>24</sup>. This paper asks: what do communities located near actual or potential sequestration sites view as the risks of carbon sequestration? What factors explain community perceptions of the risks of carbon sequestration?

To answer these questions, we conducted focus groups and interviews in two communities that could have been pilot project sites for California’s DOE-funded West Coast Regional Partnership (WESTCARB). Pilot projects are by definition not ‘real’ projects, but they reveal a number of challenges and possibilities, both technological and social, that scaled-up implementation could face<sup>25</sup>. We chose a low-income largely Hispanic community as our first study site and compared its responses to those of a relatively well-off mainly Caucasian community.

Our research finds that communities want a voice in defining the specific risks to be mitigated as well as the justice of the procedures by which the technology is implemented. Consistent with existing work on individual risk perceptions of large-scale technologies, we found that the community-defined risks of sequestration are as much social in nature as they are technological (EPA 2008, Fischhoff et al 1978, Freudenburg and Pastor 1992, Morgan et al 1992, Slovic 1987). In this literature, the social risks of technologies such as sequestration have been related, for example, to how the community is perceived by outsiders (will it be stigmatized?) or to political structures (is the risk voluntary or involuntary, and who is imposing a risk on whom?). Another risk factor cited is the ‘trustworthiness’ of the project information provider—people sometimes distrust safety information provided by government or companies (Rousseau et al 1998, Siegrist and Cvetovich 2000). Our findings extend this important work to include the risk of government and corporate neglect, meaning the risk of no compensation or damage mitigation, should the technology not perform as expected. We argue that this risk should be included in assessing the overall set of risks faced by a community when hosting any large-scale infrastructure, including carbon sequestration.

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<sup>24</sup> This would hold true whether public opinions were valued for intrinsic or for instrumental reasons.

<sup>25</sup> It is widely accepted that pilots are necessary as trial runs for the implementation of new technologies or infrastructure. But they also offer the opportunity to test social responses to such projects. Of course, pilots cannot perfectly predict the social or the technological impacts of projects at scale.

We find that while both communities were reluctant to host CCS sites a community's sense of empowerment is key to understanding its range of carbon sequestration opinions. 'Empowerment' includes (i) the ability to mitigate community-defined risks of the technology, and (ii) the ability to ensure that just procedures would be followed in implementing the technology. We argue that a community's sense of empowerment is rooted in its history and its material and social asset base. This sense of empowerment allows its members to exercise 'voice' (Hirschman 1970) and to seek redress if they think they are being harmed; it thus gives the community some protection against the downside risk of government or corporate neglect. It is the perception of this risk, more than that of technology failure associated with carbon sequestration, and that is rarely discussed in the sequestration literature, that distinguished our two study communities from each other.

In the rest of the chapter, we first recount the data collection methods followed for this research. We then report and interpret our findings on each of our two questions: how communities view the risks of hosting carbon sequestration sites and what factors might explain the range of these perceptions. We highlight in particular a community's history with local industries and its experience of past environmental harm and its mitigation. Finally, we conclude with some thoughts on the implications of our findings for CCS-related risk identification and risk communication.

### *Study sites and methods*

Underlying the Sacramento Basin, which spans over 60 miles from the Coast Ranges to the Sierra Nevada, and 140 miles from south of Stockton to just north of Black Butte, are the largest deposits of natural gas west of the Rocky Mountains. Although some deposits are still extractable, and a few new sites are found every year, most are depleted. Such are the formations that underlie Rio Vista and Thornton (figure 2). It is in these depleted gas fields, among other geologic formations such as deep saline aquifers and depleted oil fields, where WESTCARB planned to test carbon sequestration. WESTCARB originally selected the Thornton gas field as an appropriate test location. Before any outreach effort had begun, while WESTCARB was still in the process of negotiating with the owners of the land overlying the proposed site, an article about the Thornton site appeared in the Los Angeles Times (Wilson 2006). To mitigate any community concerns, WESTCARB decided to hold a town hall meeting to present the details of carbon sequestration and of the test project. Despite their efforts, WESTCARB could not reach an agreement with the landowners, and its cost-share partner pulled out of the project. Thornton was therefore a potential, but is not as of now an actual, project site.





Figure 2 shows a map of the locations of the two study communities, Thornton, CA and Rio Vista, CA. Thornton is located 30 miles south-east of Sacramento, California’s state capital. Rio Vista is located 13 miles from Thornton. (Map of Northern California is from google.maps.com and the pictures were taken by Gabrielle Wong-Parodi in February 2007.)

We conducted three focus groups in Thornton in the spring of 2007. Thornton is an unincorporated, ‘tree-lined woodsy’<sup>26</sup> farming community of about 1,500, and is located 30 miles south-east of Sacramento, the state capital. The community is largely Latino and has low socio-economic status, where fewer than half of all adults hold a high school diploma and the median household income is \$30,469 per year (\$1999) (The comparable median household income for all of California is \$47,493.) According to our interviewees, Thornton’s legal US residents have been leaving due to a sagging local economy, while its undocumented population has been increasing with the demand for (cheap) labor in the agricultural sector. A much-cited outcome of the economic downturn is the recent closure of Thornton High School. Students now commute some 8 miles away to a high school in the larger community of Galt.

To compare Thornton’s concerns with those that might be voiced by a better-off population, we also conducted two focus groups and sixteen one-on-one interviews<sup>27</sup> in a nearby town, Rio Vista. Rio Vista is a small tight-knit rural community of 4,500. Unlike Thornton, the community is largely white, with an educated population and a median household income of \$44,534 per year (\$1999). Also unlike Thornton, the community has experienced a period of rapid population growth: ‘I think a lot of people are moving here to get away from the smog and all that hustle and bustle and stuff like that in the city’ (Interview; business owner). Only 13 miles from Thornton and geologically very

<sup>26</sup> This was the description offered by one of the participants in our study.

<sup>27</sup> We did not conduct one-on-one interviews in Thornton, which, at the time of our research, was under consideration as a CCS test site. The DOE approved our focus group protocol, but did not permit individual interviews. Rio Vista had already been discounted as a CCS site; therefore no restrictions on our research activities were in effect.

similar, Rio Vista had also been considered as a sequestration host site. The complicated negotiations that its numerous landowners would have required WESTCARB to go through removed it as an actual site early in the process.

In our Thornton focus groups we informed the community that they were under consideration as a pilot site, which they then were, but that no final decision had been reached. We found that, other than some of our Chamber of Commerce participants, no one knew this: our focus group members, at least, had not read the earlier Los Angeles Times article. In Rio Vista we informed the community that their gas fields were viable sites for geologic sequestration, and that the DOE had seriously considered them as CCS pilots. We asked our participants in both communities to imagine that they had actually been selected as a host. In both cases we made clear the small and experimental nature of WESTCARB's test injections.

Our sampling method was purposive so that the first focus group in each town comprised people of local standing, such as the Fire Chief and Chamber of Commerce members. We wanted to ensure that these groups would welcome us, and our research agenda, in their towns. Some of these early individuals continued to act as key informants for our study. Other participants were recruited through snowball sampling—a non-probabilistic sampling method in which participants already in the study recommend other persons to be invited to participate. Considerable effort was made, through flyers and radio messages, to ensure that participants for the focus groups and interviews were demographically representative of their communities. To ensure that all participants would be comfortable in sharing their views, we kept the focus groups internally homogeneous (by standard socio-economic measures such as household income, level of education and primary language) but heterogeneous across groups (Bryman 2008).<sup>28</sup>

We chose focus groups as our main data collection method for two reasons. Investigating host community opinions of carbon sequestration is a relatively new area of research, and focus groups allow multiple dimensions important to participants to emerge through discussion. Because focus group participants are self-selected, their views may not represent those of the larger community and should not be treated as doing so. Rather, a series of focus group discussions reveal and clarify the range of perspectives held in the community on the focal theme; for emergent research areas this is especially valuable. Second, focus groups are an excellent way to pilot and refine surveys for any subsequent larger-scale studies (Richards and Morse 2007); we plan to conduct these in several sequestration sites in the future.

Our focus group materials were developed and piloted during the summer of 2006 in collaboration with the education and outreach teams from the Southwest Regional Partnership and the Midwest Regional Carbon Sequestration Partnership. After half of the focus groups had been conducted, we used the results from the group discussions to develop a one-on-one interview protocol. We conducted interviews so that additional views could be solicited, and to test the focus group responses for robustness.<sup>29</sup> The focus group instrument covered four areas: (a) community concerns overall; (b) climate change (c) carbon sequestration; and (d) alternatives to carbon sequestration. Our main interest was sequestration, but in order to help respondents to understand why sequestration was an issue at all, we embedded the sequestration questions within the context of climate change as well as other energy policy options. The interview protocol covered similar

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<sup>28</sup> Rio Vista's two focus groups comprised influential members of the town and lay community members respectively. The final town hall meeting was attended primarily by the second group. Thornton's three focus groups were composed of the influential, teachers and educators, and lay community members (documented and otherwise) who mainly spoke Spanish. The final town hall style meeting attracted a mix of the first two.

<sup>29</sup> Interviews were performed to assess the opinions of community members who did not choose to participate in the focus groups. These were used to validate the opinions expressed during the focus groups as being reflective of the community at large. As explained earlier, we conducted individual interviews in Rio Vista only.

themes. Examples of questions we asked are ‘Where do you think these [carbon sequestration] projects will be sited?’ and ‘In California we live with risk (e.g. earthquakes and flooding). Given the scale of these risks, how much does the additional risk of CCS (carbon sequestration) matter?’ Each focus group comprised 6–8 participants and ran up to 3 h in length. The individual interviews ranged from 25 to 60 min depending on the time constraints of the participant. At the end of the data collection period, we organized a Town Hall style meeting in each community and shared our main observations with interested residents.

### **What do host communities view as the risks of carbon sequestration?**

In this section we report the range of risks with respect to hosting a CCS site that our participants expressed in the course of our discussions. As with most small-n qualitative studies, we use quotes from our participants to illustrate our findings. We mainly report quotes that were reflective of opinions commonly expressed during our focus groups and interviews. Across focus groups within each community (including our interview results in Rio Vista) our results were remarkably similar.

In common with several studies on the siting of infrastructure projects (Kearney and Smith 1994, Lober and Green 1994), both communities in our study were overall negatively disposed towards hosting a CCS site. This reluctance was, as we show below, partly but not wholly a result of the NIMBY<sup>30</sup> phenomenon (Heiman 1990, Piller 1991, Takahashi 1998). Also in common with studies cited above we found that the community-defined risks of hosting a sequestration site were both technological and social in nature. In our study, the social risks appeared to be of greater concern; indeed, the risks of the technology and the risks of being a host site appear to be quite distinct issues. The expressed risks were related to technical problems that might arise with the sequestration process as well as to procedures to be followed during project implementation.

Both communities defined technological risks as actual physical harm and linked it to their suspicion of deficiencies in the quality of expert knowledge: “We are concerned. If we bubble up this CO<sub>2</sub>, we cannot live in it, we cannot breathe it. What could you do? You (experts) do not know, we do not know” (Thornton). Participants’ concern about unknown technical problems led some to fear that injection of CO<sub>2</sub> could result in a catastrophic leak or induced seismicity, which then could result in injury to people or things. For example, one Thornton resident said, ‘It would kill people... it is a silent gas. That is pretty scary’. Both communities also expressed doubts about either the government or companies as trustworthy sources of information, and preferred to receive information from multiple sources. Neither community felt differently about hosting a large and permanent injection project as compared to a small and temporary one; their view was that they would have “more of a problem with it if it lasted five years. They did (DOE) go through all the disruption to get it started and it would be short term” (Rio Vista).

On the social front, participants were concerned that the (actual or imagined) technological risks of a carbon sequestration project would change the nature of the town: “We would have to be forever vigilant” (Rio Vista). Some believed that the quality of life in the community would be adversely impacted, for example through increased traffic or reduced property values for their homes. The property value concern was especially strong in Thornton, a town that has experienced economic stress and de-population.

Participants in each community were equally interested in the procedures of sequestration site selection, deployment and redress in case of damages. During site selection, participants would want to know “what advantages there were for (them)” (Thornton, Rio Vista). Sequestering carbon is a

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<sup>30</sup> “Not in my back yard”. This is sometimes modified to NUMBY (“not under my back yard”) for CCS (Huijts et al 2007).

global public good, and most respondents argued that some local benefits such as better school buildings or new jobs were due to them if they were to serve as host sites. During and after project deployment, our respondents wanted transparency and participation: “Thornton wants to see (what) their reports are of gas leaking, or whatever”. It was clear that information posted on the DOE website was not what the communities wanted; they wanted consultation and information at regular intervals. Finally, if something should go wrong with the project, residents wanted to know: “is not there some law or something that says they have to explain or inform... (and) is there something that we can respond to?” (Thornton).

Although just implementation procedures such as the granting of local benefits and transparency were important to both communities, our interviews revealed that residents of Thornton did not expect to have voice or redress during the lifetime of a project, while most Rio Vista residents did. Although both communities had similar concerns about the technological risks of carbon sequestration, they did not have similar perceptions of the social risks of hosting a site. Thornton residents displayed resignation and powerlessness: “Because they say right here that they are going to test, right? They are going to do it. So you do not think that regardless of what we say it is going to happen? It is going to happen” (Thornton). This community, whose material and social assets were relatively low, was convinced that it would be unable to exercise voice or have recourse to mitigation in case of future harms. They somewhat feared the risks of sequestration per se, but feared even more the risk of being neglected or ignored if the sequestration project turned out to be more harmful than currently expected.

In contrast, Rio Vista residents believed in their power of voice and redress. For example, one resident said “(if carbon sequestration proponents) were to come to Rio Vista and shove their way in here, we would shove them right back out”. Another person, during the final town hall meeting, told us: “we will keep watching. We know what to do if we do not like what’s going on; there are people of influence here in this room.”

Thus we found Thornton to be more concerned than the relatively well-endowed Rio Vista when it came to hosting the technology. Many residents were strongly opposed to it; during one discussion, a teacher’s aide was particularly angry about the (then-planned) Thornton project and about everything else that gets ‘pulled over’ poor people. Another participant noted that most of the pilot projects were taking place in rural but populated locations: “Why are not they doing this in the desert where they cannot hurt nobody. Why is it here?”<sup>31</sup> Another chimed in saying that these projects were likely to be placed in mostly poor and Latino communities. Overall, there was considerable anger at being close to selection as a sequestration site without any degree of consultation, and at what was seen as yet another marker of their low status.

Although hardly enthusiastic about hosting a project, the residents of Rio Vista were more mixed in their responses. Every participant was unwilling to see his or her town as a host site but few were as hostile as their Thornton counterparts. The community’s confidence that it would be able to arrange some local benefits and maintain some oversight made at least some members more open to the idea. One retiree said, “If I am assured that this is a safe technology then I do not have a problem with it.” Others cited possible benefits such as job creation and “royalties to the City from mineral deeds.” Rio Vista citizens were generally more aware of climate change than Thornton citizens, and were also aware that some action to halt climate change was necessary. This knowledge had little impact on their willingness to host; they would only consider hosting a site if their local economy saw direct benefits (e.g. royalties) and the local community could exercise some control

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<sup>31</sup> California, depleted oil and gas reservoirs or deep saline aquifers are considered appropriate sites for carbon sequestration. Many of these reservoirs are close to human populations. Why WESTCARB chose or did not choose a particular site was, however, not a focus of our research.

(“we will keep watching”). No such expectations were raised in Thornton, where residents are preoccupied with life’s basic necessities: “I think survival is most important. Yeah, absolutely, I think trying to survive on a day-to-day basis.”

Our research suggests that the degree to which being a host community is considered risky is significantly influenced by a community’s sense of empowerment, or the degree to which a host community believes that it has the power to control its own future. Empowerment partly stems from the community’s ability to exercise voice and have recourse to compensation or damage mitigation, as well as its belief in that ability. In this study this sense of empowerment was correlated with a community’s affluence, education, connections to the outside world and cohesion as a community. The perceived risk of being a host site is also, as we found, a function of previous histories of environmental damage, its mitigation or lack thereof, and the role of industries in the community. These histories are themselves partly determined by a community’s capital endowments. In the next section, we present three examples of our study communities’ experiences with industrial harm, environmental harm, and the natural gas industry. These experiences, which were recounted in detail, with mention of specific dates and specific episodes, reinforced a community’s sense of empowerment or disempowerment.

### **What factors explain community perceptions of carbon sequestration risks?**

#### *Experience with industrial harm*

In general, Thornton’s experience with industry-caused environmental damage has been negative. One example of this is water contamination by the (now defunct) Tri-Valley Growers cannery. For a number of years, many residents had suspected that the cannery was polluting their drinking water; these fears were confirmed when tests by the Regional Water Quality Control Board showed that dangerous levels of lead had seeped into the groundwater via the cannery’s underground storage units. But before the community could demand abatement or reparations, the company filed for bankruptcy. Today, poor water quality still plagues the community. Many residents cited this and similar examples to explain why a carbon sequestration project, whatever the community felt about it, would go ahead anyway. They all seemed sure that if something were to go wrong during deployment, any demands for recourse would go unheard.

Rio Vista, too, has had negative experiences with industry. However, the community has also had some successes that have bolstered its sense of empowerment. In 1975 DOW Chemical started to build a \$500 million petrochemical complex along the Sacramento River near the town, but later dropped the project. Members of the community attributed the failed attempt by DOW Chemical to their protests at not being sufficiently involved, and not to the political “red tape” cited by DOW (Stammer 1977). Whatever the actual sequence of events, Rio Vista residents felt that they had collectively exercised their voice and that it had been heard. With respect to hosting a sequestration project, a significant segment, while somewhat resistant, nevertheless possessed the confidence that, if necessary, they could act collectively again.

#### *Experience with environmental harm*

Thornton’s most pressing environmental problem in the eyes of the community was its poor water quality. The drinking water was allegedly so poor that you could not only taste it, you could also see it: “If you live over here in the housing where the water drips, it stains the sink brown. Yeah, just yesterday it was coming out brown”. Many in the community were unhappy with their

water, and wanted to see improvements. However, the community felt that their voice was not heard nor their fears understood, and therefore insufficient or inappropriate solutions were offered:

“I have gone to some of the town meetings where they have (discussions) about this water thing that they say they come out and clean it out every so often. But, I do not think they do... I do not think they do it as often as they should... A lot of people cannot afford to buy (water treatment) equipment for their house” (Thornton).

The community’s failure to get its water cleaned up, even after repeated efforts, clearly contributed to the overall sense of disempowerment. As their experience with the cannery had also shown, they could not trust their local governments or any other entity to help with damage mitigation.

Neighboring Rio Vista also suffered in the recent past from water contamination; their effort for remediation, however, has largely been successful and their water quality has improved. For example, in response to the community’s ongoing concern about poor water quality, the city of Rio Vista is planning on developing its own hazardous waste program to identify sources of contamination and possible solutions. Our discussions showed that Rio Vista residents could call upon their collective social and economic capital to organize against perceived environmental harms and to ensure a degree of redress and accountability from the relevant authorities. They did not share Thornton’s feeling of powerlessness, and so did not share Thornton’s perceived risk of official neglect should “the gas project leak or something.”

#### *Experience with the natural gas industry*

Both Thornton and Rio Vista were built up on natural gas fields. Thornton’s view of the natural gas industry can best be described as one of indifference. Not many people in the community directly benefited from the gas industry; only a few people hold mineral rights and most of those no longer live in the community. Furthermore, because Thornton is unincorporated, any tax revenues generated from gas extraction royalties went to San Joaquin County and not to the community itself. To many in Thornton, the benefits from a carbon sequestration project were tied to those few who owned mineral rights or land. Hosting the technology was seen as imposing a burden on, but not benefiting, the community as a whole.

Rio Vista had a markedly different relationship with the natural gas industry. Natural gas production was one of the largest sources of town revenue, and several hundred people in town owned land or mineral rights. The discovery of gas deposits and milestones in gas production are prominently featured in the tiny, well-maintained Rio Vista Museum. The industry has had a tremendous influence on the social and cultural makeup of the community (e.g. “... most people here get mineral income, which justifies a lot of things”). To many residents of Rio Vista, hosting a carbon sequestration project was seen as imposing a modest burden, but also as a potential financial opportunity for the whole town. Our interviewees admitted that some in the community had benefited enormously from the natural gas industry, but felt that the broader community had shared in those benefits. In short, “We know them here. We trust them. Let them put the carbon dioxide in the ground. That’s a good thing, is it not? I mean, it’s not a bad thing, is it?”

## **Discussion**

Consistent with previous research on risk perceptions, we found community-defined risks could be both technological and social in nature. Both communities were concerned that inadequate

knowledge of carbon sequestration could lead to mistakes during the injection of CO<sub>2</sub>. Most of these technology related concerns echoed those reported by other studies on sequestration and the public (e.g. Palmgren et al 2004, Sharp 2000). Both communities feared that neither the government nor companies could be trusted as the sole source of safety-related information (e.g. Siegrist and Cvetovich 2000).

Social risks centered on the implications of hosting the technology and the procedures to be followed during project implementation. Common concerns were how the presence of the technology would affect the character of the community and property values. Just procedures were important to both communities and included local benefits such as jobs or compensation, upgrading school buildings, and a measure of transparency and community participation. But our focus groups revealed that residents of Thornton did not expect to have voice or redress during the lifetime of a project, while Rio Vista residents did. This difference—the downside risk of government or corporate neglect should something go wrong with the technology deployment—is what distinguished the two communities from each other. It can plausibly be argued that softer responses are to be expected when the project in question is hypothetical (Rio Vista) rather than imminent (Thornton). But our research reveals that this risk is related not just to the likelihood of a project in a community's backyard, but to the community's social and material assets, its history and its ensuing sense of empowerment.

The risk of neglect should something go wrong, and the correlation of this risk with a community's past history and experiences with industry, has not been adequately addressed in the literatures on the risks of sequestration or risk communication. But this finding is consistent with Bradbury et al (1994) who concluded that individuals evaluate the risks of a technology not with respect to the specific technology but in light of their life histories; and it is consistent with sociological studies arguing that risk perceptions are as tied to broader worldviews and beliefs as they are to actual risks (Freudenburg and Pastor 1992). It also supports arguments in the procedural justice literature that the fairness of the process is central to the legitimacy of the outcome (e.g. Thibaut and Walker 1975, Lind and Tyler 1988, Senier et al 2008).

We argue that a community's sense of empowerment, defined as its ability to exercise voice and to seek redress, acts as protection against the downside risk of neglect. To the extent that our communities are representative of other possible sequestration sites, our research suggests that communities that already feel disempowered are likely to resist hosting a site in part because they fear neglect (“... they say they come out and clean it out... but I do not think they do”) and they fear that having a site thrust upon them only cements their low social standing (“why is it here?”). Yet Thornton also knew that any resistance to a potential site would not be effective, that they would have to accept it if they were chosen (“... you do not think that regardless of what we say it is going to happen?”). What then, are the implications of our findings for gaining community acceptance of carbon sequestration?

If policy experts assume, as they still often do, that technical risks and inadequate risk communication are the main barriers to public acceptance, they could find themselves reassuring communities on the wrong front entirely. If policy implementers consult only landowners or office bearers in a community—as was the case when Thornton was under consideration as a sequestration site—the broader community and its set of concerns will remain invisible. Such an approach loses the opportunity to make the terms of technology deployment more inclusive. This acceptance through approach leads to can best be described as passive, mainly reflecting the lack of community information, engagement or organized protest. This is the sort of acceptance that the residents of Thornton were ready to bestow on a CCS site.

An alternative approach would be to seek a more active form of acceptance: to consult a range of local stakeholders throughout the site selection process, so that a grounded understanding of risks,

concerns and mitigation options can emerge. However, while lauded in theory (Beierle 1999, Chess and Purcell 1999) and in official policy documents (Bradbury et al 1994, National Academies Press 2008), this approach is often avoided because it carries the risk of prolonged negotiation or outright rejection of the proposed technology. Of course, the timing and level of community engagement are always open to debate. It is unclear which forms of participation work best, there are no guarantees of acceptance even with early consultation (e.g. Chess and Purcell 1999), and consultation is more expensive than hierarchical decision-making. Nevertheless our research supports Morgan et al (1992) in suggesting that open-ended engagement remains the best way to identify the diverse concerns of the intended hosts.

Our conclusions from this research are preliminary; while they do provide insights into community perceptions of the risks of sequestration, they are best viewed as guides to better research on risk perceptions with respect to the siting of any energy (or other large-scale) infrastructures. We believe that they can usefully inform future efforts at risk identification and communication, which previous studies have highlighted as critical to acceptance: we have to understand what each community views as its greatest risks before we know which ones to allay or communicate about.

Our particular findings relate the social risks of hosting climate change mitigation technologies to perceived levels of community empowerment and to the history of community–industry relations. Before attempts are made at public outreach and education in the service of carbon sequestration, it is crucial to understand that there are several ‘publics’, and that their risk perceptions are specific to their histories and their sense of empowerment. A risk assessment grounded in community perceptions could identify factors (such as the sense of empowerment) that are not identified in conventional risk assessments but should be included in risk assessment, communication and mitigation strategies.



## COMPARISON OF HOST COMMUNITY PERSPECTIVES

Three of the U.S. Department of Energy's (DOE's) Regional Carbon Sequestration Partnerships analyzed community perspectives on carbon capture and sequestration (CCS) through focus groups and interviews in five communities. These perspectives were analyzed in the context of each community's history and its social and economic characteristics. The results were considered for their insights into specific concerns within each region, as well as to assess inter-region commonalities. In all cases, factors such as past experience with government, existing low socioeconomic status, desire for compensation, and/or perceived benefit to the community were of greater concern than the concern about the risks of the technology itself. This paper discusses the findings from the joint review of the focus groups and the potential lessons for application to CCS deployment.

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### **Comparison of host communities' perceptions of carbon capture and sequestration risk**

Over the last decade, many of the experts and advocates working in climate change have recommended further research into whether carbon dioxide (CO<sub>2</sub>) capture and sequestration (CCS) may be a viable and important technological response to climate change. However, all new technologies face challenges with respect to social acceptability, especially those that may involve new risks, large-scale infrastructure, and significant government involvement—all features of CCS. Some of the most critical challenges to social acceptability may come from the perceptions and preferences of communities near whom CCS infrastructure may be located. Thus, it is important to evaluate what might explain and influence the views of communities that may be directly impacted by the siting of this technology.

The U.S. Department of Energy's (DOE's) Regional Carbon Sequestration Partnerships provide a valuable opportunity for examining this question. Initiated in 2003, the program forms a nationwide network of seven partnerships among government agencies, private companies, universities and non-governmental organizations designed to assess the viability of different approaches to carbon sequestration. The program is being implemented in three phases and is currently in the final year of the second phase of implementing over 20 small-scale field tests and the first year of the third phase of implementing a large-volume test in each region. Public acceptability is recognized as an important aspect of the program; outreach activities and research into public perceptions of the technology are a funded component. This paper reports on a collaborative social research effort among three partnerships—the West Coast Regional Carbon Sequestration Partnership (WESTCARB), Southwest Regional Carbon Sequestration Partnership (SWP), and the Midwest Regional Carbon Sequestration Partnership (MRCSP). Researchers from these three partnerships conducted a series of focus groups in the states of California, Ohio, Texas, New Mexico and a test

interview in Washington, D.C. The results were considered for their insights into particular concerns within each region, and they were also compared to see if common themes emerged from the multi-state effort.

In all cases, social factors, such as existing low socioeconomic status, desire for compensation, benefits to the community and past experience with government were of greater concern than concern about the risks of the technology itself. For example, in California, a community's sense of its own empowerment was an important indicator of its willingness to consider hosting a geologic sequestration project, perhaps even more than the perception of technological risks. Three factors seem to influence a community's sense of empowerment: history of environmental problems, relationship to the oil and gas industry, and socioeconomic status. In New Mexico and Texas, community members' concerns focused on fairness, trust and the logistics of CCS. Specific concerns were about surface owner rights, liability, and ownership of the injected CO<sub>2</sub>. In Ohio, issues of trust were central to focus group participants' perceptions of CCS in that they doubted the ability of the government or the project developers to ensure their safety. This underlying distrust of government and the private sector was an even greater concern than the risks of CCS technology per se.

These and other insights have significant implications for future research and the conduct of public outreach for CCS projects<sup>32</sup>. They also have implications for more fundamental issues such as the design of CCS projects and, most broadly, for appropriate practices for the planning and implementation of large-scale greenhouse gas control technologies. This paper discusses the findings from the joint review of the focus groups and the potential lessons for research and application to CCS deployment.

## Methodology

Social researchers from the three regional carbon sequestration partnerships collaborated in developing, testing and implementing a common focus group protocol to examine public perceptions of carbon sequestration, including both terrestrial and geologic sequestration. The researchers' intent was to benefit from the opportunity provided by the DOE nation-wide program to compare results from three very different geographic and cultural regions of the United States: the West (California's Central Valley), Southwest (New Mexico and Arizona), and Midwest (Ohio). The focus group discussion guides were developed, piloted, and conducted in 2006 and 2007 during the second phase of the program as plans for conducting small-scale tests were being developed.

All focus groups used a similar protocol drawn up collaboratively by the three partnership researchers. Elements were borrowed from previously published surveys in developing a discussion guide that focused on seven broad topics: (1) societal concerns, (2) familiarity with climate change, (3) attitudes about potential climate change impacts, (4) familiarity with carbon sequestration, (5) reactions to carbon sequestration policy frameworks, (6) perceived advantages and disadvantages of carbon sequestration, and (7) attitudes towards potential safeguards to mitigate risks from carbon sequestration. Focus groups were deemed to be an appropriate research tool because the approach

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<sup>32</sup> Reiner and Nuttall (2011) conducted an interesting study of the parallels and differences between the geologic disposal of carbon dioxide and radioactive waste from regulatory issues to public perceptions. The main difference between CCS and the disposal of radioactive waste is that the former is in its infancy with no full-scale commercial projects with only a handful of storage projects worldwide whereas the latter has been subject to political debate for decades where nuclear power is much debated (cultural and political context). Reiner and Nuttall argue that there are some important parallels such as the issue of NIMBYism, the link between the politics of waste streams and the underlying generating technology, the challenge of communicating highly technical nature of both issues, and the role that both play in the larger societal debate over energy policy.

allowed enough flexibility for each partnership to focus on regional concerns while also ensuring that its similar structure would enable comparison among the regions. The discussion guides were accompanied with brief DOE-approved background information sheets about both geologic and terrestrial sequestration.

The data from the focus groups were supplemented by individual discussions and observations undertaken during implementation of the pilot projects. To assist in interpreting the focus group findings, the WESTCARB and SWP Partnerships conducted individual interviews both locally (WESTCARB) and regionally (SWP). SWP also used a short questionnaire regarding opinions about sequestration. MRCSP compiled information separately from the focus groups in informal public meetings and discussions at each of the three Phase II and their Phase III field test sites. Clearly, the focus group and individual interview data make no claim to statistical significance. However, given the low level of public knowledge about climate change and geologic sequestration, these types of data, collected in a more open-ended manner than a survey questionnaire, avoid the danger of eliciting pseudo opinions, or non-attitudes (de Best and Daamen 2006). Focus groups and probing questions allow multiple dimensions important to participants to emerge through interaction and discussion and allow the researcher to understand differing public perspectives (Mischler 1986). In an emerging area such as sequestration, they are especially valuable as a first step in identifying fruitful directions for future research.

Selecting the communities for the focus groups proved to be an interesting challenge. The Phase II field demonstrations are primarily scientific research projects designed to contribute to our technical understanding of sequestration processes and techniques. At the same time, an enormous benefit of these projects is that they are providing a wealth of practical experience in the siting, permitting, constructing and implementing of carbon dioxide injection wells. The Phase II projects are so small, involving injection of about 10,000 tons of CO<sub>2</sub>/year that they are very unlikely to pose any significant risk. So on one hand, there is an emphasis on getting the projects completed to reap the scientific benefits. Yet on the other hand, a significant part of the practical experience of implemented this technology is derived by working with the public to better understand their perceptions and attitudes towards CCS.

In selecting communities for social research, the dilemma is, to what extent do social research activities themselves influence the success of the scientific research projects and/or the public perception of CCS? In response to these considerations, the focus groups were conducted in three types of communities: those under active consideration to be a host community, those that by analogy could potentially host projects but were not under active consideration for the pilots, and communities that would be unlikely to host projects.

WESTCARB conducted its discussions in both a potential and an actively considered host site community where tests of sequestration in depleted natural gas fields were planned. To conduct an injection test, surface rights and, often, mineral rights have to be acquired in the areas where the carbon dioxide will be injected. The potential host community was a site that otherwise appeared suitable for sequestration but was dropped from consideration because the cost and time necessary to obtain property rights from the large number of property owners involved were prohibitive. WESTCARB conducted two focus groups and a series of interviews in this potential host community as well as three focus groups in a second community that, at the time, was actively under consideration for locating the pilot test.

SWP conducted five focus groups as well as a series of interviews in and near (within 50 miles) two communities that were directly impacted by hosting pilot tests. The New Mexico site hosted a test for injecting CO<sub>2</sub> into coal beds to enhance the recovery of coal bed methane, the primary energy source for natural gas. The Texas site hosted tests of sequestration in depleted oil wells to achieve enhanced oil recovery (EOR). One focus group each was conducted at the New Mexico and

Texas host sites, and three were conducted in nearby New Mexico communities that were indirectly impacted. Because public interest was insufficient to support focus groups, individual interviews were conducted in nearby Texas communities.

MRCSP selected a community that would be unlikely to host a sequestration project because of population and urban density but was located in a state with significant sequestration potential and historically dependent on coal for electrical power generation. MRCSP conducted two focus groups in Columbus, Ohio.

The focus group communities differed in demographic characteristics. The WESTCARB and SWP communities were rural; MRCSP's was urban. The population in one WESTCARB community had low median incomes, low education levels, and a large proportion of Hispanics; the economy was in a downturn. The other community was largely white, well educated, and had higher median incomes. Focus group participants largely reflected these socio-cultural differences. The SWP communities varied; all had lower median incomes than the State median but the proportions of Hispanic, white and American Indian populations differed (one had a high proportion of American Indian, and another had a high proportion of white persons). However, focus group participants were largely white and well educated. The MRCSP Columbus population was largely white, and focus group participants were well educated.

Recruitment approaches also differed, depending on what was most feasible in each study community. In one community, WESTCARB recruited one group to represent people of local standing, while in the other community participants were recruited by snowball or nominated sampling, flyers, and radio advertisements. SWP recruited through newspaper and radio advertisements, local internet-based community calendars, and word of mouth. MRCSP recruited one group of "influentials" from personal contact with environmental groups, business associations, the public sector, civic groups, and another group randomly selected from the local telephone directory.

## Findings

### *Knowledge of Climate Change and CCS*

Focus group participants displayed varying levels of knowledge about climate change and its causes. <sup>33</sup>Both WESTCARB populations knew that climate change was occurring. The better-educated groups understood its anthropogenic causes and had thought about its possible impacts on their community, while the groups with lower education levels were just vaguely aware of the phenomenon. Many in the former group had heard of sequestration; almost none in the latter group

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<sup>33</sup> Research suggests that information presented to the public used for research and for education, when of poor quality tends to produce 'pseudo-opinions' that are easily changed. If the quality of the information is improved, however, people form stronger views about the information presented. Below is a brief summary of the pseudo-opinion phenomena:

- Pseudo-opinions' - general: Current surveys on public opinions/attitudes are lacking, they tend to produce pseudo opinions that are easily changed (de Best-Waldhober 2009) or reflect the pollster's or researcher's bias (Malone et al 2009).
- 'Pseudo-opinions' – CCS-specific: (pseudo-opinions when info is light on the info and facts) Uniformed respondents give their opinion about CCS however their opinions are easily changed. When given expert approved information about CCS, the general public reluctantly agrees that the large-scale implementation of CCS is necessary (de Best-Waldhober 2009). The provision of comprehensive information aimed at resolving prevalent misconceptions about CCS can decrease perceived risk and increase perceived benefits (Wallquist et al 2011).

knew about CCS as a mitigation technology or knew that they were under consideration as a test site.

Although SWP participants had heard of sequestration, they did not appear to have a clear sense of the potential scale of sequestration that might be deployed. They generally supported the idea of supporting research on the topic. They thought landowners should be encouraged to engage in terrestrial sequestration activities. They were not concerned that carbon sequestration might delay a shift away from fossil fuels and strongly supported carbon sequestration as part of a larger energy strategy. When offered potential reasons to support research on carbon sequestration, they were most supportive of doing so because they believed it is important to test new technologies prior to deployment, somewhat supportive of doing so because it would help remove carbon from the atmosphere during a transition of the overall energy system, and uncertain whether the support of DOE and relevant industry provided a good reason to conduct research on carbon sequestration. When asked about solutions, many responded that a wide range of solutions, from nuclear power to conservation measures, are needed.

In Ohio, both focus groups were familiar with climate change and most seemed to think it was happening. The groups differed, however, in their knowledge of sequestration, especially of geologic sequestration. Most of the “influentials” had heard of it and some were even familiar with non-partnership demonstrations being conducted by large locally based utilities; however, the majority in the randomly selected group were not familiar with it. In this location also, none of the participants appeared to have an accurate sense of the potential scale of sequestration that might be deployed. Concern was expressed that moving to sequestration was a short-term solution, but most agreed that if research and development could demonstrate that geologic sequestration was a safe and low-cost alternative to emitting carbon dioxide, they would support it.

### *Trust and Fairness*

The most striking finding in all three regional focus groups was the predominance of social concerns.<sup>34</sup>, <sup>35</sup> Although all of the groups expressed safety concerns, in all cases, trust in authority and concerns about the fairness of CCS implementation procedures were the most strongly expressed concerns. In the Southwest, questions regarding fairness and trust predominated. In the Midwest, trust in the government and in the information they disseminated was a pervasive issue. In the West, communities expressed distrust in both the government and the private sector, but the level of distrust was higher in the lower income, relatively disempowered community.

### West Coast Regional Partnership

In California, a community’s sense of empowerment was an important indicator of its willingness to host a geologic sequestration project. The WESTCARB researchers defined a community’s sense

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<sup>34</sup> It should be noted the public, in general, seemed ambivalent toward DOE and were uncertain about DOE’s involvement in researching CCS was a good reason for them to support the research, development, and deployment of the technology. While this issue is not brought up in this chapter, it is in the next. In both chapters 3 and 4 the participant described their mistrust of the federal government, and although the participants did not explicitly say so I suspect that the participants would include DOE in their conception of ‘government.’

<sup>35</sup> While these findings were surprising in the context of CCS, they are not novel with respect to the procedural justice literature. For examples see Lind and Tyler (1988), Thibaut and Walker (1975), O’Hare et al. (1983), Rousseau et al (1998), Johnson (1987), Jonas (1973), Siegrist and Cvetovich (2000), and Miller et al. (2007). The intended audience for this chapter are CCS engineers and scientists and therefore it was written as a policy piece rather than a broader commentary on procedural justice and CCS.

of empowerment as 1) its ability to mitigate community-defined risks of the technology and 2) its ability to ensure that just procedures would be followed in implementing that technology. They explained this finding by citing Hirschman's (Hirschman 1970) argument that a community's sense of empowerment allows its members to exercise "voice" and to seek redress if they are being harmed. Accordingly, empowerment protects against the downside risk of hosting a field test site. The community's history of environmental problems and its history with the oil and gas industry, both of which contributed to trust or distrust in the relevant authorities, seemed to influence its sense of empowerment. In both California communities, a central concern was the perceived deficiency in the quality of expert knowledge in the face of unknown technological risks. Other commonly expressed concerns were potential changes to the quality of the town, decreased property values, the need for benefit to the local community, the desire for transparency and participation and the need for redress should anything go wrong. Most notable, however, was that the two communities differed in terms of their expectation of redress. The community populated by lower income and less educated persons did not expect to have redress, whereas the higher income and educated community believed in their power to achieve recourse. The lower income community members based their fear on their previous experience of neglect both by industry and by government—and their belief that no one would listen to them and the project would go ahead regardless of their opinions. They expressed the belief that CCS sites were likely to be located in similarly poor and voiceless communities: "Why is it here?" The researchers concluded that the key fear was not the risk of sequestration per se but the risk of being neglected or ignored if the project turned out to be more harmful than expected.

#### South West Regional Partnership

In New Mexico and Texas, health concerns (air and water quality) related to the energy industry were a large part of the discussion. However, the predominant themes again centered on social issues, in particular, issues of trust and fairness. In both states, participants expressed distrust of the companies representing the fossil fuel industry and the federal government. All focus groups included participants who expressed strong reservations regarding anything related to DOE and to specific coal, oil, and gas companies. They cited negative experiences with these organizations, sometimes telling detailed stories of wrongs done to them. New Mexico participants were especially likely to express a belief that they had little control over decisions regarding energy production and were unlikely to gain that control. They repeatedly stated that both government and industry had used their region as a "sacrifice zone."

Participants in the SWP focus groups also expressed safety concerns—but again, in relationship to issues of trust. They claimed that sequestration technology was still experimental and that the companies and government wanted to use them as guinea pigs to test the new technology. Information about monitoring did not allay their concerns because they did not trust those who were conducting the monitoring. They also expressed confusion about from whom they should obtain information or whom they should contact if a problem occurred. They told of past frustrations they had experienced when attempting to communicate their concerns and saw no reason why this should change now.

A concern raised was how geologic sequestration operations might impact landowner rights. Related to this were concerns about liability. As with previous concerns, they shared horror stories—for example, the story of a large company that laid a pipeline across someone's pasture, but when increased temperatures from the pipelines severely limited both quantity and quality of forage in the alfalfa field, the rancher was unable to obtain compensation for his economic loss. Interestingly, despite all their concerns, all the SWP groups expressed generalized support for energy production.

They recognized that energy costs were increasing, but felt that they had borne an unfair proportion of the costs.

The Texas and New Mexico groups had one significant difference. While the New Mexico groups were concerned about carbon sequestration as a new development, Texas participants did not see it as anything new. Although they shared the distrust in companies representing the energy industry and the federal government, they saw no particular problem with geologic sequestration. This may be related to the fact that the pilot project was EOR, something that these communities had become accustomed to over the past several years. Also, although Texas participants were equally likely to distrust both government and industry, one of the groups was less likely to be concerned about fairness or procedural justice. Instead, they were more focused on how they might obtain a portion of the economic profit from EOR, even if all they got were the “crumbs” that fell from the table.

### Midwest Regional Partnership

In Ohio, issues of trust were central to focus group participants’ perceptions of CCS. This underlying distrust of government and the private sector to protect the public or the environment was an even greater concern than the risks of CCS technology per se. Many in the “influential” group were primarily involved with regional, state and local government; their distrust seemed to stem from the observation that the “science” of sequestration is still being researched, so the answers to some questions just are not yet known. In the case of the randomly selected group, a pervasive lack of trust in government to protect human safety and the environment from the potential adverse effects of sequestration was evident. Their lack of trust was backed up by numerous direct examples of ways in which there had previously been a breakdown – and in some cases it was suggested that there was a knowing breakdown – in governmental oversight and failure to protect the interests of the community.

### **Insights from the Sociocultural and Procedural Justice Literature**

While much of the research into CCS has pointed to public perceptions of the technological risks of the technology, sociocultural theorists point to the social processes within which opinions about a particular issue are formed. People bring to their evaluation of that issue their cultural frame of reference—their values, social interactions and differing experiences, and their way of interpreting and responding to the world (Douglas and Wildavsky 1982, Rayner 1984, Schwartz and Thompson 1992). Rather than beginning with the technology and the attributes of that technology, this school of thought would examine first the human value system and how that impacts the proposed technology. As Bradbury et al. (Bradbury et al 1994) concluded in their study of community perspectives on the risks of incineration and other technologies for disposing of the nation’s stockpile of chemical weapons, residents did not think about technology or risk in isolation from their broader life experiences. The community conflicts identified in these authors’ studies were not only about the technical risk of the proposed technology, but also about a number of broader, social issues that have been hidden by the nearly exclusive focus on technological attributes. Critical social factors included the fairness and openness of the decision-making process, previous experiences and relationships with the project developers and governmental institutions, and accountability (who will take care of our community if something goes wrong?).

Wynne (1982) similarly highlights the social nature of technology and risk and argues that technical analyses frequently fail to address the key societal issues at stake. As a result, resolution of the policy problem becomes more difficult as new technical issues are continually raised and the perception of a gap in responsibility for social issues exacerbates the overall level of concern. He

emphasizes that technology is social in origin, character, and effects—the implications of technological development are the social relationships involved in innovation and implementation, and the key uncertainties stem not so much from technical uncertainties, as addressed in technical risk analysis for example, but from uncertainties over potential social changes, social relationships, and social institutions. Similarly, as noted by Rayner and Cantor (1987), decisions about technology and risk inevitably involve decisions concerning the level, acceptability, and distribution of risk. Thus, the essential policy question is ethical: How fair is safe enough?

These findings from the sociocultural school are reinforced by the procedural justice literature. Lind and Tyler [10] define procedural justice as “the extent to which the dynamics of the decision process are judged to be fair.” They argue that whether or not they approve of the final outcome, people respond more positively to outcomes coming from social processes deemed fair than those perceived as biased (see also Thibaut and Walker (1975); Borsuk et al. (2001)). Gangl (2003) notes a difference between pragmatic and ethical issues: in pragmatic issues the outcome matters more than the fairness of the process, whereas in ethical issues, process is more important. People involved in a process want to have some impact or control over decisions. Moreover, when people deal with third parties and other authorities with which they have little direct contact, their assessments of procedural justice are more strongly influenced by trust in the institutions of the decision makers.<sup>36</sup>

### **Implications for CCS Implementation and Future Research**

Consistent with the above literature that essentially critiques the domination of technological risk issues in discussions related to CCS, the data gathered by the three research efforts point very clearly to the overriding importance of social factors in planning and implementing CCS projects. Resolution of safety issues such as those related to potential leakage, seismicity, and long-term containment are, and will continue to be, essential to successful deployment of the technology. But, as highlighted by the focus groups and interviews, management of these safety risks is the critical factor for public acceptance.

Based on these data, key management questions for the public are: ‘How can we have a say in what happens? Who is in charge? Will the process be fair and will anyone listen to us?’ ‘What will happen if something goes wrong? Can we trust the project developers and the government to take care of any problems—what have our previous relationships with these entities shown us?’ ‘What is the benefit to our community? How does the proposed project fit into or improve our way of life?’

From a development and deployment perspective, therefore, it behooves industry and government developers to place greater emphasis on these types of procedural and managerial concerns. Effectively, this will require a greater emphasis on upfront social analysis and planning than is currently practiced. The regional partnerships program is notable for its funding and recognition of the importance of outreach. But none of the three partnerships discussed here

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<sup>36</sup> Procedural justice concerns the fairness of the process by which decisions are made; it is distinct from the concepts of distributive justice (fairness in the distribution of rights or resources) and redistributive justice (fairness in the rectification of a wrong). Basically, voice and control are the two conditions that affect the degree to which a participant party (or third party) to a decision sees the procedure as being fair (Lind et al 1990, Tyler 1987). If the decision does not include the direct involvement of the public, Tyler (1988) argues that there are several issues that contribute to the public’s view of the fairness of the procedures used to reach the decision: (1) degree to which authorities were motivated to be fair; (2) judgment of the honesty of the decision-maker; (3) degree to which the decision-makers followed ethical principles of conduct; (4) extent to which opportunities for representativeness were provided; (5) quality of the decision made; (6) opportunities for error correction; and (7) whether or not the decision-makers behaved in a biased fashion. He found that the meaning of procedural justice varied according to the nature of the situation, and not to the characteristics of the people involved (Tyler 1988).



included social factors in their selection of potential host sites for field tests of sequestration. Rather, they have focused on the willingness of one of their partners to host a field test (admittedly a considerable challenge) and on the technical aspects of the proposed test. For example, the key criteria laid out by DOE in selecting a large-volume Phase III test focus on the availability of a reliable and sufficient source of carbon dioxide and a potentially effective storage formation. While these are clearly essential, our data suggest that they are not sufficient in meeting the acknowledged need for public acceptance. Indeed, one-way “outreach” after site selection is not the same as a pre-site selection, two-way mutual exchange of information and views between developers and potentially affected communities. Additional criteria would have asked the partnerships to conduct preliminary consultations with potentially affected communities, assess whether the field tests would be perceived as beneficial, and discuss with them requirements for a successful test from the community’s perspective.

Based on our findings, future research should investigate how social factors can be incorporated and used to develop mutually agreed upon projects rather than simply to aid in the site selection process. Some elements of this research might include an assessment of the advantage/disadvantages of requiring a social site characterization, in addition to a technical site characterization. This social site characterization could include a number of elements such as site-specific communication materials and compensation strategies designed to address the participant community’s perception of risks.

Some other questions worth considering are if the technology is adopted, when should a social site characterization start? How should it be factored into the selection process and how much should be conducted? The development of private enterprise is not always as encumbered as public projects – will this always be the case for CCS or just the initial projects?

People do not consider technologies in isolation rather they make sense of them and associated risks through their life histories. By extension, communities asked to host technologies like CCS will evaluate such solutions by assessing how the technology will “fit-in” to their lives – how will the presence of the technology affect their lives? Public engagement strategies that focus on the technical attributes of mitigation attributes will likely be less effective than those that focus on concerns of the public that are more social in nature.

## ENVIRONMENTAL PERSPECTIVES

Environmental non-governmental organizations (NGOs) have been influential in shaping public perceptions of environmental problems, their causes and potential solutions. Over the last decade, carbon capture and sequestration (CCS) has emerged as a potentially important technological response to climate change. In this paper we investigate how leading US NGOs perceive geologic sequestration, a potentially controversial part of CCS. We examine how and why their perceptions and strategies might differ, and if and how they plan to shape public perceptions of geologic sequestration. We approach these questions through semi-structured interviews with representatives from a range of NGOs, supplemented by content analysis of their documents. We find that while all the NGOs are committed to combating climate change, their views on CCS as a mitigation strategy vary considerably. We find that these views are correlated with NGOs' histories of activism and advocacy, as well as with their sources of funding. Overall, most of these NGOs accept the necessity of geologic sequestration, while only a small fraction do not.

This Chapter was published in *Environmental Research Letters* in 2008 and appears in this dissertation with the permission of the journal and my co-author (Isha Ray). I developed the research, study design, and research instruments in collaboration with my co-authors, recruited participants, conducted the interviews, performed data analysis, and wrote the first complete draft of the manuscript.

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### **Environmental perspectives and plans for carbon capture and sequestration**

Non-governmental organizations (NGOs) have historically been influential in shaping public perceptions of environmental problems, their causes and their potential solutions. They are therefore an important part of the political process of creating and enforcing environmental laws (Cohen 1995, Jepson 2005). This paper investigates the current and future roles of NGOs in the US in shaping public perceptions of geologic sequestration of carbon dioxide (CO<sub>2</sub>), a technology that is being widely discussed as a storage method for mitigating climate change.

Geologic sequestration is one of a set of storage technologies (e.g., terrestrial sequestration, ocean storage, and chemical mineralization) that are part of an overall climate change mitigation solution called carbon capture and sequestration (CCS)<sup>37</sup>. CCS involves capturing CO<sub>2</sub> from fossil fuel combustion exhaust or from the air, and then storing it safely away from the atmosphere, for example in porous rock deep underground. While the capture of the CO<sub>2</sub> is expensive, it is a common and uncontroversial industrial process. CCS for mitigation purposes, on the other hand, is a new and incompletely understood technology that will require government approval, and that may be visible to the public, especially at the sites where the CO<sub>2</sub> is injected (IPCC 2005). Moreover, CCS is part of a larger debate about the future of fossil fuels versus other sources of energy such as nuclear power or renewables. This paper begins to explore the political strategies that US environmental NGOs may pursue with respect to this technology.

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<sup>37</sup> In this paper CCS will refer to carbon capture with geologic sequestration.

Over the last decade, many in the expert and advocacy communities have begun to think that CCS (and therefore geologic sequestration) may be a viable and important technological response to climate change (Parson and Keith 1998, IPCC 2005). In recent years, US political leaders have begun to talk about geologic sequestration as well. Little research has been done, however, to understand what NGOs' views are of these technologies, or if and how they plan to share them with the public. In this paper we ask, how do leading environmental NGOs active in the US perceive geologic sequestration? What might explain variations among NGO positions on this topic? And, how do they plan to share their views with the public, and otherwise engage in the politics of geologic sequestration and climate change?

The political impetus for geologic sequestration as part of US energy policy is growing (Princen and Finger 1994). An example of this at the federal level is the investment in a series of 25 pilot-projects by the Office of Fossil Energy at the US Department of Energy (DOE) (Princen and Finger 1994, Carbon Sequestration Home Page 2008). At the state level, in 2006 Texas lawmakers passed House Bill 149 which provides liability protection to fossil-fuel-based power providers who sequester CO<sub>2</sub> by transferring the ownership of the CO<sub>2</sub> to the state (McDonald 2007). Additionally, in California assembly member Huffman authored Assembly Bill 705 that mandates the California Environmental Protection Agency to develop regulations and standards for geologic sequestration as a climate change mitigation strategy<sup>38</sup>. Increasingly, political leaders and advocates speak as if geologic sequestration were a well-understood, reliable technology, ready to be used in large scale in conjunction with continued fossil fuel use.

Over the past few decades, however, conflicts over unpopular energy policies such as nuclear power have demonstrated the importance of societal acceptance for the successful implementation of new technologies (Johnson 1987, Rowe and Frewer 2000). Evidence suggests that the lay public tends to trust information presented on energy technologies by NGOs, and environmental public-interest groups in particular (Jepson 2005), more than similar information presented by corporations or even government agencies.

The confluence of these environmental, political, and social factors suggests that NGOs' view of geologic sequestration may play an important role in shaping future energy policy. NGOs represent, and in a sense 'speak for', the public, especially the part of the public that constitutes their support and donor base. In this paper we investigate how environmental NGOs perceive geologic sequestration, how and why their perceptions and strategies might differ, and how they plan to share their views with the public.<sup>39</sup> Our analysis will be accomplished through the results of one-on-one interviews with representatives from selected NGOs, as well as a review of NGO histories of activism and sources of funding.

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<sup>38</sup> AB 705 did not pass in 2007.

<sup>39</sup> There is definitely some consonance between NGOs' view of CCS and other technologies. For all intents and purposes, the organizations' stance on the fuel used for the generation of electricity is the same as their view on CCS. For example, Greenpeace is an organization that is very much against coal for environmental and health reasons; this organization sees CCS as a way for the coal industry to stay afloat and to continue their 'dirty' ways. In many ways, these organizations are on the 'frontline' of the battle between the 'clean' and the 'dirty' solutions. I didn't really notice any contradiction between the types of technologies endorsed in the past, and the organization's position on CCS today. However, after the study there was a perceptible shift with respect to coal, and so with their position on CCs, within the Sierra Club.

## Methods

Climate change experts were interviewed from nineteen NGOs specializing in the environment and environmental justice<sup>40</sup>. We focused on traditional public-interest environmental groups and think-tanks, and not on industry-supported “NGOs” and think-tanks, although these are, of course, also interested in influencing the public. The NGOs were purposively selected such that their spheres of influence ranged from international policy circles to the local grassroots levels. Expert interviewees were identified through a search of NGO websites and snowball<sup>41</sup> recruiting methods. Our study covered most of the NGOs with a strong US presence that are actively working on climate change mitigation, and more specifically on mitigation technologies including, but not restricted to, CCS. In general, we sought views that were representative of the organization, but individual opinions were also stated in the course of our discussions.

Our primary method of information gathering was the semi-structured interview. We developed an open-ended interview guide in which the eventual outcome of the interview process is understood to be shaped by the interaction between interviewer and interviewee (Mishler 1986). The strength of this method is that it is more likely than a conventional survey to allow interviewees to respond in their own terms, using their own language, and also to provide unexpected arguments and descriptions (Bewley 2002).

The open-ended interview covered four topics: (a) the work done by the interviewee and organization; (b) the organization's view of geologic sequestration as a way to mitigate climate change; (c) education of the public on this technology; and (d) the public's potential reaction to this technology.<sup>42</sup> The interviews ranged from 15 to 45 min in length depending on the time constraints of the interviewee.

Based upon a content analysis of the interviews and climate change related documents, if any, we developed a typology of NGO views of geologic sequestration. The first of the two axes is the NGO's opinion of geologic sequestration (positive, neutral or negative) and the second is of its perceived necessity (necessary or unnecessary) as part of a mitigation solution (see table 1).

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<sup>40</sup> We are treating chapters of Environmental Defense and Natural Resources Defense Council as distinct organizations, because the regional chapters often have different campaign foci and region-specific views on global environmental issues.

<sup>41</sup> Snowball or nominated sampling is a non-probabilistic sampling method in which participants already in the study recommend other persons to be invited to participate (Richards and Morse 2007).

<sup>42</sup> While I did not ask the NGOs directly about their attitude toward the institutions that would be involved in the deployment, operation, and oversight of CCS I did ask them the following questions that yield some insight:

- Why do you think that CCS is being studied/pursued by DOE?
- Compared to other possible mitigation strategies, what aspects of CCS is the public most likely to be concerned with?

The responses that I got from the NGOs mostly centered on the role of the institutions will play with respect to public education and the industry's perspective. The NGOs all agreed that educational efforts should not be conducted by organizations (here, they mean gov't, industry) deemed not “credible” but rather by NGOs. The NGOs believed that the energy industry would be motivated to invest in the technology because it will allow the fossil fuel-based industry to stay afloat in the face of pending climate change policy, and it may even result in financial gain (e.g., EOR, etc.)

Table 1 shows the typology of NGO views of geologic sequestration

	Positive	Neutral	Negative
<b>Necessary</b>	7 <i>Environmental Think Tank</i>	5 <i>Environmental Think Tank</i>	4 <i>Environmental Environmental Justice Think Tank</i>
<b>Unnecessary</b>	0	0	3 <i>Environmental Environmental Justice</i>

For the first axis, we split the NGOs into three groups with respect to geologic sequestration: positive, neutral, or negative<sup>43</sup>. Positively inclined NGO interviewees described geologic sequestration with language such as “enthusiastic” or “favorable towards”<sup>44</sup>. Negatively inclined interviewees described it as “terrible” or “not a good thing”. Organizations were classified as neutral if no explicit positive or negative language was used to describe the technology, e.g.: “it is not a question of whether I like it or do not like it, but that we need it”.

Further examination of the data revealed the second axis of the typology—necessary and unnecessary. Throughout the interviews, the interviewees expressed whether they believed geologic sequestration were necessary and why they believed so. For example, one respondent viewed geologic sequestration positively and thought it to be necessary: “we see carbon sequestration as an important technology that should be developed further, and further utilized”.

From our typology in table 4.1, we classified the NGOs into four categories: the Enthusiasts, the Prudents, the Reluctants, and the Opponents. Interviewees from NGOs who viewed geologic sequestration positively and necessary are the Enthusiasts. Interviewees who were neutral towards the technology but considered it necessary are the Prudents. The development of the typology yielded an interesting category, the Reluctants, who viewed the technology negatively but suggested that it was necessary. For example, one of these respondents stated, “I have a slogan that I repeat to anyone who asks me, which is, it is a terrible idea that we desperately need”. Other mitigation solutions such as renewable energy or energy efficiency, however, should be given more emphasis than sequestration. The fourth group comprised the Opponents who viewed geologic sequestration negatively and thought it was unnecessary. Two of the cells in figure 4.1 are empty; no one interviewed viewed the technology positively or neutrally and thought it unnecessary.

It is, of course, possible that the positions of the organizations whose representatives we interviewed will change as geologic sequestration policy unfolds in the US. It is also the case that NGOs are not monoliths and that multiple viewpoints exist within them.<sup>45</sup> This is especially likely to be the case for geologic sequestration, on which people's positions have yet to solidify. Internal

<sup>43</sup> We note that on occasion, an interviewee categorized as positive identified negative aspects of the technology but overall remained extremely positive. The reverse phenomenon also occurred. We looked through each interview several times in its entirety to ensure that we represent, as accurately as possible, the overall views of the organization with respect to geologic sequestration.

<sup>44</sup> See table 1 for NGO abbreviations.

<sup>45</sup> This may also be likely to be the case for CCS, which is a new technology and positions have yet to solidify. Furthermore, it is likely that the views of the representatives of the NGOs are subject to the same issues such as pseudo-opinions found in studies on the general public's perceptions of CCS. See footnote 33 for a discussion on pseudo-opinions.

differences notwithstanding, NGOs frequently take public positions as organizations on several environmental issues. Our interviewees themselves regularly used “we” rather than “I” when responding to questions. Table 2 provides an overview of the category under which each NGO currently falls, based on our interviews and on our analysis of its documented positions (if any) on climate change mitigation.

Table 2. shows a summary of organizational positions on geologic sequestration. (Note: Table 2 represents our assessment of NGO’s overall position in 2007).

	<b>Organization</b>	<b>Type</b>
<b>Enthusiasts</b>	Climate Registry (CR)	Environment
	Environmental Defense-TX (ED)	Environment
	Natural Resources Defense Council-CA (NRDC)	Environment
	Natural Resources Defense Council-DC	Environment
	World Resources Institute (WRI)	Think Tank
	National Council on Energy Policy (NCEP)	Think Tank
	Pew Center for Global Climate Change (Pew)	Environment
<b>Prudents</b>	Environmental Defense-NY	Environment
	The Nature Conservancy (TNC)	Environment
	Stockholm Environmental Institute (SEI)	Think Tank
	Union of Concerned Scientists (UCS)	Environment
	US Climate Action Network (USCAN)	Environment
<b>Reluctants</b>	EcoEquity (EE)	Environmental Justice
	Environment California	Environment
	World Wildlife Fund (WWF)	Environment
	Redefining Progress (RP)	Environmental Justice
<b>Opponents</b>	Sierra Club (SC)	Environment
	Greenpeace	Environment
	Communities for a Better Environment (CBE)	Environmental Justice

## Findings

In this section we report our respondents' opinions on the necessity of geologic sequestration, on what the risks are of this technology, and on whether and how their NGO planned to shape public opinion on this topic. We present their views as they expressed them, without comment on the extent to which they agree or disagree with mainstream scientific opinions on specific topics. For every theme discussed below, we present only those views that were representative of at least two-thirds of each subgroup (Enthusiast, Prudent, Reluctant, and Opponents).<sup>46</sup>

### *Views on climate change*

Our findings confirm that climate change is a top environmental concern for the NGOs, a typical example being an interviewee who “realized the huge impact that climate change has on our mission”. These NGOs are actively seeking climate change mitigation solutions. For some, the most feasible mitigation solution is CCS. An Enthusiast respondent argued that “in the past five years CCS has suddenly become so mainstream (amongst NGOs); almost partly because of the fact nothing else seems to have been able to address the problem (of climate change)”.

<sup>46</sup> See appendix B.1 for a full list of questions.

### *Necessity of geologic sequestration*

All the interviewees from Enthusiast, Prudent and Reluctant NGOs viewed CCS as a necessary mitigation solution. The primary reason was the global reliance on fossil-fuel-based sources of power, especially coal, which they expected would continue. The dominant view was that the development and implementation of this technology should be the responsibility of developed countries such as the US. Although climate change would have adverse impacts in developing countries (IPCC 2007), these interviewees argued that the probability of independent mitigation by these countries was low because of immediate and pressing concerns such as healthcare or education. They also expressed concern that weak research and institutional capacities in these countries would hinder the successful implementation of geologic sequestration. In addition, they argued that the favorable political environment for geologic sequestration in the US made it a feasible mitigation solution. Examples were given of recent legislative activity on it by some states (i.e. Texas' HB 149) and an increased interest in energy independence (reduction of fossil fuel imports) within the US. On the whole, Prudents were more insistent than Enthusiast NGOs that other solutions, such as renewable energy or energy efficiency, deserve the same amount of attention as geologic sequestration. Reluctant NGO interviewees, however, expressed reservations even while accepting the (temporary) necessity of the technology: "CCS... is about winning time... it is about mitigating climate change but it is not something that is sustainable for the long-term".

Interviewees from Opponent NGOs disagreed with the others and did not accept CCS as a mitigation solution because they favored solutions such as renewable energy and increased energy efficiency. These interviewees were wary of the long history between the fossil fuel industry and geologic sequestration, given that it was originally developed for enhanced oil recovery (EOR) operations (Bondor 1992). They expressed concern that the fossil fuel industry may use geologic sequestration to continue with EOR, thereby allowing the continued use of an unsustainable energy infrastructure. Finally, they argued that the technology is itself unsustainable because the space in which to put CO<sub>2</sub> may eventually run out.

### *Risks of geologic sequestration*

In the opinion of all the NGO interviewees, a major obstacle to the development and implementation of geologic sequestration was economic uncertainty. They suggested that there were unanswered questions about the capital and maintenance costs of large-scale geologic sequestration, as well as a "yawning set of unanswered questions in the regulatory and institutional framework that would govern how the technology entered the market". These questions about costs and regulation could make investment in geologic sequestration unattractive for private firms<sup>47</sup>. Another obstacle facing geologic sequestration was technological uncertainty. Technological concerns included whether enough was known about the hydro-geologic characteristics of potential sequestration sites to ensure its safety and success. Everyone also agreed that "rigorous studies and examples" were needed to understand monitoring and verification techniques as well as site characteristics. A third obstacle was uncertainty with respect to social equity. Many argued that land use would be a major issue with the public and could prevent the implementation of geologic sequestration. Opponent interviewees in particular suggested that the technology would likely be located in poor areas: "many low-income communities of color do not have that kind of clout (economic or political); they are much more vulnerable to being the home for the sequestered CO<sub>2</sub>".

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<sup>47</sup> A key objective of the Texas bill and similar legislation is to relieve private firms of these uncertainties by transferring any long-term liability to the (state) government.

### *Policy framework for geologic sequestration*

Opinions differed on what policy framework would be the most effective for the development and implementation of geologic sequestration. The Enthusiast and Prudent interviewees viewed a cap-and-trade system as the most efficient and effective policy structure. The Reluctant and Opponent interviewees favored a mandatory cap on GHG because it would be difficult to develop a cap-and-trade system that “is not full of holes”. They expressed concern that a cap-and-trade system would allow “polluters to continue to pollute” and would not provide incentives to shift away from fossil-based forms of energy. Although there is no national US regulatory framework for geologic sequestration, all of the interviewees agreed that it should be federally regulated. They suggested, albeit with some reservations, that the Environmental Protection Agency should regulate it because “it has the legislative history, the authority, and the expertise to do it”.

### *Paying for geologic sequestration*

Most interviewees agreed that the research, development, and implementation of geologic sequestration should be paid for through a federal tax. Opponent interviewees argued that since the mitigation of climate change was a public good the costs should be borne widely, whereas the Reluctants argued that a carbon tax on industry might be more appropriate. Most conceded, however, that the consumer would end up paying for geologic sequestration: “although the polluters should pay in practice, I think we all know they essentially pass on all of those costs and it is essentially passed onto the consumer prices”. Reluctant interviewees also argued that US consumers would bear the costs of the technology in the developing world: “basically, you know Americans and Europeans are going to pay to bury carbon in China and India and everywhere else”.

### *Public perceptions*

All of the NGO interviewees viewed positive perceptions of geologic sequestration by the public as important to its success, because “as we have seen, (negative perceptions) can be enough to kill” a technology. Most interviewees suggested that the public's knowledge of the technology was low or non-existent. With greater awareness, however, people could be worried about impacts on human health: “they will be worried about their kids playing in some abandoned lot that is suddenly flooded with CO<sub>2</sub>”. They could oppose the technology “for the same reasons that people have been opposed to nuclear for years”, because of its similarities to large-scale technologies such as nuclear power; or, since geologic sequestration could take place at fossil fuel burning sources, especially coal, people may be concerned with the environmental impacts of coal mining. Finally, echoing the NGOs' own concerns, a segment of the public may be concerned with social equity issues arising from the location of potential sites.

### *Public education*

All the interviewees argued that educational efforts should be carried out by NGOs rather than by organizations they feel are deemed not “credible” in the eyes of the public. As stated by an Enthusiast interviewee: “it would be the big NGO community and the research community with the most standing in the public's eyes, you know, accurate and objective information”. In this view, “the public does not really trust the government even, I mean clearly they would not trust big coal companies or oil companies”. Each NGO category expressed different opinions of when the educational effort should begin and how it should be structured (see table 2). Only the Enthusiasts



planned to present CCS as a climate change mitigation solution to the public in the near-term, where it would be part of the “whole toolbox that we present to combat global warming”.

### *Industry perspective*

The Enthusiast, Reluctant, and Opponent NGO interviewees suggested that the fossil fuel industry would look upon geologic sequestration favorably, perhaps as an offset (compensating for emissions in one location by reducing or capturing emissions elsewhere) or under an emissions cap. Some interviewees argued that oil companies might actually gain from geologic sequestration. Industries with large stationary sources of emissions would likely pay for geologic storage, creating business opportunities that the oil industry is very well positioned to take advantage of. Finally, the Enthusiast interviewees suggested that the development of the technology may foster competition between companies: “you are going to have pulverized coal technology fighting with the gasification technology manufacturers about who can do it (geologic sequestration)”. This type of competition could fuel innovation and eventually lower the costs of the technology.

### **Interpretation of findings**

In order to understand why particular NGOs occupied particular cells in our typology (see figure 1), we classified the NGOs along two dimensions—their histories of activism and their sources of funding. Our research results, while they cannot establish causation, do suggest a correlation between an NGO's position and strategies regarding geologic sequestration, and its history of activism and sources of funding.

Histories of activism can broadly be distinguished by two strategies: cooperative bargaining or contentious politics (Conca 2007). Cooperative bargaining means a strategy in which the NGO negotiates with other actors such as government and private firms to reach consensus on how to manage an environmental problem. An example of an NGO that uses predominantly cooperative bargaining is the NRDC, which worked with California businesses and state government officials to reach an agreement on the text of Assembly Bill 32 in 2006 (the Global Warming Solutions Act of 2006). Contentious politics can be defined by outside-the-institution strategies, which may include direct action or even disruptive techniques such as public demonstrations or civil disobedience to make a political point or to change environmental policy (Conca 2007). An NGO that uses contentious politics is Greenpeace, whose strategy in their historic anti-nuclear campaign of 1971 was to sail a group of protesters to a nuclear testing facility at Amchitka, off the coast of west Alaska.

NGOs receive funding from four main sources: governments (national, international or multilateral), private firms, foundations and private individuals. Through a review of publicly available tax forms (Form 990), NGO publications such as Annual Reports, and our interviews, we determined each NGO's most significant sources of funding, as defined by its top ten donors. For example, in response to questions about funding, the SEI representative said “funders range from government institutions, like the US EPA, US DOE, other governments like the Dutch government, Swedish government, multilateral organizations like UN Environment Program, UN Development Program, (and the) World Bank”. The correlation between funding source and NGO advocacy strategies is likely to be one of feedback rather than of simple causation—NGOs' strategies may be influenced by, and may themselves influence, the sources of funding that they receive (Fisher 1997,

Fox and Brown 2000).<sup>48</sup> By tracing NGO histories of activism and sources of funding, we now explain why some NGOs favor geologic sequestration while others do not.

### *Enthusiasts*

The Enthusiast NGO history of activism reveals a dominant strategy of cooperative bargaining with businesses, policymakers, and other stakeholders on environmental problems. A review of 990 tax forms and NGO Annual Report publications shows that most of their top ten donors are foundations and private firms, including in some cases the fossil fuel and utilities industry. These characteristics enable the Enthusiasts to work collaboratively with a range of actors on climate change, the outcome of which is the endorsement of climate change mitigation solutions that all involved can accept (in this case, CCS with geologic sequestration).

### *Prudents*

The Prudent NGO history of activism shows that their strategies on environmental problems are also those of cooperative bargaining. In addition, several of these interviewees presented their organizations' primary role as that of the objective scientist for whom multi-stakeholder dialog was essential. The Prudents actively participate in the same forums as do the Enthusiasts, and provide their information directly to their funders and collaborators rather than to the public. The Prudents receive a significant portion of their funding through governments and the multilaterals, but also foundations and private firms. These characteristics enable Prudent NGOs to investigate and propose a number of different solutions to mitigate climate change, only one of those being geologic sequestration.

### *Reluctants*

The Reluctant NGO history of activism shows that their strategies include cooperative bargaining as well as contentious politics. For instance, WWF's strategies include organizing community groups among others to manage environmental problems (as in the debt-for-nature swap program in Ecuador). In the past, WWF has also used contentious politics to champion the rights of indigenous peoples in struggles over land management (e.g., in the Amazon). The Reluctant NGOs receive a significant portion of their funding from foundations and governments, but not from corporations.

### *Opponents*

The Opponent NGO history of activism reveals a dominant strategy of extra-institutional and contentious politics on environmental problems. As described above, NGOs such as Greenpeace define their advocacy strategy as “non-violent direct action”. The Opponents are mainly membership-based, with a significant portion, if not all, of their funding coming from foundations and private individuals. All of these characteristics leave Opponent NGOs free to reject consensus mitigation solutions such as CCS in favor of fossil-free alternatives such as energy efficiency or

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<sup>48</sup> I do not suggest that funding sources will have a firm view about CCS but rather that the strategies, e.g. collaboration with companies, employed by organizations may be positively related to their source of funding. For example, one would expect that an organization that tend to employ direct action strategies are also ones that are funded by private donors. Our findings suggest that there may be a relationship (not a causal link) between organizations that employ direct action strategies and those that oppose CCS as a climate change solution and favor other solutions.

renewables. For example, the Sierra Club interviewee said, “right now we have the choice between the clean stuff and the dirty stuff”. It seems likely that the Opponents will always choose the “clean stuff”.

In 1982, Douglas and Wildavsky proposed a sociocultural analysis of environmental organizations in which they classified the social structure of NGOs as either hierarchical or sectarian. They argued that hierarchical NGOs, by which they meant centrally-organized groups with clear chains of authority, would generally value social stability, and would collaborate with mainstream social and political institutions to mitigate environmental harms. Sectarian organizations, which are more flexibly organized and significantly volunteer-dependent, typically stand at the “border” (Douglas and Wildavsky 1982: p 174) of mainstream society. They would generally have less faith in established institutions, and so would favor extra-institutional strategies such as direct action in order to rescue the environment. Despite the many limitations of their analysis of the environmental movement (Winner 1982, Abel 1985, Tulloch and Lupton 2003), Douglas and Wildavsky's sociocultural perspective remains influential (see e.g., Rayner 1992, Thompson et al 1999). In our sample of 19 NGOs, we do find the correlation between NGO social structure and strategy to be loosely corroborated. Some of the NGOs are more hybrid in structure than the overly rigid hierarchical-versus-sectarian would imply.

## **Conclusions and preliminary hypotheses**

Our interview findings show that, in the US, three NGO categories favor acceptance of geologic sequestration: immediate acceptance (Enthusiasts), increased dialog on all fronts possibly with acceptance (Prudents), equal or more emphasis on other methods but including acceptance of geologic sequestration (Reluctants). Only the Opponent group favors rejection. Existing research on public perceptions of geologic sequestration shows that the public is largely unaware of the technology, and, when made aware of it, is neutral to negative about it (Sharp 2000, Curry 2004, Uno et al 2004, Palmgren et al 2004).

Our findings do not indicate whether any NGOs will eventually have much impact on the public's view of geologic sequestration, but we suspect that their effectiveness may be limited. Despite the universal agreement that the public should be educated about geologic sequestration, and educated by “credible” NGOs, only the Enthusiasts plan to engage in public education in the near-term. Industry-supported NGOs have already started advertising campaigns to convince the public that geologic sequestration is essential, but they may not be considered as impartial as the traditional public-interest NGOs (Siegrist and Cvetovich 2000). Furthermore, the history of Enthusiast activism suggests that policy makers in government and business are more often the targets of their science and advocacy than is the general public, so it is unclear how effective they can be in influencing public opinion directly. On the other hand, the Reluctants do have a history of direct public engagement, but they are only lukewarm about geologic sequestration and will place equal or more emphasis on other approaches to climate change.

Our interviews indicate that while most Enthusiast, Prudent and Reluctant NGOs plan to actively advocate for CCS, or at least include this technology in their mitigation portfolios, there are fewer who plan to support nuclear power and terrestrial sequestration as mitigation options. Most NGOs see CCS as a superior option to nuclear power. However, one Reluctant NGO interviewee explained his position thus: “the issue of how we get energy in a carbon constrained world does not allow us the luxury of demonizing anything”. For different reasons, this stance holds true for terrestrial sequestration vis-à-vis geologic. Geologic sequestration was uniformly seen as a better storage technology because of concerns that forested land used for terrestrial sequestration may not permanently remain forested (“how permanent is permanent? I mean you know, Vermont 50 years

ago was 20% forested and now it is 70% forested, but it could easily be 20% forested again”). Nearly all of the NGOs agreed that renewables and energy efficiency must be part of a comprehensive mitigation portfolio, and perhaps as superior to CCS. The Enthusiasts, however, seemed more prepared to present CCS as a mitigation solution that was on par with the other two, because “you need to throw everything at it (climate change)”, and because “CCS was designed to deal with the coal issue” in a way that renewable energy and energy efficiency are not.

Our review of the interviews and dimensions analysis (history of activism and sources of funding) allows us to hypothesize how other US NGOs not interviewed for this paper might view CCS with geologic sequestration. This technology was in general seen by all but the Opponents as a bridging technology towards a less coal-dependent economy. The perception that geologic sequestration was necessary was driven largely by the beliefs that the technology was already viable, and that the use of coal would continue for some time because a significant reduction in coal was politically infeasible. Our findings indicate that US NGOs that use predominantly cooperative bargaining strategies to manage environmental problems, and receive a significant portion of their funding from governments or private firms, are likely to endorse emissions reductions through a range of technical solutions. Solutions that seem politically viable, such as CCS or cap-and-trade systems, are especially likely to be supported. NGOs that use contentious or extra-institutional politics to address environmental problems, and receive most of their funding from members and other private sources, are likely to pay less attention to political feasibility and to view geologic sequestration negatively. They will prefer “the clean stuff” and mandatory emissions caps. Overall it seems that the majority of US environmental NGOs will accept CCS with geologic sequestration as a mitigation solution, while only a small fraction will not.

## INFLUENCING ATTITUDES THROUGH SOCIAL MARKETING METHODS

Carbon capture and sequestration (CCS), while controversial, is seen as promising because it will allow the US to continue using its vast fossil fuel resources in a carbon constrained world. The public is an important stakeholder in the national debate about whether or not the US should include CCS as a significant part of its climate change strategy. Understanding how to effectively engage with the public about CCS has become important in recent years, as interest in the technology has intensified. We argue that engagement efforts should be focused on places where CCS will first be deployed, i.e. places with many ‘energy veteran’ (EV) citizens. We also argue that, in addition to information on CCS, messages with emotional appeal may be necessary in order to engage the public. In this paper we take a citizen-guided social marketing approach towards understanding how to (positively or negatively) influence EV citizens’ attitudes towards CCS. We develop open-ended interview protocols, and a ‘CCS campaign activity,’ for Wyoming residents from Gillette and Rock Springs. We conclude that our participants believed expert-informed CCS messages, embedded within an emotionally self-referent (ESR) framework that was relevant to Wyoming, to be more persuasive than the expert messages alone. The appeal to core values of Wyomingites played a significant role in the citizen-guided CCS messages.

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### **Influencing attitudes towards carbon capture and sequestration: a social marketing approach**

Without substantial reductions in the emissions of greenhouse gases from the energy sector, it will be impossible to avoid catastrophic climate change (IPCC 2007). One possible technological solution is carbon capture and sequestration (CCS), where CO<sub>2</sub> emissions are captured from stationary sources such as coal-fired power plants and stored deep underground (NETL 2010a). This solution, while controversial, is seen as promising, because it will allow the US to continue using its vast fossil fuel resources and existing energy infrastructure in a “carbon constrained world” (NETL 2010b, NETL 2010c). With today’s technologies, retrofitting a coal-fired power plant with CCS is extremely expensive (NETL 2010c). Thus, energy engineers are very interested in developing projects at minimal cost and risk, located at geologically well characterized sites, where mineral resources can be extracted at profit. For at least the first round of projects, therefore, should CCS become part of US climate policy, the technology will be deployed in places that already depend on mineral extraction and fossil fuel based electricity generation. At these sites, livelihoods are heavily dependent on the health of the local energy sector (Petroleum Association of Wyoming 2010). In this paper we refer to people living in such places as ‘energy veteran’ (EV) citizens.

History has shown that the US public reacts quickly and negatively to accidents both in the production of energy (Rosa 1994), e.g. the Three Mile Island reactor meltdown (1979), and in the extraction of resources, e.g. the Deepwater Horizon oil spill (2010). These and other events have contributed to the public's general suspicion of the energy industry, and surveys suggest that these negative views extend to CCS.<sup>7</sup> The public seems to think of CCS as similar in scale and risk to that of nuclear energy, even in the face of evidence to the contrary (Reiner and Nuttall 2011). Some see this technology as pointless when more appealing alternatives such as solar power exist (Bradbury et al 2009, Fleishman et al. 2010).

CCS policymakers and industry officials know that without public acceptance, formal or implicit, it is unlikely that the technology will go to scale in the US. Research is beginning to move beyond the investigation of the public's perceptions of CCS, towards developing strategies to effectively engage with the general public. In recent years, studies have shown that CCS information used in research (Malone et al. 2010) and for public education (EPRI 2008) is of poor quality, tending to produce 'pseudo-opinions' that are easily changed (de Best-Waldhober et al. 2009). If the quality of the information is improved (de Best-Waldhober et al. 2009, Wallquist et al. 2010, Wallquist et al. 2011), however, participants can form stronger and more favorable views of the technology.

Recognizing the importance of public support, CCS proponents have launched a "clean coal" campaign designed to influence the attitudes of the general public ([www.AmericanPower.org](http://www.AmericanPower.org)). The messages put forth by these efforts focus on how CCS could contribute to energy independence and economic stability. For the few CCS experiments conducted at places with an EV public, the approach has been to communicate messages that emphasize technical and risk expert information. Such communication efforts at the Department of Energy's CCS pilot sites did not garner positive attitudes towards the technology, but rather seemed to have the opposite effect.<sup>9</sup> Largely anecdotal evidence from other countries supports this observation, where several small-scale CCS experiments have been shut down in part due to local protest (Global CCS Institute 2010, EENEWS 2010, Brunsting et al. 2010, Times 2010).

This paper does not analyze, or take a position on, the arguments in favor of or against CCS as a rational response to mitigating climate change. Rather, we recognize that the public is an important stakeholder in the national debate about whether or not the US should include CCS as a significant part of its climate change strategy. Understanding how to effectively engage with the public about CCS has become important in recent years, as federal and energy industry interest in the technology has intensified. Engagement efforts should be on places where the technology will be first deployed, which are mostly places with EV citizens. Early deployments often set the tone for future deployments, and local protests have been rallying points for larger social movements against large-scale energy technologies (Hess 2005, Van der Horst 2006). We suggest that social marketing, or the application of marketing techniques to achieve social change, is an effective approach towards engaging with the public about CCS. In this study we develop a citizen-guided social marketing approach towards understanding how to influence EV citizens' attitudes towards CCS.

#### *The role of emotionally self-referent triggers in persuasive messages*

What little research has been done on CCS-related messages for citizens has centered on creating easily digestible and readily understood messages (Fleishman et al. 2010). This work is influenced by dual process models (Petty et al. 1981, Chaiken 1980), which posit that if the message is 'well designed,' meaning that it is well reasoned, contains relevant information, and appeals to the logic of

an able recipient, then it should be successful.<sup>49</sup> By these criteria, CCS messages developed to date are well designed – they contain ‘expert’ approved information presented in an attractive and logical manner.

Mounting evidence suggests that the best messages are not only informational and logical, but also trigger an emotional response in recipients (Dillard and Peck 2001). These emotional ‘triggers’, it is argued, tend to induce thoughts about the recipients’ sense of identity (Dunlop 2008). ‘Emotionally self-referent’ (ESR) messages are better remembered, and are viewed as more persuasive than those that do not arouse such a response. Emotionally self-referent messages may also have the additional benefit of being talked about with recipients’ friends and families. Research suggests that exposure to these messages encourages discussion, wherein information flows through social networks, potentially influencing those not exposed to the original message (David et al. 2006, Maibach et al. 2007).

We argue that an effective CCS campaign aimed at changing EV citizens’ attitudes should target the multiple channels through which an individual is influenced. A useful starting point would be a systematic investigation of the emotional *and* informational elements that could comprise a persuasive message about the technology. While ESR-type messages have a long history of use in public health and political campaigns, they have not been applied to carbon management technologies in the energy policy domain.

We also argue that emotional triggers in a community are best identified from within that community. We therefore relied on the expertise of EV citizens to develop the ESR messages most likely to affect attitudes. To do this, we divided our study into two parts. For the first part, we identified the triggers that elicited thoughts about identity for our study group of EV citizens – the Wyoming public. For the second, we had our EV citizens use these triggers to develop emotionally self-referent messages with respect to CCS. They compared these messages to expert developed CCS messages to analyze which were the most and the least persuasive in promoting CCS to the Wyoming public.

#### *Wyoming - a state of energy dependent citizens*

For Midwest states that rely heavily on the revenues generated from coal-related exports, the ‘writing is on the wall’ (Casper Star Tribune 2005). Their industry is threatened by policies enacted in other states, for example California’s 2006 Global Warming Solutions Act, that limit the CO<sub>2</sub> to be emitted during the generation of electricity. A perceived threat also comes from the development of advanced power plant technology such as Integrated Gasification Combined Cycle (IGCC). Designed to remove virtually all pollutants such as SO<sub>2</sub>, large-scale IGCC deployment may eliminate the cost advantage enjoyed for the past few decades by low-sulfur Midwest coal (EIA 2011).

More than in any other Midwest state, coal is king in Wyoming. In 2009, mining operations comprised more than 90% (\$3.45 billion) of local and state revenue. State assessments suggest that three secondary jobs are created for every direct industry job, making the fossil fuel industry the single most important employer in the state (Petroleum Association of Wyoming 2010, Wyoming Mining Association). But times are changing and, to protect their coal industry, Wyoming state and industry officials know the state must adapt.

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<sup>49</sup> For challenges to this paradigm, see Unimodel (Kruglanski, Fischbach, Erb, Pierro and Mannetti 2004, Kruglanski and Thompson 1999, Kruglanski, Thompson, and Spiegel 1999) and Cognition in Persuasion Model (Albarracin and Wyer 2001, Albarracin et al 2000).

Over the past decade, policymakers and industry officials have advocated that the state move away from being an exporter of coal (a low-value ‘shovel-and-ship’ industry) to becoming an exporter of coal-generated electricity (a high-value industry). In the face of evolving national priorities on climate change where coal is now seen as “dirty,” IGCC and CCS have been embraced as a way for the state’s coal industry to stay afloat. State legislators have taken many steps to foster the development of CCS-related activities, such as submitting a proposal for FutureGen and passing the ‘CCS statutes’ (WY State 2008, WY State 2008, Casper Star Tribune 2010).

To date, several government and industry-funded projects have been proposed, and some are in the process of being implemented. The “Wyoming Underground Storage Project” near Rock Springs, WY is generally considered to be the most successful. Characterization of the underlying geology began in 2009 with \$4.95 million federal funding. Project developers are now in the process of obtaining building permits, and they plan to start construction in the next few years. In late 2010, the federal government promised \$5 million in additional funds for the project (University of Wyoming 2010). Wyoming’s EV citizenry and its proactive policies to foster the development and deployment of CCS make it, perhaps, the best place to learn how to develop persuasive CCS messages.

### **Part 1 - Emotionally self-referent triggers for Wyoming**

It would be impossible to develop emotionally self-referent triggers without expert assistance. In our study, the relevant experts are Wyoming citizens. To identify what their triggers might be, we conducted 20 open-ended face-to-face interviews with selected participants in Wyoming. Without mentioning CCS, we asked each participant just one question: “what specific values identify you as a Wyoming citizen?”

Throughout this study, we recruited our participants by snowball sampling. We were well aware of our outsider status in Wyoming, and decided that this method would be the best way to gain access to, and the trust of, our participants. Through a review of US census data and with help from the University of Wyoming’s Energy Center, we determined that there were sub-communities defined largely by local economic activities: tourism, government, mining, and education. With the assistance of the Energy Center, we recruited ‘key informants’ in each type of community— Laramie (education; home to the University of Wyoming), Cheyenne (government; the state capital), Gillette (mining; the self-proclaimed “energy capital of the world”), and Jackson (tourism; gateway to the Grand Teton and Yellowstone National Parks). With the help of our key informants we recruited participants in each community. Thus our purposively drawn sample included state legislators (including the CCS statutes co-authors), ranchers, educators, housing developers, media representatives, members of the Governor’s cabinet, and geologists.

As our sample is purposive rather than random, we present and analyze only those responses that were frequently expressed; such responses are more likely to be illustrative of the broader EV citizenry in Wyoming. Through a content analysis of our interview notes, we identified five Wyoming ESR triggers (or values): state independence, locals versus outsiders, outdoor space, lifestyle, and water (see Table 1). The term ‘value’ was not predefined for the participants, and values expressed were ones seen as being nearly universal for the people of Wyoming.



Table 1 shows the most frequent ESR triggers identified from interviews with WY participants.

<i>Trigger</i>	<i>Definition</i>
State independence	"...value of state sovereignty. There is this notion that we want to develop our own legislation and regulations because we don't need to have someone tell us how to run our state. We don't need the federal government telling us how to run our state."
Water	"...water issue in terms of water scarcity and water conflict between Wyoming and neighboring states."
Locals versus outsiders	"Most people think of outsiders as people who come in for a few years, and then leave. Ranchers define outsiders as anyone who was not a 5 <sup>th</sup> generation rancher."
Outdoor space	"...an appreciation of nature for its aesthetic purposes and...this notion that people here aren't separate from nature. And people talk about recreating on <i>open spaces</i> , on lands, and hunting and fishing and along with that, a sense of <i>stewardship</i> ."
Lifestyle	"...the prevailing philosophies are: first, you say what you do, and you do what you say. Second, you work to live, not live to work. You live by these so that you can do the things that you like to do."
Other	Education, Privacy, Jobs, Financial responsibility, Generosity to neighbors and strangers

While these triggers were reported as capturing the essence of WY citizens' sense of identity, our interviews suggest that their relative importance may differ among sub-groups of citizens with differing relationships to the energy industry. Four professional categories emerged (see Figure 1): policymakers (local and state), energy industry employees, ranchers, and broader community members. By no means does membership in one group exclude membership in another; e.g., a rancher in Gillette raises cattle and also leases her land to an oil company.

The identification of the ESR triggers was only our first step toward understanding how to develop a persuasive message about CCS. In the next section, using what we learned from our initial interviews, we asked a new set of Wyoming participants to design emotionally self-referent CCS marketing messages.

## **Part 2 - Citizen-designed emotionally self-referent CCS messages**

### *Developing ESR CCS messages*

We developed an interview protocol designed to elicit views about CCS, as well as to understand views of the technology in relation to the ESR triggers. Based on the responses from the 'trigger' interviews we conducted in April 2010, we developed and pre-tested this CCS interview guide in May 2010 in Berkeley, California. With the help of the Energy Center, we refined the guide and piloted it in Casper, Wyoming – once a hub of industry in the state. Based on our interviews in Casper, we tailored the guide for the final study.

While most citizens in the state are familiar with its energy industry, for this part of the study we decided to recruit participants who live where commercial CCS projects may occur in the future. We recruited in the two largest mining communities: Gillette and Rock Springs. All of our participants were EV citizens. They were already aware of CCS and many had loosely-formed opinions of the technology prior to their participation in this study. Therefore the provision of educational materials on CCS, which surveys with the general public often require, was not needed.

Gillette, where we conducted 18 interviews in July 2010, is *the* coal-mining town. Most of the town's 25,293 residents (US Census 2010) are directly or indirectly employed at one of its six coalmines. More coal (90%) is mined in this area than in any other in the state, and a quarter of all

coal consumed in the US comes from the Gillette area alone. Rock Springs, where we conducted 21 interviews in July 2010, is an older and more well established community than Gillette. Many of its 18,708 residents are employed at the local trona mines, and some are employed by coal and natural gas operations (see appendix D.3).

We found that while the ESR triggers may be (nearly) universal, their relative importance varies by subsets of the state’s population. Since a CCS campaign in Wyoming could be more effective if it included multiple CCS messages targeted at these subsets, we recruited from each of these groups in each community (see Figure 1): policymakers, energy industry managers and employees, ranchers, and community members not directly related to the energy sector.

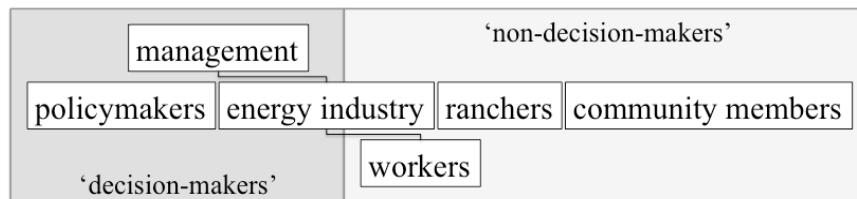


Figure 1 shows how we categorized our participants into groups for our analysis. In all we had 8 partially overlapping groups.

The CCS interview began with several open-ended questions such as “what are the challenges facing Wyoming over the next 20 to 25 years?” Then we had our participants design a ‘CCS campaign’ in which, based on their responses during the interview, they created either a statewide pro- or anti-CCS marketing message. We had some of the participants develop messages contrary to their stated opinion of the technology. We did this to encourage our participants to share views they believed to be persuasive not only to themselves, but that might be persuasive to others. This activity involved several steps.

We first asked our participants what persons, groups, and/or institutions they believed would be trusted sources of information. Second, we assessed the relative importance of each ESR trigger by having our participants rank them (from 1 to 5) by what was most central to their own sense of identity as a Wyomingite. When questioned, without exception, every participant confirmed that the ESR triggers were central to their sense of identity. “I would say these values,” said an older Rock Springs librarian, “are what connect the people of Wyoming” (RS7).

Third, we asked our participants to design a statewide pro- or anti-CCS marketing message using the ESR triggers. We asked our participants to imagine that they had a fixed pool of resources (i.e. money or time) from which they could draw to develop their message. Then, using an interactive budget allocation tool (see appendix D.2), we had our participants divide the pool of resources among the ESR triggers (see Table 1). Our underlying assumption was that larger resource allocations to specific triggers would be a proxy for greater emphasis to be placed on those triggers in a hypothetical CCS campaign. While the participants were using the allocation tool, we encouraged them to follow the Think Aloud Protocol (Lewis and Mack 1982); this protocol asks participants to describe what they are looking at, doing, thinking and feeling. We did this so that we could better understand both what our participants believed to be a persuasive CCS message for their fellow Wyomingites, as well as to understand why they thought so. The Think Aloud method can sometimes lead to illogical or unrelated utterances and possible cognitive overload (Lewis and Mack 1982); we tried to mitigate these disadvantages by asking the participants follow-up questions to ensure that they had expressed themselves to their satisfaction.

Fourth, to gauge the importance placed on CCS we asked our participants to estimate how much should be spent on a pro- or anti-CCS campaign to be successful – one generating CCS support or

rejection. To help our participants with their estimates, we provided them information on how much was spent on advertising for the last gubernatorial election.

Finally, we showed our participants six expert-developed, primarily informational, CCS messages (Table 2), drawn from a range of economic and scientific assessments. We asked them to rank these (from 1 to 6) in the order they believed would be most important to an average Wyoming citizen. Then, we invited our participants to re-rank the ESR triggers with respect to their CCS messages. We encouraged the participants to include the expert messages in this re-ranking if, and where, they saw fit. During the ranking exercises, we again asked our participants to tell us aloud what they were looking at, doing, thinking, and feeling.

Table 2 shows the expert CCS messages drawn from a range of current scientific and economic assessments. The definitions quoted here are taken from the interviewer’s script developed for the second part of this study (For a range of CCS-related messages, see Metz 2005, NETL 2010, Fleishman et al. 2010).

<i>Trigger</i>	<i>Definition</i>
Benefits to Wyoming	There are local benefits from carbon storage in the form of increased investment employment in the energy sector. It helps to get more energy out of a given location. Doing research and demonstration for CCS now will also help Wyoming residents learn whether this is a good approach to managing greenhouse gas emissions on a large scale. Another benefit is to improve market access to customers of Wyoming energy who seek cleaner energy sources.
Suited to Wyoming	Because of its geology and energy industries, carbon storage may work particularly well in Wyoming, and may be part of Wyoming’s contribution to the US and worldwide efforts to reduce carbon emissions.
A known technology	Carbon dioxide injection underground is a relatively well-understood technology that has been applied in the Western United States for decades. Carbon dioxide injection has been done to enhance energy production, or dispose of acid gas in safe locations. It has not been done at the large scale expected in the future.
Costs	CCS may be costly for energy consumers, particularly for electricity. But coal fired power plants are big emitters of carbon dioxide and are likely to be regulated more in the future in any case.
Low expected risk	Carbon dioxide storage does have some risks, which seem to be low. Experience suggests these risks can be made still lower by selecting good sites, and using the most appropriate technologies.
Climate change	Carbon dioxide released to the atmosphere today will continue to have its greenhouse-impact for about 100 years. Therefore the positive effects from actions taken today to reduce GHG emissions will not be seen for a long while. Addressing greenhouse gases and climate change will be a long process.

## *Analysis*

### *ESR Triggers*

We had our participants rank the ESR triggers on a scale from 1 to 5, with 1 representing the trigger most important to their identity as Wyoming citizens and 5 being the least. Given our small and purposive sample, we could not assume that the rankings for the groups were either normally distributed or fully representative of the larger population. To get a sense of the magnitude of differences in the ranking of the ESR triggers among the groups, we employed robust nonparametric tests. We used the Wilcoxon test (chi-square for 2 groups) to assess the differences in means between our two communities (Gillette vs. Rock Springs) and status (decision-makers vs. non-decision-makers). We used the Kruskal-Wallis test (chi-square for 2 or more groups) to assess

differences by profession. If a trigger were equally important between two or more groups (e.g. between Gillette participants and Rock Springs participants), we would expect an average rank of 2.5 (based on a scale of 1-5).

### ESR CCS messages and expert CCS messages

The resource allocation to each ESR trigger for the CCS campaign comprised the heart of their persuasive CCS message. To assess the importance of each trigger, we took the average of the percentages allotted to each ESR trigger to identify the “average CCS campaign.” We took this average campaign allotment and mapped it in Figure 2. Each bubble represents one ESR trigger and the size of the bubble corresponds to the percentage allocated to it. We also had our participants rank the expert CCS messages on a scale from 1 to 6, with 1 representing the message most important to them. We performed a similar analysis for the expert CCS messages as we did for the ESR triggers.

To get a sense of the magnitude of the differences in resource allocation among the groups, we again employed nonparametric tests. We used the Wilcoxon test to assess the differences in mean percentages allocated for each trigger between our two communities and status. We used the Kruskal-Wallis test to assess differences by profession. If a trigger were equally important as all the other triggers for a particular group, we would expect to see an average resource allocation of 20%. If there were no differences between groups we would expect to see average allocations of 20% for each trigger for all groups.

To better understand and contextualize our results, we performed a content analysis of the interview transcripts. Through this analysis we assessed the sources that our participants believed would be trusted with respect to encouraging or discouraging CCS, as well as their views on CCS and how it related to the energy industry.

## *Results*

### ESR triggers

On balance, our participants ranked lifestyle ( $M=2.16$ ,  $SD=1.26$ ) and outdoor space ( $M=2.18$ ,  $SD=1.16$ ) higher than the other ESR triggers (see Table 3). The trigger ranked as least important was locals versus outsiders ( $M=4.39$ ,  $SD=1.17$ ).

Table 3 shows the average (and standard deviation) rank for each ESR trigger for the groups, as well as for all of the participants (1=most important, 5=least important). A **low average value** means that the ESR trigger was considered **more important** than the other triggers.

	Lifestyle		Outdoor Space		Water		State Independence		Locals vs. Outsiders	
	M	SD	M	SD	M	SD	M	SD	M	SD
Community										
<i>Gillette</i>	2.61	1.42	2.39	1.33	3.11	1.18	3.11	1.18	4.28	1.41
<i>Rock Springs</i>	1.75	0.97	2.00	0.97	2.60	1.39	3.15	1.18	4.50	0.95
Status										
<i>Decision-makers</i>	1.67	1.02	2.00	0.89	3.05	1.36	3.29	1.19	4.19	1.21
<i>Non-decision-makers</i>	2.76	1.30	2.41	1.42	2.59	1.23	2.94	1.14	4.65	1.11
Profession										
<i>Policymakers</i>	1.75	1.16	1.63	0.52	3.00	1.51	3.50	1.31	4.38	1.06
<i>Energy Industry</i>	1.83	1.11	2.58	0.79	3.33	1.07	3.25	0.97	4.58	1.24
<i>Rancher</i>	2.29	1.38	2.29	1.70	2.86	1.35	2.57	1.27	3.86	1.35
<i>Community members</i>	2.80	1.40	2.00	1.41	2.30	1.25	2.90	1.10	4.60	1.17
<b><i>All participants</i></b>	<b>2.16</b>	<b>1.26</b>	<b>2.18</b>	<b>1.16</b>	<b>2.84</b>	<b>1.31</b>	<b>3.13</b>	<b>1.17</b>	<b>4.39</b>	<b>1.17</b>

### ESR CCS messages and expert CCS messages

The maps in Figure 2 represent the allocation decisions by all our participants and by community groups for the CCS marketing message. For the average CCS campaign, our participants allocated nearly half of their resources to lifestyle and locals versus outsiders (25% and 24% respectively). Next, they allocated 20% of their resources to outdoor space and 20% to state independence. The rest was given to water and other topics.

According to our respondents, a persuasive pro-CCS marketing message would open with how CCS would enhance their lifestyle and enjoyment of outdoor space. Then it would move to how CCS does not threaten jobs (locals versus outsiders) but instead retains, and maybe even creates, jobs. The message would then show how the development of the technology in Wyoming contributes to and maintains state independence. A state senator, for instance, said that he would say, “we are tired of the federal government coming in and telling us how to run things when we can do this ourselves” (G16). While water was not seen as central to a persuasive message, our participants said they would mention that CCS would not adversely affect water quality or supply.

The most commonly formulated anti-CCS marketing message rested on exactly the same triggers and exactly the same order of triggers as the pro-CCS message. The difference lay, our participants said, in how they would “spin” each of the ESR triggers. For the anti- message, our participants would open with how the technology might adversely affect their lifestyle and outdoor space. A historian in Rock Springs said he would say how CCS “negatively affects...my lifestyle in terms of me backpacking and seeing no signs of man” (RS1). The message would move on to how the technology threatens jobs (locals versus outsiders). One coal miner in Gillette responded that he would say, “we [Wyomingites] don’t want outsiders here, even if it hurts our economy” (G2). The message would suggest that CCS is being considered by the state only because of federal pressure (state independence), and conclude with how the technology, because it is not yet proven, could threaten water quality and supply.

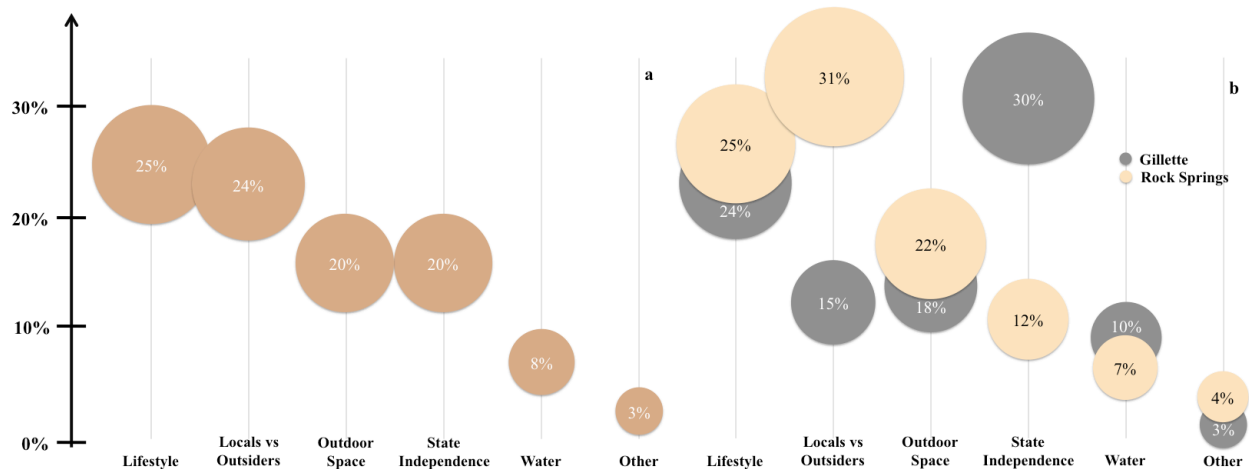


Figure 2 shows a graphical depiction of the average percentage of resources allocated for each ESR trigger for all of our participants (a) and by community (b).

When we compared the CCS message maps by our different groups, we found differences in how resources were allocated by community. Our Gillette participants allocated significantly more resources to state independence than our Rock Springs participants ( $\chi^2=10.65, p=.00$ ). Our Rock Springs participants allocated significantly more of their resources to locals versus outsiders ( $\chi^2=8.96, p=.00$ ). Our data do not allow us to explain these inter-group differences, however.

On balance, a trusted source to deliver the CCS message would be one seen as unbiased (“no bias...100% no bias” (RS12)), down-to-earth (“not just some hotshot, but somebody who has been through the good and bad times” (G16)), and native-born (“These guys are natives, they have grown up with the cattle industry and the oil discovery. That’s a lot of credibility in our community, I think, if you have those roots” (G17)). Untrustworthy sources are energy industry representatives: as one male rancher in Gillette put it, “Basically you can’t trust anybody anymore. Especially people in the energy industry because they’ll lie” (G3). Another untrustworthy source would be “elite” environmentally-oriented non-governmental organizations. A local conservative radio personality said emphatically, “it *can’t* be environmentalists” (G6).<sup>50</sup>

We found differences by status as to how the CCS campaign should be presented. While all agreed that local and state policymakers would be trusted, non-decision-makers strongly believed that, given Wyoming citizens’ preference for ‘hands-on’ campaigns, community members delivering the message would be best. A coal miner in Rock Springs suggested that “a collective of local citizens who would be formed to study the issue and present the results” (RS19) could be a

<sup>50</sup> Although trust is not something that I explicitly examine in this chapter, I do think that it is a very important issue with respect to how the energy public perceives CCS.

These are the conditions of trust listed in LaPorte and Metlay (1996):

1. Parties have a reasonably high respect/regard for each other based on general familiarity and perceived high degree of mutual understanding and integrity.
2. Parties possess the competence to understand the problems others face and the solutions advanced to address them.
3. Parties have a reasonably equal part in defining the terms of their relationship.
4. Parties maintain a positive history of relationships during which agreements have been kept, even in the face of apparently very demanding challenges, and they take seriously the implications of their actions for sustaining the relationship.
5. Parties are able to determine unambiguously the effects of their relationship on each other in a full and timely fashion

successful way to deliver a pro- or anti-CCS message. Our ranchers recommended that “a cowboy-type or agricultural representative” (G3) would be trusted, because they would be perceived as having no vested interest in the energy industry. Unprompted, several participants suggested that the most effective way to reach Wyoming citizens would not be through media outlets but rather through their workplaces or community meetings (“take it to every Lions Club in the state and have a speaker” (RS17)).

When asked to rank the expert-developed CCS informational messages, our participants ranked benefits (M=2.29, SD=1.66) and suited to Wyoming (M=2.53, SD=1.64) higher than the other CCS expert messages (see Table 4). The message ranked as least important was climate change (M=4.32, SD=2.17), though climate change is the main reason for policy-level interest in CCS.

Our participants did not see their emotionally self-referent CCS messages as supplanting the more traditional expert points of view. Rather, they argued that CCS expert messages should go “hand-in-hand” (RS11) with the ESR triggers to create a message that would be part of a successful (pro- or anti-) CCS campaign. One Rock Spring participant reflected on the primacy of ESR triggers in her CCS message, “you have to draw out the emotion. You...have to get it, so they [Wyomingites] wonder how this affects them” (RS7). Most reshaped their original campaigns to include some of the expert messages, but retained the ESR message’s centrality.

A pro-CCS message (see Figure 3) that includes the expert messages would focus on how the technology would positively affect lifestyle and outdoor space, mediated by benefits. An energy industry executive in Gillette said, “the only way I can think to run a campaign like that is if you showed people that it would create more jobs – because it is about the only argument you can present” (G16). The link between benefits and lifestyle and outdoor space would be a central message, where the important questions would be: “How can I be employed at a reasonable salary to do things? How is it [CCS] going to affect hunting and fishing?” (RS4)

Table 4 shows the average (and standard deviation) rank for each CCS expert message for the groups, as well as for all of the participants (1=most important, 6=least important).

	Benefits		Suited to Wyoming		Known Technology		Low Expected Risk		Costs		Climate Change	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Community												
<i>Gillette</i>	3.06	1.70	2.67	1.81	2.83	1.15	3.72	1.53	4.11	1.60	4.78	1.96
<i>Rock Springs</i>	1.60	1.31	2.40	1.50	3.20	1.54	3.75	1.94	3.95	2.11	3.90	2.31
Status												
<i>Decision-makers</i>	1.71	1.10	2.05	1.07	3.14	1.31	3.62	1.83	4.33	1.77	4.86	1.80
<i>Non-decision-makers</i>	3.00	1.97	3.12	2.03	2.88	1.45	3.88	1.65	3.65	1.97	3.65	2.45
Profession												
<i>Policymakers</i>	1.88	1.25	1.63	1.30	2.63	1.51	3.88	2.10	4.50	2.27	3.75	2.31
<i>Energy Industry</i>	1.67	1.07	2.42	1.24	3.50	0.90	3.33	1.44	3.67	1.30	6.00	0.00
<i>Rancher</i>	3.00	2.00	3.14	1.77	3.00	1.29	4.14	1.21	4.57	2.15	3.86	2.27
<i>Community members</i>	3.00	2.05	2.60	1.84	2.50	1.43	3.60	2.12	3.90	2.02	3.30	2.41
<b><i>All participants</i></b>	<b>2.29</b>	<b>1.66</b>	<b>2.53</b>	<b>1.64</b>	<b>3.03</b>	<b>1.37</b>	<b>3.74</b>	<b>1.73</b>	<b>4.03</b>	<b>1.87</b>	<b>4.32</b>	<b>2.17</b>

An anti-CCS message focuses on the same ESR triggers, but highlights the expert messages most likely to generate suspicion or anger by Wyomingites (see Figure 3). For example, a coal miner in Gillette (G16) augmented his original anti-CCS message to include the expert messages:

“...well these, actually all three of these (gestures to CCS expert message in front of him) would have an impact on nature. You can certainly use the argument that it is going to hurt our nature here...lifestyle...and from the standpoint of nature and water. Um. Again, state independence is related to global warming...climate change is something that the feds have dreamed up and they are shoving it down our throats. Locals versus outsiders go along with this. You know, we don’t want the outsiders here.”

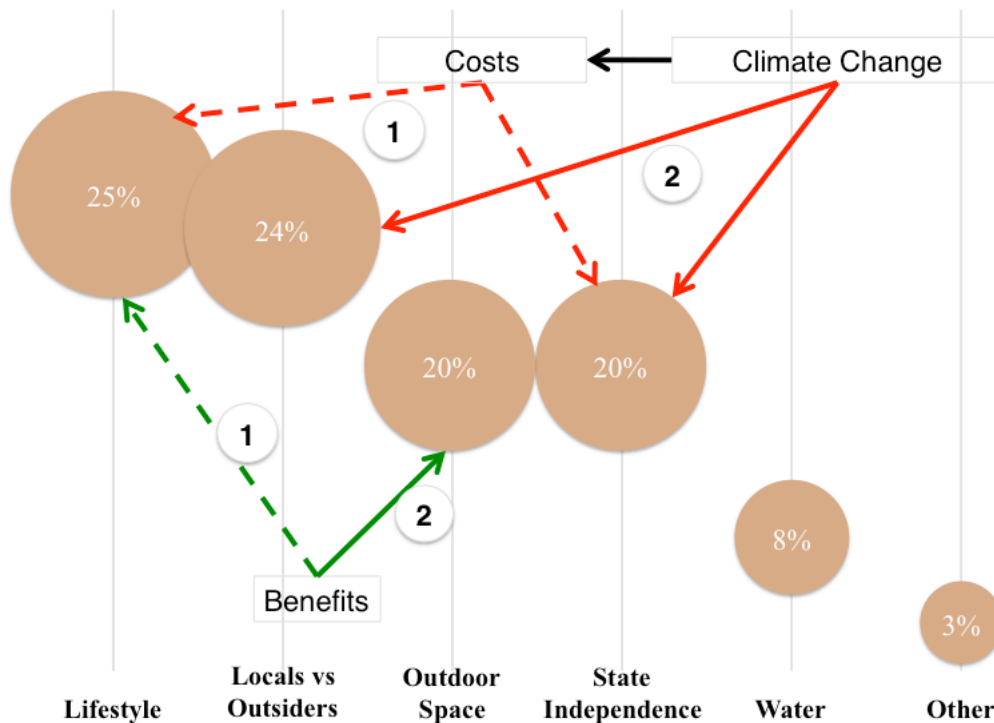


Figure 3 shows the general pro-CCS message including the average pro-CCS expert message (green), and the anti-CCS message (red). A pro-CCS marketing message would include how benefits (1) allow for the Wyoming lifestyle, thereby (2) enhancing Wyomingites’ enjoyment of outdoor space. An anti-CCS marketing message would include how CCS will (1) cost jobs and threaten lifestyle thereby reducing Wyomingites’ ability to enjoy outdoor space. Then, it would explain that climate change is a problem (2) created by outsiders (meaning, the federal government) and will mean fewer jobs (transient workers), and therefore threatens state sovereignty.

## Discussion

From our study of energy-sector veteran residents of Wyoming, we conclude that our participants believed that expert-produced informational CCS messages, embedded within an ESR framework that was relevant to Wyoming, were more persuasive than the expert messages alone. Indeed, our participants thought that the most persuasive pro- or anti- CCS campaigns should lean more heavily on the ESR triggers. The triggers themselves do not change, no matter the intent of the message. However, the relative importance placed on these triggers appears to differ by subsets of the population, and any CCS campaign should be sensitive to those differences. Potentially, a successful



way to influence EV citizens' attitudes towards CCS would appeal to the place-based values and identity issues they find most important. The expert-based information on CCS is important, but for the purposes of influencing attitudes it may be secondary.<sup>51, 52</sup>

Our findings show only what our participants believed would be persuasive CCS messages, and not what actually are persuasive messages. Future research should test this social marketing approach to assess the degree to which citizen-guided messages are indeed persuasive. One possible way to do this would be to have members of an EV public "vote" on a fictional CCS referendum after exposure to information about the technology, after the technology is presented either within an ESR framework or alone. Furthermore, while our findings suggested that ESR triggers are key to a persuasive CCS message, there may be a distinction between an ESR trigger that is important and one that is persuasive. For example, our participants ranked locals versus outsiders as low in importance relative to the other ESR triggers, but allocated a substantial portion of their resources (24%) to it for their persuasive CCS message. There are a number of different models that might explain our findings. First, ESR triggers may have multiple and contextual meanings for our participants (Kecskes 2008). Alternatively, certain ESR triggers may require more cognitive effort to understand than others and therefore may not be emphasized in a persuasive CCS campaign (Kellogg 1987). Finally, lower ranked triggers may be used in order to appeal to the broadest audience possible (Rice 2001). Further study is needed to understand the contribution of these models to our participants' selection of ESR triggers.

While not enthused about the technology, our EV citizens saw the energy industry, and coal in particular, as the state's "bread and butter" (G1). Coal, they reported, kept the state running, and the state gave them the resources necessary to fund their independent, outdoor-loving, you-work-to-live

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<sup>51</sup> There is the so-called "affect-cognition-behavior" trinity of attitude organization. Emotionally referent messages are designed to trigger an emotional response (targets "affect"). From a social psychological perspective, the affect primary hypothesis postulates that emotional associations to an attitude object are activated more rapidly than non-emotion (cognitive) association. In the classic model, information is presented, processed, and if successful, move recipients' attitudes toward the advocated position → the revised attitude may influence behavior under appropriate conditions. Conditions for 'success': (1) IF recipients are able and properly motivated, they will analyze persuasive messages, (2) IF messages is persuasive (well-reasoned, data based, logical (i.e. strong), (3) IF unmotivated or unable → rely on peripheral cues (attractiveness) or on heuristics (dad is always right). → These attitudes are LESS resistant to change, stable, likely to impel behavior change, (4) Matching hypothesis (1990) – persuasive appeals are effective to the extent they match the structural (affective-cognitive) makeup the targeted audience ((a) Affective persuasion more effective in changing attitudes based on affect, (b) Cognitive persuasion was not more effective at changing attitudes based on cognitions), (5) Fear ((a) Two types of feelings and emotions – those activated by the persuasive message and general feelings and emotions unrelated to the persuasive appeal, (b) Message-activated fear and persuasive campaigns at health-related attitudes - Fear appeals generated favorable cog responses and consequent attitude change if felt vulnerable to threat and vulnerability as motivator), (6) Information and processing (a) At moderate levels of processing – affect served as info in persuasion, (b) Low levels of processing – affect not identified, (c) High – irrelevant for judgments, (d) Affect – processing: (i) Supremacy of negative states in promoting argument elaboration (MORE COMPLEX – facilitative effects of negative affect only when appeal consider legitimate and OPPOSITE EFFECT – positive mood serve as a resource when processing self-relevant appeals), (ii) + mood serve as buffers enabling a person to process potentially threatening but useful info, (iii) + mood → high relevance → careful scrutiny of negative info → attitude change, (iv)-mood → low relevance → careful scrutiny, (7) Certainty and Carryover ((a) Certainty with an emotion carries over to determine certainty about subsequent persuasive situations and resultant processing, (b) More to affect-persuasion relationship than mere valence of emotional states: (i) Emotions function as signals persuasive appeals about their environment, (ii) The biasing effect of emotional effects has been demonstrated under a restricted range of conditions.

<sup>52</sup> Here, I do privilege Social Identity Theory because the design of the study relies solely on the notion that emotionally self-referent messages trigger the recipients' thoughts about one's sense of identity as a Wyomingite. Therefore, the notions of 'ingroup' versus 'outgroup' were valuable for understanding how the participants saw themselves as Wyomingites. This study however did yield interesting and unexpected findings that I plan to investigate further in a stand-alone paper (e.g. issues of 'access' and 'ownership') where I plan to expand the scope of my theoretical framing.

self-image. If CCS were the way to maintain that identity, then they would be for it, and believed that their fellow-citizens would be, too.

Social identity theory posits that people derive part of their identity from their group membership, and that this social identity has emotional significance (Ellemers et al. 1993). Our EV citizens' sense of identity – Wyomingite – was a product partly of birth and partly of self-selection. The economic and political pressure from the outside (which includes the federal government) was seen as an attack on the coal industry, as well as on the collective values held dear by Wyomingites. The increasingly negative rhetoric around coal was perceived as a personal attack against Wyomingites themselves. These factors fueled the fear that Wyoming's social identity was under threat, further causing the participants to defend the integrity of the 'ingroup' (Turner et al. 1987). Almost all participants expressed resentment at the power of 'outsiders' over the 'locals': one city commissioner said ruefully, "we've been a colony here our entire history...a lot of our economy is run by multinational companies who couldn't even find our state on a map in their board room" (G18).

The strategy adopted by decision-makers in the state has been to use 'outgroup' political and economic pressure to do something about coal, as an opportunity to "save" the coal industry through CCS. Thus, they are able both to maintain the status quo<sup>53</sup> by keeping the industry in place and try to increase Wyoming's status by promoting the state as "technology pioneers" (G2) and "energy policy leaders" (G11). The rest of the population, in effect, goes along with this plan, because so many of them are either indirectly or directly dependent on the mineral extraction industry. For Wyomingites, at stake is not just their financial security but also the very fabric of their society.<sup>54</sup>

Difficult decisions about what carbon management technologies to invest in will need to be made over the next few years if the US wants to make a meaningful contribution to the mitigation of climate change. In many instances this will require energy veteran citizens to assume the local burden of living close to these potentially risky technologies for the benefit of the nation. Furthermore, EV citizens will be asked to assume an unknown financial burden, potentially costing jobs and undermining a valued way of life.

This study is premised on the understanding that the public is an important stakeholder in the national debate about CCS, and, given growing interest in the technology by policymakers and energy industry officials, developing effective ways to engage with the public is becoming more important. Most ongoing CCS perceptions research has emphasized 'well designed' expert messages, i.e. messages that seek to convey information about the technology in a scientific but simple manner. The main goal is to target the general public and therefore to understand the factors that influence the public's attitudes towards the technology (EPRI 2008, de Best-Waldhober 2009, Wallquist et al. 2010, Wallquist et al. 2011). We have argued that the perceptions of EV citizens in the frontline states are different from those of the general public, and that these should be the focus of the next wave of CCS campaigns. We have also argued that emotionally self-referent messages are at least as important as expert informed messages if EV attitudes are to be influenced.

In this study we do not advocate either for or against the implementation of CCS. Rather, we suggest that social marketing is a potentially powerful approach in engaging with the public about CCS, whatever be the intent of the engagement. Our application of social marketing methods to the energy domain contributes to an emerging set of studies investigating ways to communicate with the public about carbon management technologies. Our method of identifying citizen-guided ESR triggers, and campaigns based on these, could be useful to persuasive messaging in a wide range of

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<sup>53</sup> For examples of explanations of status quo as understood by Social Identity Theory, see Tetlock 2002 and Winter and Barenbaum 1985.

<sup>54</sup> See footnote 32.

domains, including energy policy, environmental policy and public health. Finally, while we recognize that ESR triggers are place-based and specific, we believe that the methods we developed to elicit these triggers will hold with other EV citizens in states with significant fossil fuel operations.

## CONCLUSIONS AND DISCUSSIONS

*Our species thinks in metaphors and learns through stories. – Mary Catherine Bateson*

Overall, this dissertation examines a sequence of important interconnected issues: the perspectives of potential and actual CCS host communities, the perspectives of the environmental community on the rationality of CCS as viable mitigation solution for the United States, and strategies for engaging about CCS with the energy dependent public. Much of this research is original work addressing major interdisciplinary gaps in existing literature as well as in industry and government public engagement practice. Each of the chapters is a stand-alone paper that provides a unique contribution to a series of different types of carbon management technologies and academic disciplines. They are assembled together to provide a unique integrated evaluation of these related problems. Collectively, these chapters capture some of the major challenges facing mitigation technology engagement from the potentially time consuming need for careful social site characterization to the opportunities for using citizen-guided marketing methods to identify factors that may enhance public support for the technology. This final chapter presents a brief examination of how, and by whom, technologies like CCS should be presented to the energy public. Next, this dissertation considers the implications of public engagement with the energy public and concludes with a brief discussion of general areas for further research

### **Presenting CCS to the energy public**

Effective engagement with the energy public, whether it is for educational purposes or to encourage acceptance of CCS, may be more effective if the information is presented by a local trusted source within an emotionally self-referent framework. This dissertation proposes that one potential way to develop an ESR framework is to identify self-referent ‘triggers’ for the energy public of interest through a citizen-guided social marketing method. Triggers are values that elicit thoughts about one’s self, and may provide a way to develop ways to effectively engage with the energy public about technologies like CCS.<sup>55</sup>

Finally, while environmental NGOs are, in general, more trusted sources of information about issues pertaining to energy and environmental quality, their influence with respect to CCS may be limited. However, the NGOs with plans to educate the public in the near-term are those who are financially supported, in large part, by the energy industry. These NGOs therefore may not be considered as impartial in the view the energy public as the traditional public interest NGOs.

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<sup>55</sup> It is important to note that individuals *do* belong to multiple groups (e.g., soccer team, US citizen, etc.), and that characteristics integral for membership and identification to one particular group may be mutually exclusive for the same person’s membership to another. However, social psychologists argue that there is, in general, consistency between ‘selves’ due to an individual’s need to understand reality, achieve a positive and coherent self concept, and relate to and convey an appropriate impression to others in our group (Petty and Briñol 2008, Hogg and Smith 2007, Prislín and Wood 2005, Chen and Chaiken 1999, Kraus 1995, Hogg and Abrams 1988, Tajfel and Turner 1986, Turner, Hoggs, Oakes, Reicher and Wetherell 1987).

## Implications for public engagement

In the US, the practice of public engagement vis-à-vis technology deployment for climate change policy is a relatively recent phenomenon in our country's history (Petersen 1984, Rothham 1991, Weisstub 1998). The interest in public input with respect to energy and environmental policy is part of a larger movement in our society where the American public demands greater governmental transparency (Brito 2008, Fenster 2006, Fung et al 2009) and adherence to the democratic ideal (Fishkin 1991, Delli Carpini et al 2004). Public engagement with respect to carbon management technologies like CCS is therefore part of this societal movement.

While public engagement is lauded as an important element for the development of credible and legitimate policy, as PytlikZillig and Tomkins (2011) eloquently argue, more work needs to be done to answer the important question of “which *forms, features, and conditions* of public engagement are optimal for *what* purposes, and *why* (p 2)?”

To date, there are two reasons why researchers are interested in understanding the public's perceptions of CCS as input for designing effective engagement strategies: enhancing democratic public participation or enhancing the success of CCS. While not necessarily competing or mutually exclusive goals, they often are presented as such in the CCS literature and in discussions among CCS perceptions researchers (e.g., see presentations from the Annual Social Science Research Network Meetings from 2009 and 2010). There is a fuzzy, and for some, uncomfortable line between ‘basic’ (or academic) research and ‘applied’ (or advocate) research. Given that this area of research is in its infancy, now is a perfect time to honestly and openly interrogate the question of “which *forms, features, and conditions* of public engagement about CCS are optimal for *what* purposes, and *why*? (underlined words added by author, PytlikZillig and Tomkins 2011, p 2). As research on CCS perceptions moves from understanding and explaining how host communities view the technology towards developing strategies to enhance education and public acceptance, researchers will need to answer these challenging questions. The work presented in this dissertation builds upon the vast scholarship on modes of public participation (see NAS 2008 for an overview).

### *Preparation and execution (form, features, and conditions)*

There are two main implications for the preparation and execution of public engagement practice with the energy public that affect: the information selected (sources, details, framing), and the procedures by which projects are selected and deployed (justice and fairness).

First, those practicing public engagement should carefully consider the source, details and framing of the information presented to the energy public when developing a public engagement protocol. The findings in this dissertation suggest that while the general public tend to trust environmental and energy policy information from environmental NGOs, for the energy public CCS is attractive for other reasons that are more contextually important, such as job creation, status enhancer, and identity validation. Immediate reliance therefore on teaming up with an environmental NGO for an engagement effort may not always be an effective way to convey information about the technology. In some cases, a better approach could be to first identify who are *locally* trusted sources of information on issues pertaining to the energy industry, and to work with the trusted source during an engagement effort.

In addition, the findings in this dissertation indicate that the energy public requires the inclusion of information about technical *and* social risks of CCS. The details provided during engagement should therefore include information about how the presence of the technology may affects the lives of the energy public e.g. job prospects, potential stigma, and relationship between local energy industry and the community. Clearly, the particular social concerns of the energy public are not be

apparent at the beginning of an engagement effort and so it is important that communications are a two-way dialog as well as an iterative process.

Furthermore, the findings indicate that the details of the CCS information shared with the energy public should be presented within an emotionally self-referent (ESR) framework. ESR messages are better remembered by the recipient and have the additional benefit of being talked about with recipients' friends and families. Research suggests that exposure to these messages encourages discussion, wherein information flows through social networks, potentially influencing those not exposed to the original message (David et al 2006, Luke and Harris 2007, Maibach et al 2007). The citizen-guided method outlined in Chapter 5 provides one potential way for identifying an appropriate ESR framework for an energy public.

Second, the findings suggest that the energy public believes they have the right, as well as the obligation and desire, to participate in the development of energy policy pertaining to carbon management technologies. The energy public not only want the procedures for the deployment and operation of CCS to be just (defined by experts), they want a voice in developing the terms of the procedures. Thus, suggesting that engagement with energy public should not be a one-time occurrence but rather must be an ongoing iterative process. This approach is especially important for a carbon management technology like CCS where the cooperation and goodwill of the local energy public can only enhance the long-term success of a project. The findings also support the argument in the procedural justice literature that the fairness of the process is central to the legitimacy of the outcome (e.g., Thibaut and Walker 1975, Lind and Tyler 1988, and Senier et al 2008).

#### *Outcomes (what purposes, and why)*

There are two main implications for engagement outcome with the energy public: link between the purpose for the engagement to the outcome, and active versus passive assent (justice).

First, those interested in developing effective ways to engage with energy publics need to carefully articulate what they hope to accomplish, and why. Articulating intent may provide a useful guide for selecting the most appropriate method and energy public to achieve the desired goals. For example, those who intend to educate the public may choose to present educational information presented by local trusted sources whereas those who intend to persuade the public may choose to present the same information within the most persuasive recipient-specific ESR framework.

Second, the findings in this dissertation suggest that host communities considered for CCS projects may have different levels capital (social, cultural, economic) (Bourdieu 1983), and that those with high levels of capital may be better equipped to participate in such a way as to ensure that just procedures developed and followed. Communities that feel disempowered and were subject to past environmental harm such as those in Thornton, CA may not be an ideal place to locate a project ("Because they say right here that they are going to test, right? They are going to do it. So you do not think that regardless of what we say it is going to happen? It is going to happen" (Thornton, Chapter 2, p 30)).

Furthermore, the current DOE practice of focusing on landowners and office bearers may miss the opportunity to make the deployment of CCS more inclusive. What may result, in a community like Thornton, is what is at best mainly passive acceptance reflecting a relative deficit of social, cultural, and economic capital. While this type of acceptance may not lead to active protest against CCS, a long term project will likely benefit from a positive relationship with the host community.

## Further research

Over the period of time during which much of the research for this dissertation was conducted, it became clear that a model for evaluating the effectiveness of public engagement on carbon management technologies is needed. Little empirical work has been done to establish causal relationships between preparation (e.g., sources, framing, stakeholders, etc.) and execution (e.g., venue, facilitation, activities and tasks, timing) and outcomes (e.g. participant satisfaction and knowledge, legitimacy of resulting policy). PytlikZillig and Tomkins (2011) developed an evaluation framework that may provide a useful guide for developing more effective public engagement protocols for technologies like CCS (see figure 1). Using this framework, researchers can vary the features of the chosen participation method and then systematically evaluate the process and outcomes. Potentially this is one efficient way to develop clear links between the purpose for engagement with an energy public and the desired outcome.

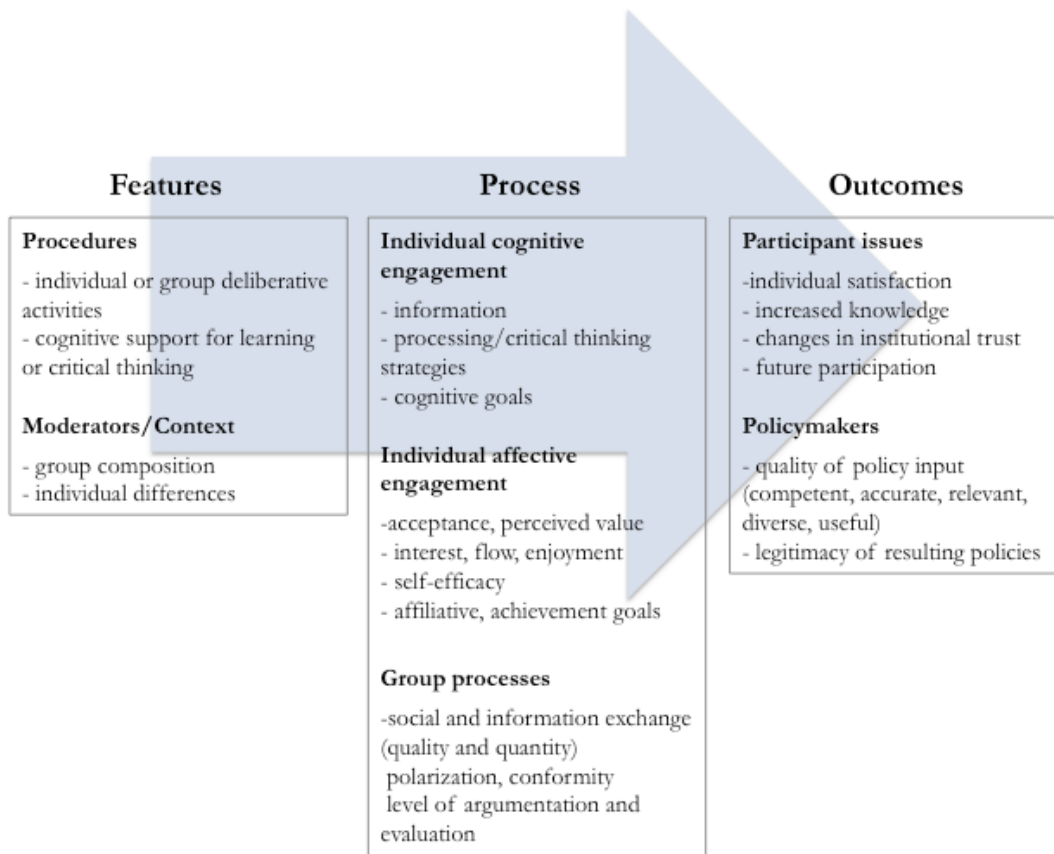


Figure 1 framework for evaluating public engagement on carbon management technologies (adapted from PytlikZillig and Tomkins (2011)).

Beyond the original intent of its designers and proponents, CCS took on a distinct meaning for the energy publics encountered in this research. For some energy publics, CCS was seen as a vehicle for enhancing status where by hosting this technology they could become “technology pioneers” (G2, Chapter 5, p 67) and “energy policy leaders” (G11, Chapter 5, p 67). For others, CCS was seen as a symbol of low-status and disempowerment, “...regardless of what we say it is going to happen...” (Thornton, Chapter 2, p 30). And still for others, it was seen as a symbol for the salvation of coal, their “bread and butter” (G1, Chapter 5, p 66), and therefore the life of their

local energy industry. For this energy public, the energy dependent public, CCS symbolized a means for achieving larger development goals where they could go from an economy that shipped out low-value raw resources such as coal to one that produced high-value refined goods such as electricity.

Future study about the symbolic meaning of carbon management technologies such as CCS, as well as the underlying reasons for the multiple meanings (e.g. land ownership), may contribute to our theoretical understanding of the political economy of climate change solutions and energy policy. Reiner and Nuttall's (2011) comparative analysis of the geologic disposal of carbon dioxide and radioactive waste presents a useful starting point from which to understand the parallel trajectories of energy policy and climate policy in the US. Investigation of what is at stake, and where, as a society, we are going and how we plan to achieve our goals can help the US be better prepared for future governance and social requirements.

## **Conclusions**

This dissertation is not intended to be a complete guide for developing an effective strategy for engagement with the energy public about CCS, rather the collection of essays presented here provide different perspectives of relevant stakeholders that may be useful for developing engagement practices. The citizen-guided social marketing method described in this dissertation supplement and complement existing techniques. The method developed in this dissertation, along with the others already in use, should be evaluated within a comprehensive public engagement framework to establish predictive links between engagement purpose and outcome.

Over past 50 years the US has undergone a societal shift from a public that trusted, and believed, in science and technology, to one that has become largely mistrustful of the intentions of scientists and frightened of the consequences of technology. At the same time, many in the scientific community are convinced that changes, indeed technological changes, must be made in the energy sector if catastrophic climate change is to be avoided. Perhaps the most lauded solution to real and potential conflicts between technology proponents and the public has been the development of public engagement processes from town hall style meetings to deliberative participation (see the National Academies report on public participation 2008). This dissertation makes an important contribution both to the practice of public engagement about CCS, and also to the theoretical understanding of perceptions of carbon management technologies that will be useful beyond the energy policy arena.



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## Appendix A.1 Climate change science timeline

Table 1 Climate change science timeline, from 1800 to today

Year	Milestone
1800-1870	<ul style="list-style-type: none"> <li>Level of carbon dioxide (CO<sub>2</sub>) in the atmosphere, as later measured in ancient ice, is about 290 ppm (parts per million)</li> <li>Mean global temperature (1850-1879) is about 13.6°C</li> <li>First Industrial Revolution – coal, railroads, and land clearing speed up greenhouse gas emissions, while better agriculture and sanitation speed up population growth</li> </ul>
1824	<ul style="list-style-type: none"> <li>Fourier calculates that the Earth would be far colder if it lacked an atmosphere</li> </ul>
1859	<ul style="list-style-type: none"> <li>Tyndall discovers that some gases block infrared radiation. He suggests that changes in the concentration of the gases could bring about climate change</li> </ul>
1896	<ul style="list-style-type: none"> <li>Arrhenius publishes first calculation of global warming from human emissions of CO<sub>2</sub></li> </ul>
1897	<ul style="list-style-type: none"> <li>Chamberlin produced a model for global carbon exchange including feedbacks</li> </ul>
1870-1910	<ul style="list-style-type: none"> <li>Second Industrial Revolution – Fertilizers and other chemicals, electricity, and public health further accelerate growth</li> </ul>
1914-1918	<ul style="list-style-type: none"> <li>World War 1 – governments learn to mobilize and control industrial societies</li> </ul>
1920-1925	<ul style="list-style-type: none"> <li>Opening of Texas and Persian Gulf oil fields inaugurates era of cheap energy</li> </ul>
1930s	<ul style="list-style-type: none"> <li>Global warming trend science late 19<sup>th</sup> century reported</li> <li>Milankovitch proposes orbital changes as the causes of ice ages</li> </ul>
1938	<ul style="list-style-type: none"> <li>Callendar argues that CO<sub>2</sub> greenhouse gas global warming is underway, reviving interest in the question</li> </ul>
1939-1945	<ul style="list-style-type: none"> <li>World War 2 – Grand strategy is largely driven by a struggle to control oil fields</li> </ul>
1945	<ul style="list-style-type: none"> <li>US Office of Naval Research begins generous funding of many fields of science, some of which happen to be useful for understanding climate change</li> </ul>
1956	<ul style="list-style-type: none"> <li>Ewing and Donn offer a feedback model for quick ice age onset</li> <li>Phillips produces a somewhat realistic computer model of the global atmosphere</li> <li>Platt calculates that adding CO<sub>2</sub> to the atmosphere will have a significant effect on the radiation balance</li> </ul>
1957	<ul style="list-style-type: none"> <li>Launch of Soviet Sputnik satellite. Cold War concerns support 1957-1958 International Geophysical Year, bringing new funding and coordination to climate studies</li> <li>Revelle finds that CO<sub>2</sub> produced by humans will not be readily absorbed by the oceans</li> </ul>
1958	<ul style="list-style-type: none"> <li>Telescope studies show a greenhouse effect raises temperature of the atmosphere of Venus far above the boiling point of water</li> </ul>
1960	<ul style="list-style-type: none"> <li>Mitchell reports downturn of global temperatures since the early 1940s</li> <li>Keeling accurately measures CO<sub>2</sub> in the Earth's atmosphere and detects an annual rise. The level is 315 ppm. Mean global temperature (5-year average) is 13.9°C</li> </ul>
1962	<ul style="list-style-type: none"> <li>Cuban Missile Crisis (peak of the Cold War)</li> </ul>
1963	<ul style="list-style-type: none"> <li>Calculations suggest that feedback with water vapor could make the climate acutely sensitive to changes in CO<sub>2</sub> level</li> </ul>
1965	<ul style="list-style-type: none"> <li>Boulder, CO meeting on causes of climate change. Lorenz and others point out the chaotic nature of climate system and the possibility of sudden shifts</li> </ul>
1966	<ul style="list-style-type: none"> <li>Emiliani's analysis of deep-sea cores shows the timing of ice ages was set by small orbital shifts, suggesting that the climate system is sensitive to small changes</li> </ul>
1967	<ul style="list-style-type: none"> <li>International Global Atmospheric Research Program established, mainly to gather data for better short-range weather prediction, but including climate</li> <li>Manabe and Wetherald make a convincing calculation that doubling CO<sub>2</sub> would raise world temperatures a couple of degrees</li> </ul>
1968	<ul style="list-style-type: none"> <li>Studies suggest a possibility of collapse of Antarctic ice sheets, which would raise sea levels catastrophically</li> </ul>
1969	<ul style="list-style-type: none"> <li>Astronauts walk on the Moon, and people first perceive the Earth as a fragile whole</li> <li>Budyko and Sellers present models of catastrophic ice-albedo feedbacks</li> <li>Nimbus III satellite begins to provide comprehensive global atmospheric temperature</li> </ul>

	measurements
1970	<ul style="list-style-type: none"> <li>• First Earth Day – Environmental movement attains strong influence, spreads concern global degradation</li> <li>• Creation of US National Oceanic and Atmospheric Administration, the world's leading funder of climate research</li> <li>• Aerosols from human activity are shown to be increasing swiftly. Bryson claims they counteract global warming and may bring serious cooling</li> </ul>
1971	<ul style="list-style-type: none"> <li>• Study of Man's Impact on Climate – conference of leading scientists reports a danger of rapid and serious global change caused by humans, calls for an organized research effort</li> <li>• Mariner 9 spacecraft finds a great dust storm warming the atmosphere of Mars, plus indications of a radically different climate in the past</li> </ul>
1972	<ul style="list-style-type: none"> <li>• Ice cores and other evidence show big climate shifts in the past between relatively stable modes in the space of a thousand years or so, especially around 11,000 years ago</li> </ul>
1973	<ul style="list-style-type: none"> <li>• Oil embargo and price rise bring first "energy crisis"</li> </ul>
1974	<ul style="list-style-type: none"> <li>• Serious droughts since 1972 increase concern about climate, with cooling from aerosols suspected to be as likely as warming; scientists are doubtful as journalists talk of a new ice age</li> </ul>
1975	<ul style="list-style-type: none"> <li>• Warnings about environmental effects of airplanes leads to investigations of trace gases in the stratosphere and discovery of danger to ozone layer</li> <li>• Manabe and collaborators produce complex but plausible computer models which show a temperature rise of several degrees for doubled CO<sub>2</sub></li> </ul>
1976	<ul style="list-style-type: none"> <li>• Studies show that CFCs (1975) and also methane and ozone (1976) can make a serious contribution to the greenhouse effect</li> <li>• Deep-sea cores show a dominating influence from 100,000-year Milankovitch orbital changes, emphasizing the role of feedbacks</li> <li>• Deforestation and other ecosystem changes are recognized as major factors in the future of the climate</li> <li>• Eddy shows that there were prolonged periods without sunspots in past centuries, corresponding to cold periods</li> </ul>
1977	<ul style="list-style-type: none"> <li>• Scientific opinion tends to converge on global warming, not cooling, as the chief climate risk in next century</li> </ul>
1978	<ul style="list-style-type: none"> <li>• Attempts to coordinate climate research in US end with an inadequate National Climate Program Act, accompanied by rapid but temporary growth in funding</li> </ul>
1979	<ul style="list-style-type: none"> <li>• Second oil "energy crisis." Strengthened environmental movement encourages renewable energy sources, inhibits nuclear energy growth</li> <li>• US National Academy of Sciences report finds it highly credible that doubling CO<sub>2</sub> will bring 1.5-4.5°C global warming</li> <li>• World Climate Research Programme launched to coordinate international research</li> </ul>
1981	<ul style="list-style-type: none"> <li>• Election of Reagan brings backlash against environmental movement to power. Political conservatism is linked to skepticism about global warming</li> <li>• IBM Personal Computer introduced. Advanced economies are increasingly delinked from energy</li> <li>• Hansen and others show that sulfate aerosols can significantly cool the climate, raising confidence in models showing future greenhouse warming</li> <li>• Some scientists predict greenhouse warming "signal" should be visible by about the year 2000</li> </ul>
1982	<ul style="list-style-type: none"> <li>• Greenland ice cores reveal drastic temperature oscillations in the space of a century in the distant past</li> <li>• Strong global warming since mid-1970s is reported, with 1981 the warmest year on record</li> </ul>
1983	<ul style="list-style-type: none"> <li>• Reports from US National Academy of Sciences and Environmental Protection Agency spark conflict, as greenhouse warming becomes prominent in mainstream politics</li> </ul>
1985	<ul style="list-style-type: none"> <li>• Ramanathan and collaborators announce that global warming may come twice as fast as expected, from rise of methane and other trace greenhouse gases</li> <li>• Villach Conference declares consensus among experts that some global warming seems inevitable, calls on governments to consider international agreements to restrict emissions</li> <li>• Antarctic ice cores show that CO<sub>2</sub> and temperature went up and down together through past ice ages, pointing to powerful biological and geochemical feedbacks</li> <li>• Broecker speculates that a reorganization of North Atlantic Ocean circulation can bring swift and</li> </ul>

	radical climate change
1987	<ul style="list-style-type: none"> <li>• Montreal Protocol of the Vienna Convention imposes international restrictions on emission of ozone-destroying gases</li> </ul>
1988	<ul style="list-style-type: none"> <li>• News media coverage of global warming leaps upward following record heat and droughts plus testimony by Hansen</li> <li>• Toronto conference calls for strict, specific limits on greenhouse gas emissions; UK Prime Minister Thatcher is first major leader to call for action</li> <li>• Ice-core and biology studies confirm living ecosystems give climate feedback by way of methane, which could accelerate global warming</li> <li>• Intergovernmental Panel on Climate Change (IPCC) is established</li> </ul>
1989	<ul style="list-style-type: none"> <li>• Fossil-fuel and other U.S. industries form Global Climate Coalition to tell politicians and the public that climate science is too uncertain to justify action</li> </ul>
1990	<ul style="list-style-type: none"> <li>• First IPCC report says world has been warming and future warming seems likely</li> </ul>
1991	<ul style="list-style-type: none"> <li>• Mt. Pinatubo explodes; Hansen predicts cooling pattern, verifying (by 1995) computer models of aerosol effects</li> <li>• Global warming skeptics claim that 20th-century temperature changes followed from solar influences. (The solar-climate correlation would fail in the following decade.)</li> <li>• Studies from 55 million years ago show possibility of eruption of methane from the seabed with enormous self-sustained warming</li> </ul>
1992	<ul style="list-style-type: none"> <li>• Conference in Rio de Janeiro produces UN Framework Convention on Climate Change, but US blocks calls for serious action</li> <li>• Study of ancient climates reveals climate sensitivity in same range as predicted independently by computer models</li> </ul>
1993	<ul style="list-style-type: none"> <li>• Greenland ice cores suggest that great climate changes (at least on a regional scale) can occur in the space of a single decade</li> </ul>
1995	<ul style="list-style-type: none"> <li>• Second IPCC report detects "signature" of human-caused greenhouse effect warming, declares that serious warming is likely in the coming century</li> <li>• Reports of the breaking up of Antarctic ice shelves and other signs of actual current warming in polar regions begin affecting public opinion</li> </ul>
1997	<ul style="list-style-type: none"> <li>• Toyota introduces Prius in Japan, first mass-market electric hybrid car; swift progress in large wind turbines and other energy alternatives</li> <li>• International conference produces Kyoto Protocol, setting targets to reduce greenhouse gas emissions if enough nations sign onto a treaty</li> </ul>
1998	<ul style="list-style-type: none"> <li>• "Super El Niño" causes weather disasters and warmest year on record (approximately matched by 2005 and 2007). Borehole data confirm extraordinary warming trend</li> <li>• Qualms about arbitrariness in computer models diminish as teams model ice-age climate and dispense with special adjustments to reproduce current climate</li> </ul>
1999	<ul style="list-style-type: none"> <li>• Criticism that satellite measurements show no warming are dismissed by National Academy Panel</li> <li>• Ramanathan detects massive "brown cloud" of aerosols from South Asia</li> </ul>
2000	<ul style="list-style-type: none"> <li>• Global Climate Coalition dissolves as many corporations grapple with threat of warming, but oil lobby convinces US administration to deny problem</li> <li>• Variety of studies emphasize variability and importance of biological feedbacks in carbon cycle, liable to accelerate warming</li> </ul>
2001	<ul style="list-style-type: none"> <li>• Third IPCC report states baldly that global warming, unprecedented since end of last ice age, is "very likely," with possible severe surprises. Effective end of debate among all but a few scientists</li> <li>• Bonn meeting, with participation of most countries but not US, develops mechanisms for working towards Kyoto targets</li> <li>• National Academy panel sees a "paradigm shift" in scientific recognition of the risk of abrupt climate change (decade-scale)</li> <li>• Warming observed in ocean basins; match with computer models gives a clear signature of greenhouse effect warming</li> </ul>
2002	<ul style="list-style-type: none"> <li>• Studies find surprisingly strong "global dimming," due to pollution, has retarded arrival of greenhouse warming, but dimming is now decreasing</li> </ul>
2003	<ul style="list-style-type: none"> <li>• Numerous observations raise concern that collapse of ice sheets (West Antarctica, Greenland) can raise sea levels faster than most had believed</li> <li>• Deadly summer heat wave in Europe accelerates divergence between European and US public</li> </ul>

	opinion
2004	<ul style="list-style-type: none"> <li>• In controversy over temperature data covering past millenium, most conclude climate variations were not comparable to the post-1980 warming</li> <li>• First major books, movie and art work featuring global warming appear</li> </ul>
2005	<ul style="list-style-type: none"> <li>• Kyoto treaty goes into effect, signed by major industrial nations except US. Work to retard emissions accelerates in Japan, Western Europe, US regional governments and corporations</li> <li>• Hurricane Katrina and other major tropical storms spur debate over impact of global warming on storm intensity</li> </ul>
2007	<ul style="list-style-type: none"> <li>• Fourth IPCC report warns that serious effects of warming have become evident; cost of reducing emissions would be far less than the damage they will cause</li> <li>• Greenland and Antarctic ice sheets and Arctic Ocean sea-ice cover found to be shrinking faster than expected</li> </ul>
2009	<ul style="list-style-type: none"> <li>• Many experts warn that global warming is arriving at a faster and more dangerous pace than anticipated just a few years earlier</li> <li>• Level of CO<sub>2</sub> in the atmosphere reaches 385 ppm</li> <li>• Mean global temperature (five-year average) is 14.5°C, the warmest in hundreds, perhaps thousands of years</li> </ul>

(source: Weart 2008)



## Appendix A.2 Greenhouse gas mitigation technologies timeline

Table 1 Greenhouse gas mitigation technologies timeline

Year	Milestone
1920s -	<ul style="list-style-type: none"> <li>• Many studies from the petrochemical and ammonia industry for the removal and recovery of CO<sub>2</sub></li> </ul>
Early 1960s	<ul style="list-style-type: none"> <li>• Meyer Steinberger and colleagues at Brookhaven National Laboratory researching ways to produce hydrogen at low cost. With hydrogen, one could reduce CO<sub>2</sub> to CO and again to have the building blocks of all basic organic chemistry. The group looked to combustion of fossil fuels as a source of CO<sub>2</sub>. Led to the possibility of removing and concentrating CO<sub>2</sub> from the atmosphere. Even investigated extracting CO<sub>2</sub> from the ocean to produce fuels using nuclear power ships at sea.</li> </ul>
Early 1970s	<ul style="list-style-type: none"> <li>• Fred Baes (at Oak Ridge National Laboratory) compiled statistics on fossil combustion and correlating that with measured atmospheric CO<sub>2</sub>.</li> <li>• Baes suggested pumping liquid CO<sub>2</sub> deep into the ocean where, because of its increasing density, the CO<sub>2</sub> would sink into the bottom of the ocean and remain there for a long period of time.</li> </ul>
1976	<ul style="list-style-type: none"> <li>• Cesare Marchetti of the International Energy Agency publishes 'On Geoengineering and the CO<sub>2</sub> problem,' where he proposes injecting CO<sub>2</sub> into the Atlantic Ocean off the straits of Gibraltar.</li> </ul>
1970s to early 1980s	<ul style="list-style-type: none"> <li>• Carbon Dioxide Research Division in the Office of Energy Research at DOE organized under Fred Koomanoff funneled resources to perform studies: (1) the removal, recovery and disposal of CO<sub>2</sub> into the ocean, (2) CO<sub>2</sub> disposal in depleted oil, coal, gas wells and (3) CO<sub>2</sub> disposal in solution mined salt domes, (4) the effect of improved energy efficiency and conservation on CO<sub>2</sub> emissions, (5) the effect of fuel substitution on CO<sub>2</sub> emissions, and (6) using oxy-fuel burning of fossil fuel with recycled CO<sub>2</sub> for recovery of CO<sub>2</sub> from power plants.</li> </ul>
	<ul style="list-style-type: none"> <li>• Arrhenius publishes first calculation of global warming from human emissions of CO<sub>2</sub></li> </ul>

### Appendix A.3 Commercial uses for carbon dioxide

Table 1 Commercial uses for carbon dioxide

Industry	Application
Multi	<ul style="list-style-type: none"> <li>• Refrigeration and cooling</li> <li>• Inert gas in chemical processes</li> <li>• Storage of carbon powder and in fire extinguishers</li> </ul>
Metals	<ul style="list-style-type: none"> <li>• Manufacture of casting molds to enhance their hardness</li> </ul>
Manufacturing and construction	<ul style="list-style-type: none"> <li>• Shield gas in MIG/MAG welding (gas protects the weld puddle against oxidation by the surrounding air)</li> <li>• Dry ice pellets to replace sandblasting when removing paint from surfaces</li> </ul>
Chemicals, pharmaceuticals and petroleum	<ul style="list-style-type: none"> <li>• Raw material in the chemical processes industry, especially for methanol and urea production</li> <li>• Enhanced oil extraction and oil well pressure maintenance. When CO<sub>2</sub> is pumped into an oil well, it is partially dissolved into the oil, rendering it less viscous and allows the oil to be extracted more easily</li> </ul>
Rubber and plastics	<ul style="list-style-type: none"> <li>• Flash removed from rubber objects by tumbling them with crushed dry ice in a rotating drum</li> </ul>
Food and beverages	<ul style="list-style-type: none"> <li>• Quick freezing, surface freezing, chilling and refrigeration in the transport of foods.</li> <li>• Carbonate soft drinks, beers, and wines; prevent fungal and bacterial growth</li> <li>• Solvent for organic compounds (e.g., de-caffeinate coffee)</li> <li>• Used as an inert blanket, product-dispensing propellant, and extraction agent; used to displace air during canning</li> <li>• Supercritical CO<sub>2</sub> extraction coupled with fractional separation technique is used by producers of flavors and fragrances to separate and purify volatile flavor and fragrances concentrates</li> <li>• Cold sterilization</li> </ul>
Health care	<ul style="list-style-type: none"> <li>• Additive to oxygen as a respiration stimulant</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>• Propellant in aerosol cans</li> <li>• Replaces sandblasting</li> <li>• Neutralize alkaline water</li> </ul>
Cleaning service	<ul style="list-style-type: none"> <li>• Substitute for conventional solvents in dry cleaning</li> </ul>
Agriculture	<ul style="list-style-type: none"> <li>• Greenhouses to enhance yields</li> </ul>

## Appendix A.4 Carbon capture and sequestration technology

Today, carbon capture and sequestration means a technology where CO<sub>2</sub> emissions are captured from stationary sources of emissions, e.g. coal-fired power plants or cement manufacturing plants, and put deep underground. Since a pure stream of CO<sub>2</sub> is needed<sup>56</sup>, commercial CCS projects are likely to be constructed in conjunction with the construction of new coal-fired power plants. The CO<sub>2</sub> would then be pumped via a CO<sub>2</sub> pipeline infrastructure, and injected permanently into one of three types of geologic reservoirs (see Figure 2): unminable coal seam, depleted oil and gas fields, and/or deep saline aquifers.

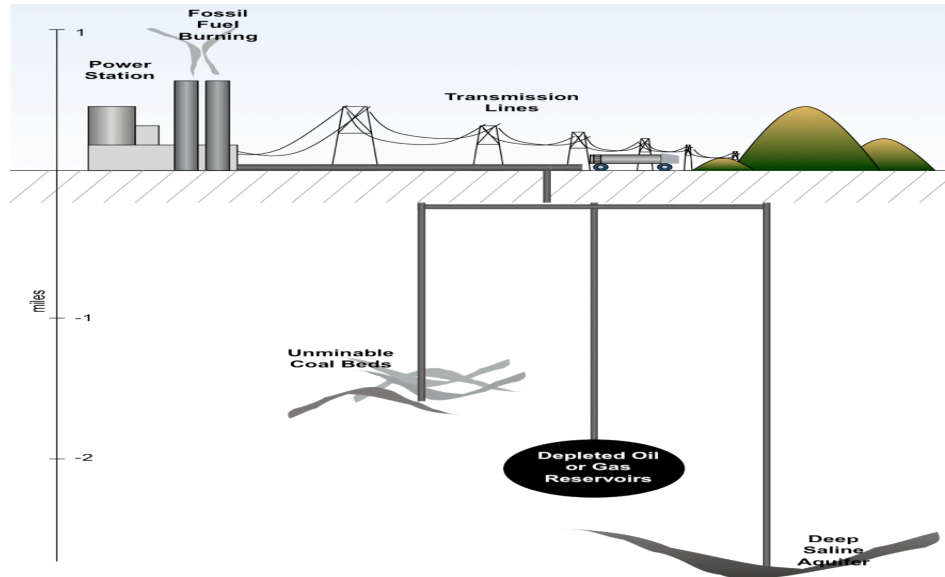


Figure 1 shows carbon capture and sequestration where CO<sub>2</sub> emissions are captured from a fossil fuel burning power plant, transmitted via a CO<sub>2</sub> pipeline and injected permanently several miles below the surface of the earth

### Capture technologies

*Flue gas separation.* Practiced at 12 facilities, this technology involves chemical absorption where gas is absorbed in a liquid solvent. The most common absorbant is monoethanolamine (MEA). With this technology, the flue gas is bubbled through the solvent in a packed absorber column where the solvent preferentially removes the CO<sub>2</sub> from the flue gas. The absorbed CO<sub>2</sub> is stripped from the solvent by a counter-flowing stream, then the water vapor is condensed leaving behind a highly concentrated (99% pure) stream of CO<sub>2</sub>. This stream can be compressed for commercial use or for disposal.

<sup>56</sup> Concentration of CO<sub>2</sub> in the flue gas of a natural gas power plant is 3-5% and 13-15% at a coal-fired power plant.

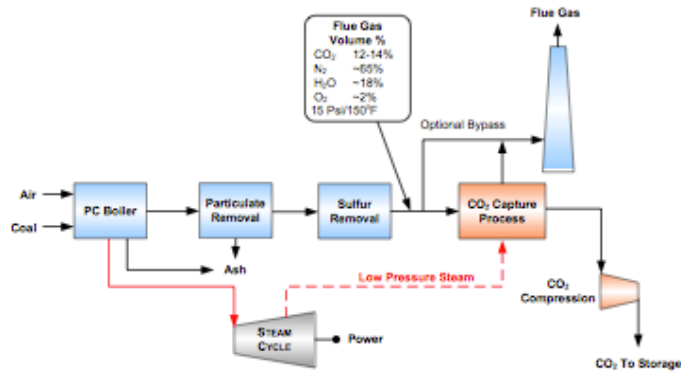


Figure 2 shows post-combustion CO<sub>2</sub> capture from a pulverized coal plant

*Oxyfuel combustion.* For this technology, fossil fuel is burned in an enriched oxygen environment where the flue gas contains mostly CO<sub>2</sub> and H<sub>2</sub>O. The separation process is shifted to the intake air where the oxygen is separated from the nitrogen. This step involves the consumption of up to 15% of a power plant’s electric output, requiring a commensurate increase of fossil fuel to achieve the rated electric output of the plant. This method can be used to retrofit existing pulverized coal plants.

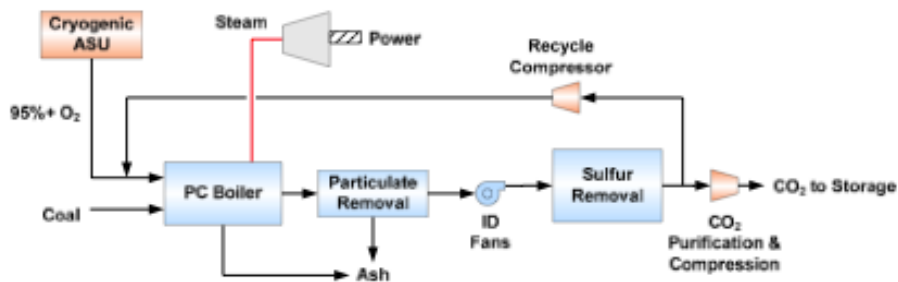


Figure 3 shows oxy-combustion CO<sub>2</sub> capture at a pulverized coal plant

*Precombustion separation.* This process involves the gasification of coal to produce a synthesis gas comprised of CO and H<sub>2</sub>, which reacts the CO<sub>2</sub> with H<sub>2</sub>O (water-gas shift reduction) to produce CO<sub>2</sub> and H<sub>2</sub>. The CO<sub>2</sub> is then captured, and the H<sub>2</sub> is sent to a turbine to produce electricity (this is an integrated combined cycle power plant).

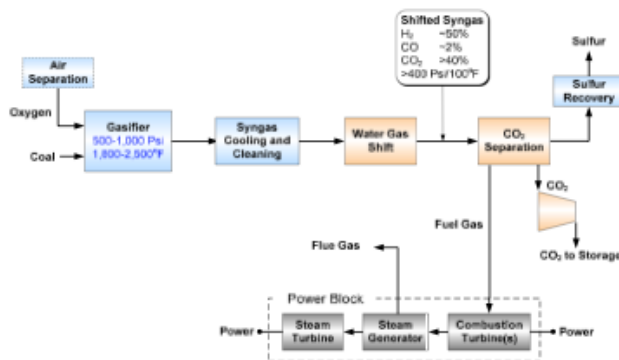


Figure 4 shows precombustion capture at an integrated gasification combined cycle power plant

## Transportation

The design considerations for a CO<sub>2</sub> pipeline are very similar to those of natural gas and hazardous liquid pipeline. For example, the operating pressure and temperature, protection outdoor and underground environments, and the development of a control room management system. One major threat to the integrity of a CO<sub>2</sub> system is the generation of carbon acid from the ambient moisture in a pipeline system. Pipeline operators must follow specific requirements outlined by the Department of Transportation Pipeline and Hazardous Materials Safety Administration's Hazardous Liquid Safety Regulations.

There is already a pipeline network in place in the United States (see figure 6), where commercial CO<sub>2</sub> is transported for enhanced oil/gas recovery and for other commercial purposes (see table x in the appendix).

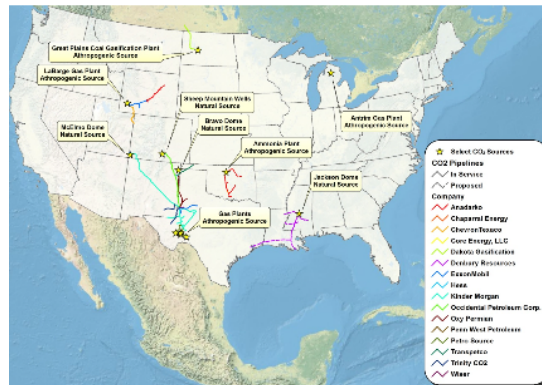
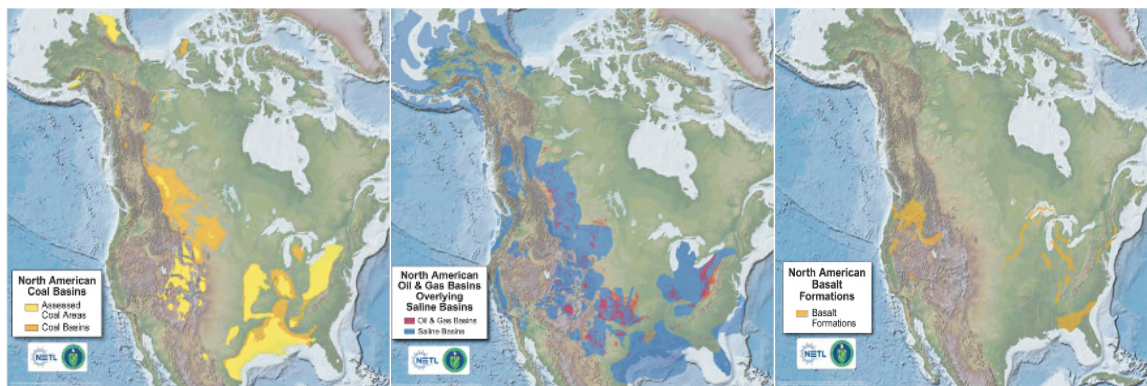


Figure 6 shows existing and planned CO<sub>2</sub> pipeline infrastructure in the United States

## Sequestration technologies

After the CO<sub>2</sub> is compressed into a liquid form, it will be transported via pipeline to a geologic reservoir for permanent storage. Figure 7 shows the three types of reservoirs under consideration: un-minable coal beds, depleted oil or gas reservoirs, and deep saline aquifers. The storage period is on the time scale of 100s to 1000s of years.



Once the CO<sub>2</sub> is injected into the reservoir, either as a supercritical liquid or in gas form, the CO<sub>2</sub> is captured through a combination of the structure of the geologic formation and capillary forces that

hold the CO<sub>2</sub> in place. Over time, the CO<sub>2</sub> reacts with its surrounding environment and precipitates into solid.

### Costs

Of the whole process, the capture of CO<sub>2</sub> is by far the most expensive component – representing between 70% and 90% of the total estimated cost. For example, the capturing and sequestering of 90% of the CO<sub>2</sub> from an average pulverized coal plant would result in an additional \$.02/kWh to cost of electricity (see table A.3 in the appendix for a full breakdown by capture technology and power plant type). The transportation of CO<sub>2</sub> via pipeline begin to make economic sense when more than 10 million MT of CO<sub>2</sub> are transported annually (equivalent to about a 1500 MW coal-fired power plant). This would result in a cost of about \$.50/100 km. This option is much less expensive than transporting CO<sub>2</sub> by truck, which would cost about \$6/100 km. The injection and permanent storage of CO<sub>2</sub> would cost between \$3 and \$55 per tons of C. The estimated cost will be less if this is done in combination with enhanced oil recovery, however the cost savings will depend on market conditions.

## Appendix A.5 US CCS projects

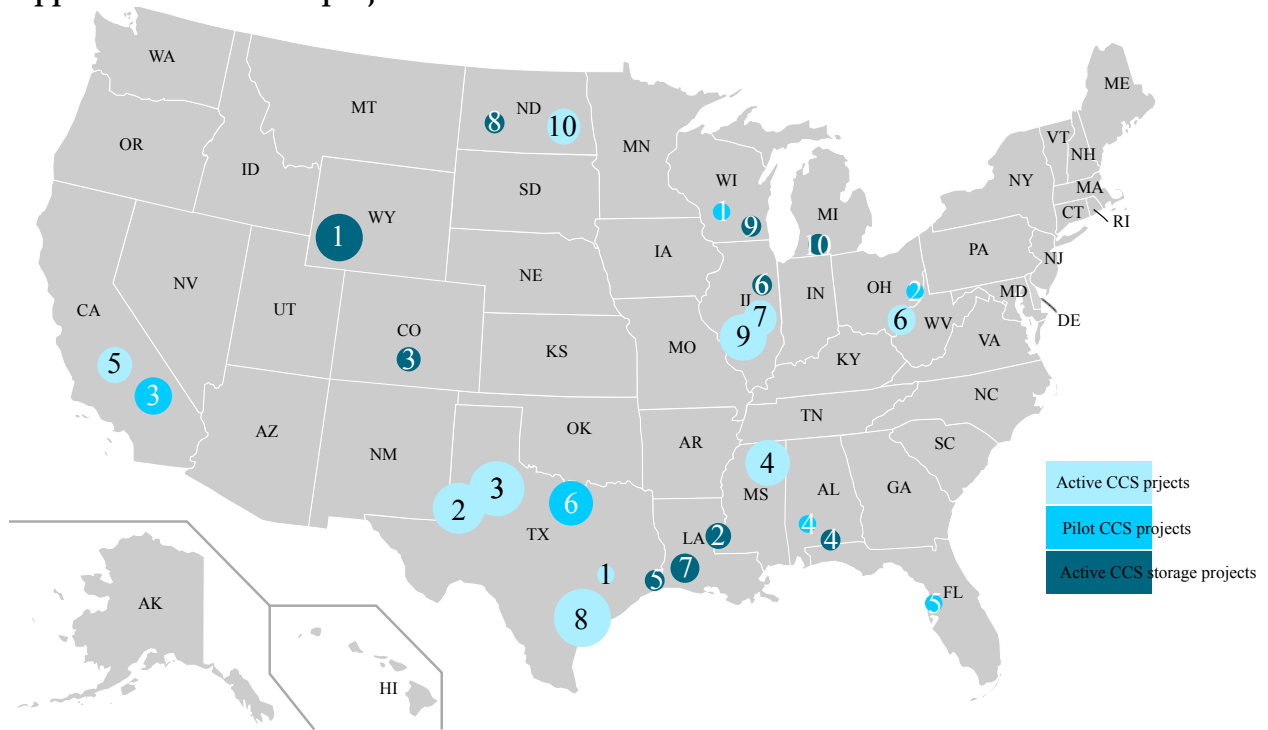


Figure 1 shows active CCS projects, pilot CCS projects and active CCS storage projects. The size of the bubble on the map corresponds to the amount of CO<sub>2</sub> that will be sequestered in total, or annually. Details about the projects are shown in Table 1 (see below), which can be matched to the numbers on the map.

Table 1 Active and pilot CCS projects in the US

#	Project	Leader	State	Feed	CO <sub>2</sub> source	MW	Size MT/Yr	Capt. Proc.	CO <sub>2</sub> fate	Start
<i>Active CCS projects</i>										
1	WA Parish	NRG En.	TX	coal		60		post	EOR	2013
2	TCEP	Summit	TX	coal		400		pre	EOR	2014
3	Trailblazer	Tenaska	TX	coal		600		post	EOR	2014
4	Kemper Co	Southern	MS	coal		582		pre	EOR	2014
5	HECA	HEI	CA	pet coke		390		post	EOR	2014
6	AEP Mtn.	AEP	WV	coal		235		post	saline	2016
7	FutureGen	FutureGen	IL	coal		200		oxy	saline	TBD
8	Sweeny G.	Conoco- Phillips	TX	coal		680		pre	saline/ EOR	TBD
9	Taylorville	Tenaska	IL	coal		602		pre	saline	TBD
10	Antelope V	Basin Elec.	ND	coal		120		post	EOR	on hold
<i>Pilot CCS projects</i>										
1	Pleasant Prairie	Alstom	WI	Coal		5		post	vented	2008
2	ECO2 Berger	1 <sup>st</sup> Energy/ Powerspan	OH	Coal		1		post	vented	2008
3	Kimberlina	WEST- CARB	CA	Coal		50		oxy	saline	2011
4	Plant Barry	SECARB	AL	Coal		25-160		post	EOR	2011
5	Big Bend	Ruskin FL	FL	Coal		1		post	vented	2014
6	Zeng Worsham- Steed	Falcon	TX	NG		70		oxy	EOR	TBD
<i>Active CCS storage projects</i>										
1	LaBarge	ExMo.	WY		gas proc.		6		EOR	2008
2	Entrada	SWP	CO		gas proc.		1.1		saline	2008
3	Cranfield	SECARB	MS		gas proc.		1.5		EOR	2009
4	Citronelle	SECARB	AL		carbon capture		.25		saline	2011
5	Port Arthur	Air Products	TX		steam-methane		1		EOR	2012
6	Decatur	MGSC	IL		ethanol prod.		1		saline	2012
7	Leucadia	Leucadia	LA		methanol prod.		4.5		EOR	2014
8	Williston	PCOR	ND		methanol prod.		.5		EOR	2014
9	Riley Ridge	Big Sky	WI		gas proc.		.5		saline	2015
10	Otsego Co.	MRCSP	MI		gas proc.		TBD		saline	TBD



## Appendix A.6 Picture of US coal

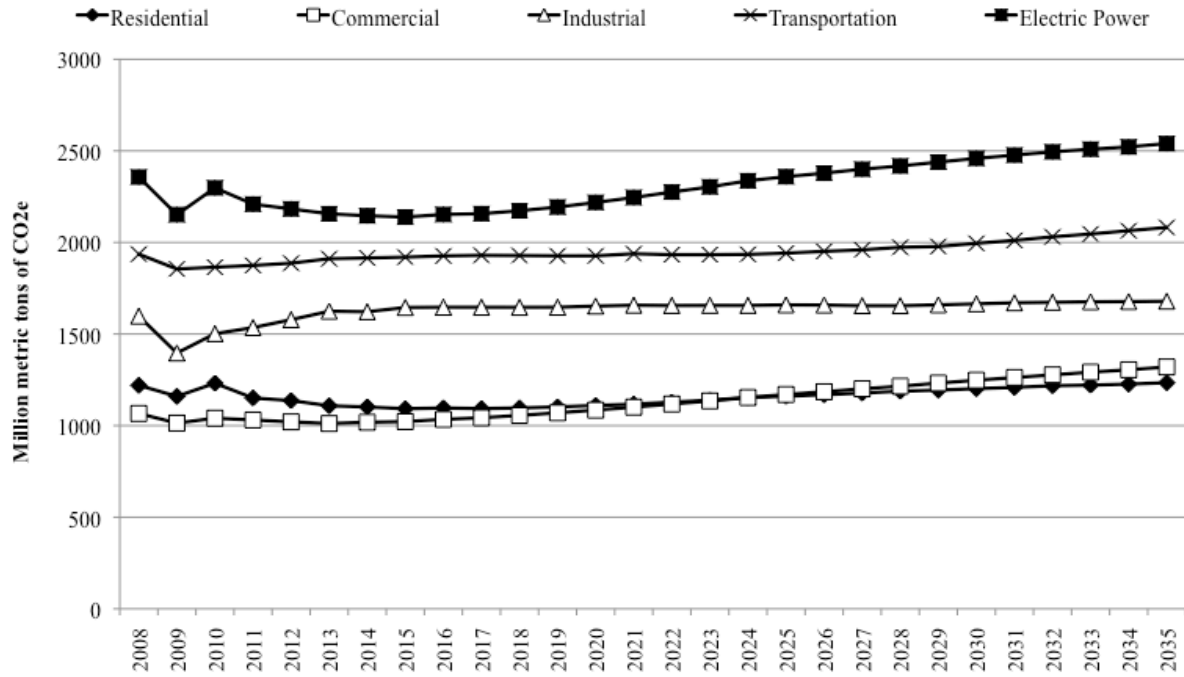


Figure 1 shows projected CO<sub>2e</sub> emissions by sector from 2010 to 2035. The largest source of emissions throughout this period will be from the electric power sector.

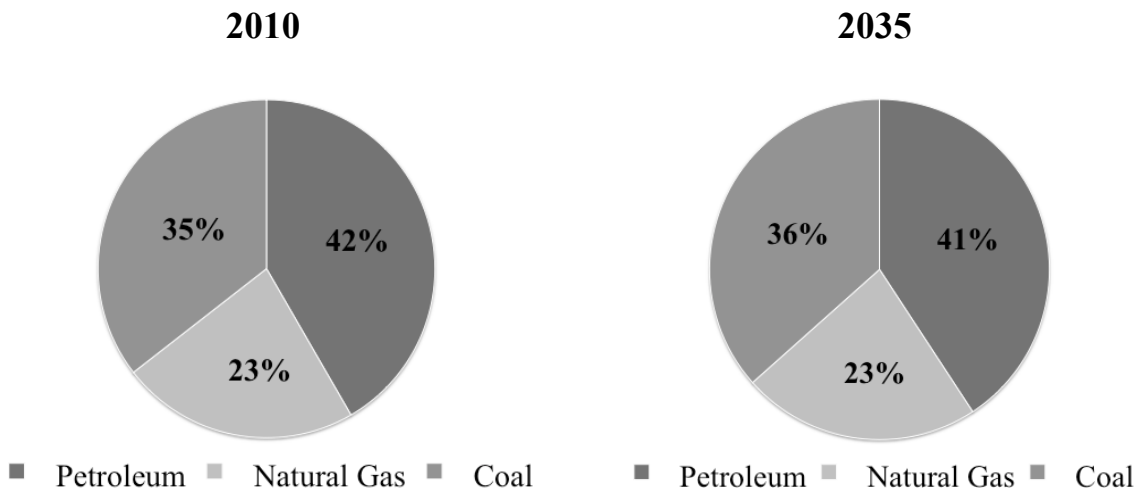


Figure 2 shows CO<sub>2e</sub> emissions by fuel source in 2010, and in 2035. The contribution to emissions from each fuel source remains stable.

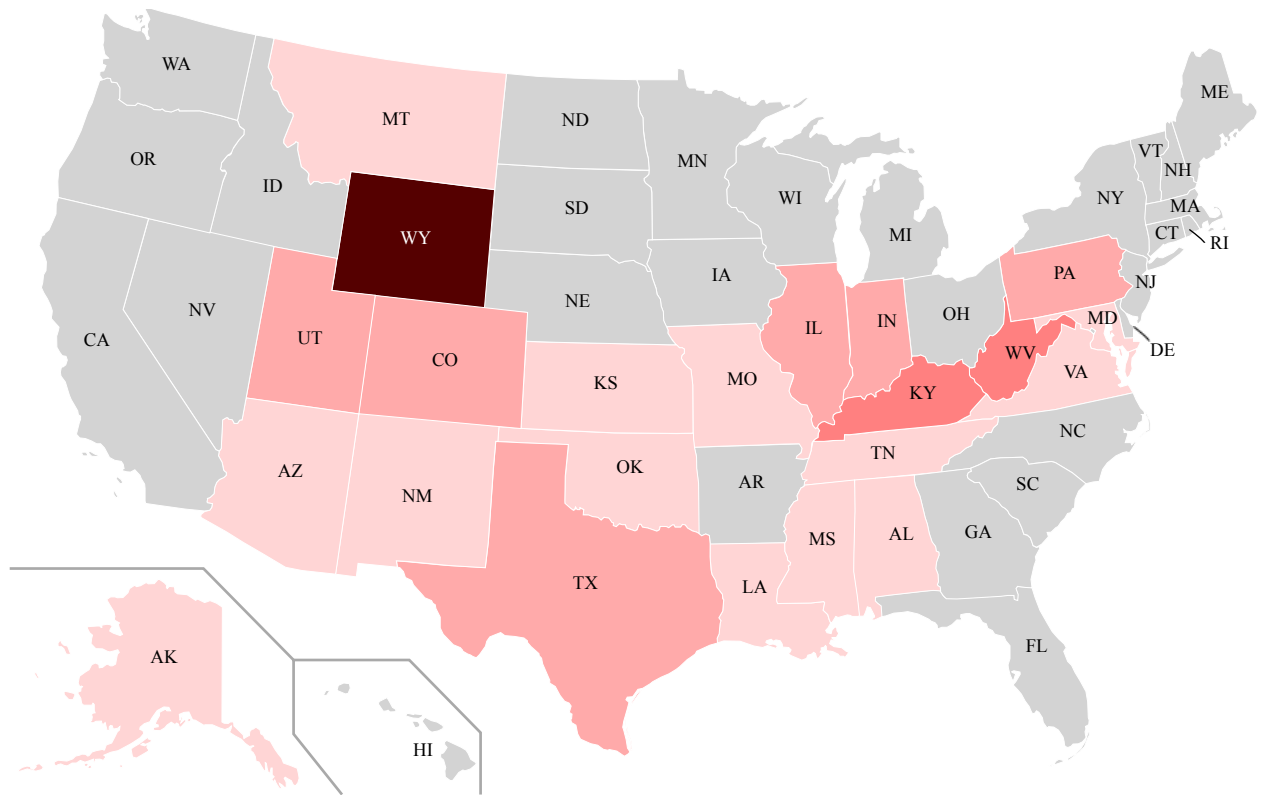


Figure 3 shows the places in the US. The figure shows that between 45% and 50% of all recoverable coal reserves are located in Wyoming.

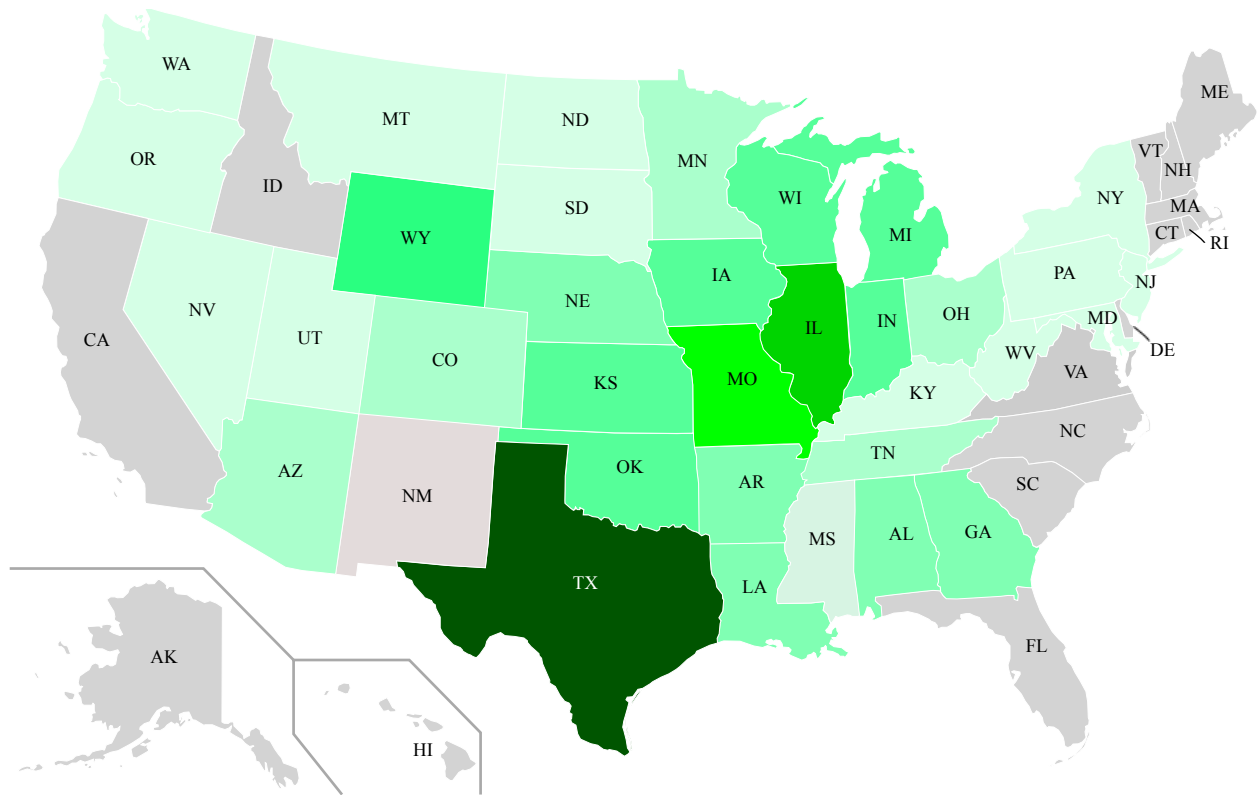


Figure 4 shows where domestic shipments of coal end up. This figure shows that between 16% and 18% of domestic shipments go to Texas.

## A.7 Theories of risk

### *Risk perspectives*

- Extremes in risk perspectives (2) (Renn) → risk is both (risk is both a normative and descriptive concept):
  - Risk is seen as an objective property
  - Risk is seen as a cultural or social construction
- Classification of risk perspectives: [assessments] 1) actuarial approach (insurance); 2) toxicology/epidemiology (health/environmental protection), 3) probabilistic risk analysis (safety engineering); 4) economics of risk; [political legitimation] → [policy making and regulations, conflict resolution (mediation), risk communication] 5) psychology of risk, 6) social theories of risk, 7) cultural theory of risk → All have one element in common: the distinction between reality and possibility
  - Technical Risk Analysis – the narrowness of this approach is strength and weakness: universal – physical harm may be the only consequence that (almost) all social groups and culture agree is undesirable
    - Actuarial (relative frequency of an event averaged over time); toxicology/epidemiology (causal relationships modeled); probabilistic → normative implication: physical harm is perceived as being an undesirable effect, tech risk analysis can be used to reveal, avoid, or modify the causes that lead to these unwanted effects
    - Criticisms: 1) undesirable effects depends on values and preferences; 2) interactions between human activities and consequences are more complex than can be modeled; 3) institutional structure of managing and controlling risks is prone to org failures and deficits; 4) numerical combo of magnitude and prob assumes equal weight
      - Move away from deterministic to probabilistic risk assessment → acknowledgement that major accident could happen
      - Major weakness – calculating the probability for various accidents next to impossible because of the complexity of the system. Rasmussen report (nuclear power might be safe, but few believed that the report actually proved this) – 3 Mile Island reshaped thinking on risk
        - The biggest accidents could be triggered by the smallest things
      - Sociotechnical systems are powerful and complex (how can we know if a system has flaws if we only know how the components work?) (Pool) → assessing and minimizing risk is very hard
  - Economic Risk Analysis – utility is universal and one-dimensional; strengths – 1) techniques and instruments to measure and compare utility losses or gains from diff decision options; 2) broader def of undesirable effects; 3) under assumption that market prices represent social utilities, provides techniques to measure distinctly different types of benefits and risks with the same unit; 4) includes a model for rational decision-making
    - Based on probabilities, a social definition of undesirable effects based on individual utilities, and the treatment of these effects as real gains or losses
    - Criticisms: 1) how to measure the welfare of society; 2) social costs or external effects; 3) rational actor paradigm (softer version – assumes people have subjective motives for performing an action and they try to assess consequences of their actions in the light of these motives) and the reliance on utilitarian ethics

- Psychological Perspectives on Risk – strength/weakness: includes all undesirable effects that people associate with a specific cause; the broadness of the dimensions that people use to make judgments and the reliance on intuitive heuristics and anecdotal knowledge make it hard, if not impossible, to aggregate individual preferences and find a common denominator. They fail to explain why individuals select certain characteristics and ignore others.
  - Focuses on personal preferences for probabilities and attempts to explain why individuals do not base their risk judgments on expected values; perception of probabilities in decision making identified several biases in people’s ability to draw inferences from probabilistic information; importance of contextual variables for shaping individual risk estimations and evaluations: a) the expected number of fatalities, 2) the catastrophic potential, 3) qualitative risk characteristics, and 4) beliefs associated with the cause of risk
  - What can risk perceptions studies do?
    - Reveal public concerns and values; serve as indicators for public preferences; document desired lifestyles; help to design risk communication strategies; represent personal experiences in ways that may not be possible in the scientific assessment of risk
- Sociological Perspectives on Risk – not really a cohesive field – sociological perspective include undesirable events that are socially defined and (in some cases) socially constructed
  - Major sociological perspectives on risk can be seen as occupying two dimensions – a) individualistic and structural indicate the base unit of analysis (it is the individual or a social aggregate such as an institution, a social group, a subculture, or a society) and b) objective and constructivist (the objective concept implies that risks and their manifestation are real, observable events, the constructivist concept claims that risks and their manifestations are social artifacts fabricated by social groups or institutions):
    - Rational actor concept – social actions seen as a result of deliberate intentions by individual or social actors to promote their interests
    - Social mobilization theory – under what circumstances are individuals motivate to take actions, and what are the structural conditions necessary for social groups to succeed
    - Organizational theory – the routinization of tasks and the diffusion of responsibility
    - Systems theory – risks as an element of a larger social or institutional unit
    - Neo-Marxist and critical theory – focus is on the normative aspect of emancipation rather than explanation of risk experience or policies for risk reduction
    - Social constructionist concepts – risk as social constructs that are determined by structural forces in society
    - All share a common interest in explaining or predicting the experience of social injustice and unfairness in relation to distributional inequities
  - Criticisms: 1) necessity to reduce the complexity opens the door for subjective selection and ideological reasoning, 2) outcome is of a sociological analysis is at least partially determined by the theoretical concept on which the analysis was based, 3) offers empirical proof for almost any perspective

- Cultural Perspective on Risk – social responses to risks are determined by prototypes of cultural belief patterns, that is, clusters of related convictions and perceptions of reality.
  - Number and type of cultural patterns are not consistent in the literature: center and periphery (Douglas and Wildavsky); Ryner four prototypes; Thompson five. The types differ in the degree of group cohesiveness (the extent to which individuals take on a group mind-set and find identity in a social group) and the degree of grid (the extent to which someone accepts and respects a formal system of hierarchy and procedural rules) → atomized individuals (life is a lottery); bureaucrats (risks are acceptable as long as institutions can control them); the hermit (risks are acceptable as long as they do not involve the coercion of others); entrepreneur (risks offer opportunities); and egalitarian (risks should be avoided unless they are inevitable to protect the public good)
  - Criticisms: 1) groups are mixtures of prototypes; 2) cultural prototype and organizational interest is unclear and problematic; 3) the selection of the five prototypes as the only relevant cultural patterns in modern society needs more evidence than the reference to tribal organizations; 4) not provided sufficient empirical evidence of its validity
  - Should be seen as a hypothesis rather than an explanation → It can offer additional evidence for the importance of cultural factors in risk perceptions and risk policies.

*Appendix B*

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## Appendix B.1 Interview instrument

Hi, my name is [NAME] from UC Berkeley's Energy and Resources Group. Thank you for taking time to meet with me today. This interview should take no more than about 45 minutes. All of the information discussed today will remain confidential. I will combine information from all the interviews to prepare a report that reflects what I have found, but I will not be identifying individuals by name and will not attribute any statements or information to any person. Do you have any questions before I begin? Would it be Ok if I recorded this interview?

Goal of this inquiry: perceptions of carbon sequestration as a climate change mitigation measure within environmental NGOs

### Question 1 (introductions)

Describe a normal day at work for me

- How would you describe the work that you do?
- How would you describe the work that your organization does?
- What other types of activities do you perform?
- Is there anything else that you would like to tell me about your work?

### Question 2 (CCS)

What are your thoughts on CCS as a climate change mitigation strategy?

- How does CCS compare to other mitigation strategies?
- What costs do you think CCS might impose and on whom?
- What risks do you have in mind with this technology?
- Whom might this technology benefit?
- If above question not addressed: why do you think that CCS is being studied/pursued by DOE?

### Question 3 (public debate)

If there is a public debate on CCS, where is it happening? Who is involved? In what forum?

- If there is no public debate, what do you think the response to CCS will be?
- Compared to other possible mitigation strategies, what aspects of CCS is the public most likely to be concerned with?

### Question 4 (outreach)

How will you reach out to the public on CCS?

- What strategies have you employed in the past for similar environmental problems such as stratospheric ozone?
- In hindsight, what do you think were strengths and weaknesses of approaches taken?
- Do you plan to reach out to the public on CCS?
  - If yes, how do you plan to reach out to the public on this topic?
  - If no, do you think that there should be outreach by your organization or other non governmental organizations?



Those are all of the questions that I have for now. Do you have any questions? I appreciate your time and input. If I have any additional questions, would it be alright to contact you? If you have any questions or would like further information on this study, here is my contact information.

## Appendix B.2 Email introduction

Dear [NAME],

My name is Gabrielle Wong-Parodi. I am a graduate student at UC Berkeley's Energy and Resources Group. I am carrying out my Masters research on the prevailing perceptions of carbon sequestration within non-governmental organizations. I will be conducting this study from this Fall through August 2007. I would like to interview you for the purpose of gaining a more detailed understanding of NGO perceptions of this climate change mitigation strategy. The interview should take about 45 minutes, and will be used for research purposes only.

If you are willing and able to be interviewed (for approximately 45 minutes); I would greatly appreciate an email response from you and I will then call you in a few days to set up an interview at a time and place of your choosing or some other location we can both agree on.

Sincerely,

Gabrielle Wong-Parodi

Energy and Resources Group

University of California, Berkeley

(510) 486-4419

[gwongpar@berkeley.edu](mailto:gwongpar@berkeley.edu)

## Appendix B.3 Data analysis

Table 1 shows the answers given for typology 1

		Typology 1			
	<i>Geologic Sequestration</i>	<i>Positive &amp; Necessary</i>	<i>Neutral &amp; Necessary</i>	<i>Negative &amp; Necessary</i>	<i>Negative &amp; Not Necessary</i>
CCS?	<i>Positive</i> <i>Neutral</i> <i>Negative</i>	x	x	x	x
Necessary?	<i>Yes</i> <i>No</i>	x	x	x	x
If yes, justification	<i>Coal (national)</i> <i>Coal (international)</i>	x	x	x	x
If yes, qualification	<i>Low Opportunity Cost</i> <i>Part of broader mix</i> <i>Time Now</i> <i>Max other tech first</i>	x	x	x	
Views on CCS	<i>Status Quo</i> <i>Distraction</i>			x	x
Economic/Financial	<i>Regulatory uncertainty</i> <i>Cost</i>			x	x
Feasibility	<i>Permanence</i> <i>Works (general)</i> <i>Infrastructure</i> <i>Monitoring</i>	x	x	x	x
What	<i>Technical</i>			x	x
International Need	<i>International Need</i>			x	
Who should pay?	<i>Federal Tax</i> <i>Industry (utility, oil, coal, gas)</i>		x	x	x
Who will pay	<i>Rate-payer</i> <i>United States</i>	x		x	
Market	<i>Cap and Trade No</i> <i>Cap</i>				x
Regulation	<i>Federal</i>	x			
Industry Supportive	<i>Financial Pay-off</i>	x		x	x
Public Perspective (now)	<i>Does not know</i>	x		x	
Public Perspective (future)	<i>Worried/Skeptical</i>	x		x	
Public Concerns	<i>Power-plant pollution</i> <i>Create incentives for coal</i> <i>Safety</i> <i>Health</i>	x	x	x	x
Should there be CCS Education?	<i>Yes</i>	x	x	x	x
Will Educate?	<i>Yes</i>	x			
Who should educate?	<i>NGOs</i>	x	x		x
Who to educate?	<i>Policymakers</i> <i>Public</i>	x		x	x
How to educate? Strategies	<i>Public reports</i> <i>Press</i>			x	x
Current	<i>Global Warming</i> <i>Pollution</i> <i>Equity</i> <i>Other</i>	x	x	x	x
Past	<i>Pollution</i> <i>Other</i>	x	x		
Focus	<i>Policymakers</i> <i>Members</i>	x	x	x	x

Note: inclusion criteria is 50% or more responses for each category

Table 2 shows the answers given for typology 2: California and US (positive, neutral, negative)

Typology 2

	<i>Geologic Sequestration</i>	<i>CA pos</i>	<i>CA neu</i>	<i>CA neg</i>	<i>US pos</i>	<i>US neu</i>	<i>US neg</i>
CCS?	<i>Positive</i>	x			x		
	<i>Neutral</i>		x			x	
	<i>Negative</i>			x			x
Necessary?	<i>Yes</i>	x	x	x	x	x	x
	<i>No</i>						
If yes, justification	<i>Coal (national)</i>	x			x	x	x
	<i>Coal (international)</i>	x			x	x	x
If yes, qualification	<i>Low Opportunity Cost</i>	x				x	
	<i>Part of broader mix</i>		x	x			
	<i>Time Now</i>		x	x			x
	<i>Max other tech first</i>	x	x	x	x	x	x
Views on CCS	<i>Status Quo</i>	x			x		
	<i>Distraction</i>		x				x
Economic/Financial	<i>Regulatory uncertainty</i>					x	x
	<i>Cost</i>			x			x
Feasibility	<i>Permanence</i>		x				
	<i>Works (general)</i>					x	
	<i>Infrastructure</i>		x		x		
	<i>Monitoring</i>		x		x		
What	<i>Technical</i>				x	x	
International Need	<i>International Need</i>	x					
Who should pay?	<i>Federal Tax</i>	x					x
	<i>Industry (utility, oil, coal, gas)</i>	x			x	x	x
Who will pay	<i>Rate-payer</i>		x	x	x	x	x
	<i>United States</i>						
Market	<i>Cap and Trade No</i>	x	x				
Regulation	<i>Cap</i>					x	
Industry Supportive	<i>Federal</i>			x	x		x
Public Perspective (now)	<i>Financial Pay-off</i>						
Public Perspective (future)	<i>Does not know</i>						x
Public Concerns	<i>Worried/Skeptical</i>				x	x	x
	<i>Power-plant pollution</i>	x		x		x	
	<i>Create incentives for coal</i>				x	x	x
	<i>Safety</i>					x	x
Should there be CCS Education?	<i>Health</i>		x		x		
	<i>Yes</i>			x			
Will Educate?	<i>Yes</i>		x				x
Who should educate?	<i>NGOs</i>				x	x	
Who to educate?	<i>Policymakers</i>					x	
	<i>Public</i>	x					
How to educate? Strategies	<i>Public reports</i>	x		x	x		x
	<i>Press</i>	x					
Current	<i>Global Warming</i>	x		x	x		x
	<i>Pollution</i>			x			
	<i>Equity</i>					x	
	<i>Other</i>				x		
Past	<i>Pollution</i>						x
	<i>Other</i>	x		x	x	x	
Focus	<i>Policymakers</i>						
	<i>Members</i>					x	

Note: inclusion criteria is 50% or more responses for each category

Table 3 shows the answers given for typology 2: Environmental Justice (neutral, negative) and Non-environmental justice (positive, neutral, negative)

		Typology 3				
		EJN	EJNeg	Not EJP	Not EJN	Not EJNeg
	<i>Geologic Sequestration</i>					
CCS?	Positive Neutral Negative	x		x	x	x
Necessary?	Yes No		x	x	x	x
If yes, justification	Coal (national) Coal (international)		x	x	x	x
If yes, qualification	Low Opportunity Cost Part of broader mix Time Now Max: other tech first	x	x	x	x	x
Views on CCS	Status Quo Distraction	x	x			x
Economic/Financial	Regulatory uncertainty Cost	x	x			
Feasibility	Permanence Works (general) Infrastructure Monitoring	x	x			x
What	Technical			x		x
International Need	International Need		x		x	
Who should pay?	Federal Tax Industry (utility, oil, coal, gas)		x			
Who will pay	Rate-payer United States	x				x
Market	Cap and Trade No Cap			x	x	
Regulation	Federal		x			
Industry Supportive	Financial Pay-off		x			
Public Perspective (now)	Does not know		x			
Public Perspective (future)	Worried/ Skeptical		x			x
Public Concerns	Power-plant pollution Create incentives for coal Safety Health	x	x	x		x
Should there be CCS Education?	Yes			x		
Will Educate?	Yes		x			
Who should educate?	NGOs		x			
Who to educate?	Policymakers Public		x	x		
How to educate? Strategies	Public reports Press		x			
Current	Global Warming Pollution Equity Other	x	x	x		
Past	Pollution Other		x	x	x	x
Focus	Policymakers Members		x	x		

Note: inclusion criteria is 50% or more responses for each category

Table 4 shows the answers given for the basic typology: positive, neutral, and negative

		Positive	Neutral	Negative
<i>Geologic Sequestration</i>				
CCS?	<i>Positive</i>	x		
	<i>Neutral</i>		x	
	<i>Negative</i>			x
Necessary?	<i>Yes</i>	x	x	x
	<i>No</i>			
If yes, justification	<i>Coal (national)</i>	x		x
	<i>Coal (international)</i>	x	x	x
If yes, qualification	<i>Low Opportunity Cost</i>			x
	<i>Part of broader mix</i>	x	x	x
	<i>Time Now</i>	x		
	<i>Max other tech first</i>			
Views on CCS	<i>Status Quo</i>			
	<i>Distraction</i>			x
Economic/Financial	<i>Regulatory uncertainty</i>			
	<i>Cost</i>			x
Feasibility	<i>Permanence</i>	x		x
	<i>Works (general)</i>		x	x
	<i>Infrastructure</i>			
	<i>Monitoring</i>		x	
What	<i>Technical</i>			x
International Need	<i>International Need</i>			
Who should pay?	<i>Federal Tax</i>		x	x
	<i>Industry (utility, oil, coal, gas)</i>			
Who will pay	<i>Rate-payer</i>	x		
	<i>United States</i>	x		x
Market	<i>Cap and Trade No</i>			
Regulation	<i>Cap</i>			
Industry Supportive	<i>Federal</i>			
Industry Supportive	<i>Financial Pay-off</i>	x		x
Public Perspective (now)	<i>Does not know</i>	x		x
Public Perspective (future)	<i>Worried/ Skeptical</i>	x		
Public Concerns	<i>Power-plant pollution</i>			x
	<i>Create incentives for coal</i>		x	
	<i>Safety</i>			
	<i>Health</i>			
Should there be CCS Education?	<i>Yes</i>	x	x	x
Will Educate?	<i>Yes</i>	x		
Who should educate?	<i>NGOs</i>	x	x	
Who to educate?	<i>Policymakers</i>	x		
	<i>Public</i>	x		x
How to educate? Strategies	<i>Public reports</i>			
	<i>Press</i>			
Current	<i>Global Warming</i>		x	x
	<i>Pollution</i>	x	x	
	<i>Equity</i>			
	<i>Other</i>	x		
Past	<i>Pollution</i>			
	<i>Other</i>			
Focus	<i>Policymakers</i>	x	x	x
	<i>Members</i>	x		x

Note: inclusion criteria is 50% or more responses for each category

## Appendix B.4 Summary of interview results

### Determination of Positive, Neutral or Negative

The determination of positive, neutral or negative involved “looking” for key terms, basically the participants told me whether they liked the technology or not<sup>57</sup>. To determine if the participant viewed carbon sequestration in positive terms, I obviously looked for positive language such as “excited” or “enthusiastic” or “favorable towards.” The participant was determined to be “neutral” if they used language like, “it is not a question of whether I like them or don’t like them but that we need them” (ED, NY) or there was no explicit positive or negative language used during the interview. The participant was determined to be “negative” if they used language like, “a terrible idea” (EcoEquity) or “it’s not a good thing” (RP).

### Determination of Necessary and Unnecessary

During the course of the interviews, I noticed that each of the organizations ended up telling me whether or not they believed that carbon sequestration was necessary. Most organizational views on carbon sequestration, whether that be positive, neutral, or negative, provided enough information so that you could predict whether or not they believed the technology was necessary for mitigating climate change, when asked about carbon sequestration the COO of WSPA responded, “we are very excited about this technology...it cuts down on the emissions so it is actually a whole package that works out very well for everyone, your citizens, it works out for the company, and it just makes for more cleaner use of our fossil fuels. Interestingly, for some organizations, whether or not they believed this technology was necessary seemed to be independent of their own personal views about the technology. For example, some organizations stated outright that they viewed this technology negatively however, still believed that this technology was necessary, when asked about his thoughts on carbon sequestration, the co-founder of EcoEquity said “I have a slogan that I repeat to anyone who asks me which is, it is a terrible idea that we desperately need.” This indicates that there may be a split in the group that views this technology negatively, those who are steadfast in their view that there are better ways to go about doing this and others who take a more practical stance. The next section will explore some of those differences and similarities.

The typology of positive, neutral, negative versus necessary and unnecessary reveal four distinct groups: positive/necessary, neutral/necessary, negative/necessary, and negative/unnecessary.

## Mitigation of Climate Change

### *The Necessity of Carbon Sequestration in the US*

One striking similarity between all four groups is the reason given for why it might be necessary for the United States to adopt carbon sequestration as a way to mitigate climate change; structural dependence on coal supplied energy with huge global coal supplies, especially in developing countries. Many organizations the United States as an active “laboratory” for carbon sequestration where lessons learned can then be transferred to developing countries such as China and India. A realistic stance was adopted by many towards the continued reliance on coal in the developing world and cited several reasons why: (1) coal is cheap and there is a lot of it; (2) cheap labor; (3) lax

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<sup>57</sup> It is important to note that sometimes during the course of an interview, some of the participants used contradictory language (i.e., sometimes positive or sometimes negative). So I had to look throughout the whole of the interview to get at the “essence” of the message.

environmental standards; (4) cheap coal burning technologies; and, (5) huge economic and population growth. In addition, several organizations stated why, in fact, carbon sequestration *needs* to be adopted in the US first before it can be successfully adopted in the developing world: (1) weak research capabilities; (2) cost-prohibitive in the near-term in developing countries; (3) weak intellectual property rights, contract law, regulatory regimes, and institutional capacity; (4) future of carbon sequestration in clean development mechanisms.

Not surprisingly, most organizations, with the exception of Neutral/Necessary, cited our domestic structural dependence on coal and huge supplies of coal as main reasons why carbon sequestration is necessary in the United States. Specifically, some organizations cited: (1) strong coal industry, (2) new coal plant proposals, (3) changing regulatory and legislative environment towards greenhouse gas emissions by some States, and (4) perceived need for energy independence.

### *Vision for Domestic Carbon Sequestration*

All of the groups who viewed it *necessary* for carbon sequestration to be adopted in the United States (with the exception of Negative/Unnecessary) viewed carbon sequestration as one part of a comprehensive strategy to mitigate climate change that includes measures such as energy efficiency and renewables. Many organizations cited the Socolow Wedges analogy and explained that carbon sequestration is one of the “wedges” that should be employed others suggested that carbon sequestration is one tool in our toolbox of possible solutions to climate change. Many organizations emphasized that there is no “silver bullet” to the mitigation of climate change and that in fact, they had no “favorite” technology and explained that whatever technology rises to top is the technology that should be endorsed; carbon sequestration might be one such technological solution.

Negative/Necessary further qualified its support for carbon sequestration by stressing that carbon sequestration should not be adopted at the expense of other solutions. Some of the organizations stressed that the solutions laid out for the mitigation of climate change should not be a “zero-sum” game meaning, for example, that “the” solution is either carbon sequestration or energy efficiency and renewables. Furthermore, this group stressed that other solutions *must* be given priority over carbon sequestration as a possible solution to mitigate climate change.

Positive/Necessary also further qualified its support for carbon sequestration by stressing that carbon sequestration is a technology that *needs* to be adopted in the near-term. Positive/Necessary acknowledged that not all of the research on carbon sequestration is in, but explained that it is important to go forward with this technology: (1) many coal power plant proposals, these should be carbon neutral from day one (i.e., don’t want to be stuck with an emitter for the next 50 years), (2) there is an immediate need to reduce emissions, (3) solid interim solution, and (4) it “fits” in with our existing energy infrastructure.

### *Views on CCS*

Groups negatively inclined towards carbon sequestration, Negative/Necessary and Negative/Unnecessary, viewed the technology as a distraction from “better” technological solutions and from the issue of our dependence on unsustainable energy sources (i.e., fossil fuels). Several organizations described carbon sequestration as being a distraction from superior solutions:

[Carbon sequestration] shouldn’t be a distraction from the things we know we need to do now and we can do now to reduce global warming pollution right away with renewables, energy efficiency, with conservation. (Environment California)

Not only does carbon sequestration divert our attention, it also diverts financial resources:



[Greenpeace] is concerned that it diverts attention away from the real solution in our opinion which is renewable energy and energy efficiency...our big picture concern is that it takes away money and funding from renewables generally which it is starting to do. (Greenpeace)

Several groups argued that carbon sequestration has been “sold” to the public by the fossil fuel industry (WWF) as a way to maintain our dependence on essentially unsustainable resources:

If CCS relieves that pressure, relieves the climate change pressure, then it could sustain an otherwise unsustainable energy supply. (SEI)

A few organizations stressed that not only does carbon sequestration support an unsustainable resource; the technology itself is an unsustainable technology:

CCS will never be part of the kind of vision of energy policy, it will never be part of a kind of looking forward new technology, what goes to the heart of the people, it is always something that is necessary to give us time for the next 40 to 50 years to bridge toward a real renewable age it is about winning time you know, it is about mitigating climate change but it is not something that is a sustainable technology for the long-term. (WWF)

Furthermore, Negative/Unnecessary explained that not only is carbon sequestration a distraction for all of the reasons stated above, it is also a “status quo” technology. CBE comments that carbon sequestration is:

Weak. A very weak strategy. We don't like strategies that kind of let things kind of continue as they are. (CBE)

## **Carbon Sequestration: Risks**

The organizations mentioned several categories of risks associated with carbon sequestration, those dealing with safety, human health, environmental impact, economic growth, financial, and the feasibility of the technology. However, the analysis revealed that the primary concerns of the organizations deal mostly with economic growth, financial, and the feasibility of the technology.

### *Economic Growth and Financial Risks*

Groups negatively inclined toward carbon sequestration, Negative/Necessary and Negative/Unnecessary, cited cost as a barrier to the adoption of technology. Several organizations cited that the technology will be expensive:

It's a cost issue...the trick thing about this technology is when you are capturing CO<sub>2</sub> emissions from a coal power plant you are reducing the overall efficiency and power output so you are essentially making your plant produce less energy for a higher cost which is sort of the opposite of what you would want where they are looking for ways to run this as cheaply as possible. (PEW)

Furthermore, some organizations don't believe that carbon sequestration will be able to effectively financially compete with other mitigation strategies (Sierra Club). Not only is this technology likely to be expensive, it is uncertain *how expensive* this technology is likely to be. The uncertainty in costs make it difficult to assess the monetary risks of commercial-scale carbon sequestration projects:

What are the costs when we talk to companies? Different companies will tell you different things and I think a lot of people will say that it is really difficult for them to even have a sense of what the costs are. (PEW)

...there are a lot of unknowns and questions that still need to be answered clearly, both in terms of cost and the downside to cost... (Environment California)

Negative/Unnecessary suggested that another economic growth and financial risk of carbon sequestration is the regulatory uncertainty. These organizations suggested that reducing regulatory uncertainty, in addition to other measures, would make carbon sequestration more palatable:

If you were able to build a commercially viable and cost effective IGGC-CCS plants today you know and it was proven that it wasn't going to leak and that it wasn't a safety risk and we actually knew how was going to be responsible for actually monitoring the sequestration for eternity to make sure that it wasn't leaking or about to release, if all that were true, OK...sure. (Environment California)

Other groups explained that the “yawning set of unanswered questions in the regulatory and institutional framework that would govern how the technology entered the market” (WRI) Interestingly, one organization cited regulatory uncertainty in developing countries as an opportunity to strengthen not only climate change mitigation aims but to also strengthen the developing countries' institutional capacity:

A lot of things go hand-in-hand with tackling the climatic issue, better more predictable legal regimes, better respect for individual rights, respect for property rights; they are pieces of the same puzzle... (Environmental Defense, NY)

### *Feasibility Risks*

There were four main concerns with respect to feasibility of carbon sequestration that can broadly be categorized as uncertainties that deal with (1) permanence, (2) technology, (3) monitoring, and (4) infrastructure.

All of the groups with the exception of Positive/Necessary were concerned with the uncertainties surrounding the technological feasibility of carbon sequestration. Most of the concerns are that this technology isn't as effective or doesn't provide the benefits intended:

On the technology side there is the risk that the technology won't work as originally planned for or designed for and that can you know, really be a killer. It is why people are sometimes very unwilling to be the first to try a new technology; it's a big race to be second. (EPRI)

Well, the biggest risk is it doesn't work as well as we need it to work, and it doesn't have the net benefits that we hope it has because it takes more energy to separate, capture, store and transport than we think it does. (Environmental Defense, TX)

Furthermore, organizations were concerned with the uncertainty surrounding our understanding of potential geologic sites:

I don't think we understand the geologic deposits in which we are going to put this stuff so I would not be surprised if we come across surprises as we go that may work in certain instances to limit what we thought was the potential for geologic sequestration. (Environmental Defense, NY)

And also the hydrological uncertainties:

Another issue is various hydrological concerns, like is there the potential for CO<sub>2</sub> or carbonates or whatnot to liberate heavy metals and release them into groundwater, heavy metals or

other geological contaminants that could be released in a slightly more acidic environment. (SEI)

All of the groups, with the exception of Neutral/Necessary, are concerned with the uncertainties surrounding issues of permanence. The major concern with respect to uncertainties surrounding permanence was that carbon sequestration could inadvertently be a solution that “borrows from the future”:

If we rely on CCS to a really large degree, and then we find out “oh this stuff is leaking out”, even a fraction of a percent per year, then that adds up. It could become the major source of CO<sub>2</sub> relative to the budget we have available if we’re trying to keep to any kind of a reasonable carbon trajectory. (SEI)

Furthermore, there is also a concern that leaks could lead to larger environmental or health impacts:

[Carbon sequestration] that is exacerbating the climate problem or creating a local safety and environmental hazard for people or animals or plants that are nearby. (WRI)

Neutral/Necessary is concerned with uncertainty surrounding the monitoring of carbon sequestration projects:

I think one of the risks is the challenge of actually monitoring, verifying, and doing what is hard to do. It is something that we can talk about and characterize on paper, but there are a lot of regulations that are enforced in the world. (The Nature Conservancy)

Negative/Necessary is particularly concerned with uncertainties dealing with infrastructure. Organizations expressed concern over the time in which an infrastructure for carbon sequestration would need to be developed, however, the largest concern about infrastructure centered on land-use:

There are problems associated with the infrastructure for CCS you know, if you are going to have an existing refinery in a location where it is far from a CCS reservoir that means you are going to have to create a new pipeline, you know? [A pipeline] that goes through some kind of protected area or an urban area, people aren’t going to enjoy having the northern part of LA cut right through because it is the busiest place on the planet. (Environmental Defense, CA)

Although the minority, it should also be noted that other organizations outside of Negative/Necessary also are acutely aware of and concerned with land-use issues:

I mean if you are thinking about piping CO<sub>2</sub> from a Wilmington refinery to Bakersfield where the oil fields are prominent and very geologically sound for CO<sub>2</sub> sequestration, you can imagine the land permitting SEQWA issues around building a pipeline in this state...huge...HUGE. So that is not a perception of CO<sub>2</sub> concern or a sequestration concern, it is a going to be a whole land-use issue. What is that pipeline carrying? I don’t want that in my backyard! (WSPA)

## **Carbon Sequestration Research**

The negatively inclined groups would like to see more research on carbon sequestration. Those who are negatively inclined but believe that carbon sequestration is necessary would like to see more evidence that carbon sequestration has been thoroughly technologically vetted. Some organizations want to see “rigorous studies and examples” (Environmental Defense, CA) so that:

the success of these [pilot] projects I think is going to be really crucial in whether we end up doing this on a broader scale. (PEW)

However, organizations who are negatively inclined and believe carbon sequestration is unnecessary concede that:

We should know if it [carbon sequestration] is going to work. (Sierra Club)

But for the purposes of understanding carbon sequestration from the perspective of furthering our scientific understanding; one organization cautioned that research should be done “for the benefit of humanity and not necessarily for the benefit of the coal industry” (Sierra Club)

A primary reason why Negative/Necessary group supports carbon sequestration and carbon sequestration research in the United States is because of the perceived need to transfer this technology to developing countries such as India and China. Several organizations explained that due to the lack of technological, financial and regulatory regimes in developing countries it is very unlikely that developing countries will independently research carbon sequestration:

The greatest research institutions in the world are not in China, and they don’t have the resources to pour into something like this (carbon sequestration). It is our job to do that. (Redefining Progress)

If it’s done somewhere where there aren’t enough safety protocols put in place where if there were to be a catastrophe there would likely to happen there and sort of kill the potential of this technology even if it has good potential. (PEW)

Although developed countries should develop the mitigation technologies, it is, however, solely the prerogative of the recipient country to decide whether or not to adopt the technology:

It doesn’t mean it’s sort of the international community should be pushing that on a place like China you know, it would have to be a domestic decision. (PEW)

## **Carbon Sequestration in Practice**

### *Regulation of Carbon Sequestration*

Positive/Necessary group recognizes the need for identification and development of a regulatory regime for carbon sequestration. All of the organizations believe that the regulatory regime should ultimately be at the federal level. Furthermore, most of the organizations cite the US EPA as the most likely regulatory agency:

EPA has sort of more credibility than other federal agencies on this stuff and probably are the right people to handle it... (NCEP)

I think that EPA has the legislative history, the authority, and the expertise to do it... (WRI)

However there are reservations, “there is a fear that there is clearly a lack of resources for EPA to do it quickly, you know budgets have been cut significantly over the past few years, the past decade in fact, they don’t have the resources to do it” (WRI)

There has been discussion that carbon sequestration can enter the market most successfully if there were signals that incentivized this technology such as a cap and trade program. However, the

organizations who are negatively inclined towards carbon sequestration and/or believe that this technology is unnecessary expressed significant concerns regarding a cap and trade system for carbon sequestration. Several organizations stated that it will be difficult to develop a trading program that is “not full of holes” (Sierra Club) and pointed to evidence that these types of market mechanisms have been unsuccessful in Europe. Further, it seems that these organizations fundamentally oppose trading systems for carbon sequestration because of political reasons:

We have historically been opposed to pollution trading, we think at some point in the not so distant future that will officially change, we will always be skeptics of programs that want to hand out allowances to get political buy-ins for industry. (Sierra Club)

The idea that we should create any kind of a system which basically allows, especially major polluters to continue to pollute, we don't know. We don't like carbon trading programs. I think we really need to take a very different approach then relying on market mechanisms. (CBE)

Even organizations that are supportive of carbon sequestration question the appropriateness of market mechanisms<sup>58</sup>:

In my mind, I see it as something that will be directly incentivized by a cap, so I think that if you have power plants that are subject to a cap, I think geologic sequestration is going to be one of their compliance mechanisms. This is the way that I best see this playing out and I don't know if there needs to be additional incentives on top of that, maybe in the early stages, but I don't think of that (geologic sequestration) as an offset mechanism that makes a lot of sense. (Climate Registry)

#### *Bearing the Cost of Carbon Sequestration*

All of the negatively inclined groups believe that carbon sequestration, both research and projects, should be paid for through a federal tax. Organizations differed, however, in who should be taxed. Some organizations believed that since the mitigation of carbon sequestration is a public good, then the costs should be borne widely:

I suppose we could all tax ourselves and then the federal government could subsidize it on the theory that it provides and environmental benefit to all, this is a legitimate cost of burning coal. (Redefining Progress)

Other organizations believed that a carbon tax on industry might be appropriate:

I think it would be entirely reasonable for us to have an economy-wide carbon tax, the revenues of which are used for this type of research. It is an externality of using those carbon intensive resources, the need to do CCS, the need to research and develop and pilot CCS. So it seems like it would be an appropriate use of carbon tax. Rather than coming from general tax-payer revenues, which have all kinds of other things that they're competing with. (SEI)

However, most organizations recognize that ultimately the consumer will be paying for carbon sequestration:

Theoretically, the polluters should pay but in practice, I think we all know they essentially pass on all of those costs and it is essentially passed on to the consumer prices. (Environmental Defense)

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<sup>58</sup> It should be noted that most of the organizations positively inclined towards carbon sequestration believed that market mechanisms offer the best incentives for carbon sequestration.

In an indirect way when you say, who should pay for it, of course the first burden is going to be on the people who have to reduce and comply but they can do that in a way where they can still stay a viable business. (WSPA)

Furthermore, Negative/Necessary believes that not only will US consumers pay for domestic carbon sequestration; US consumers will ultimately pay for the carbon sequestration in the developing world.

Basically, you know Americans and Europeans are going to pay to bury carbon in China and India and everywhere else. It is going to have to be done because they are going to do it. (EcoEquity)

## Perceptions of Carbon Sequestration

### *Industry Perspective*

In general, the groups (with the exception of Neutral/Necessary) believed that industry (i.e., utilities, manufacturers, and fossil fuel) will look upon carbon sequestration, as an offset or under a cap, favorably. To some extent, all of the organizations realized that the adoption of carbon sequestration would be motivated by some sort of pay-off whether that is monetary or not. Most of the negatively inclined organizations were more cynical about the motivations of industry with respect to carbon sequestration and viewed the adoption of the technology as “green-washing”:

I think that, especially given that in all likelihood this is a fully cost-effective, remunerative, positive financial return, I think that there is a lot of potential for this to be another green-wash project right? We're are doing something wonderful, but it suits perfectly well our bottom line. Aren't we sustainable and by the way can we get some credit on your market for it? (SEI)

The more positively inclined organizations emphasized the opportunities that carbon sequestration could foster. Especially potential mutually beneficial relationships between companies that improve both the bottom line and the environment:

In our industry, cogeneration is high on the list. So now you have a source of CO<sub>2</sub> (from the refiner), the producer doesn't have to find someone who is making it, it is going out of the facility, they do what they've always done which is move more oil. So now they can reduce their carbon footprint as a producer of oil and the refiner can reduce their now as an electricity producer...it's a very exciting technology. (WSPA)

Most of the organizations recognized that that some companies will be winners and some will be losers. In the oil industry, the more forward thinking companies could be winners:

BP and their stockholders decided that their company, their new forward thinking and planning was going to evolve into the alternative and renewable fuels area, they aren't giving up petroleum. Petroleum will be with us for a very long time, but I think their vision of the future, and again their vision has to be supported by their stockholders, that there is in their mind an opportunity here. Let's talk about risk, they are the first of the shoot that is a risk, their crystal ball right or wrong. They think its right but if it is not, they have put in a huge investment that others hadn't made; now they are ahead of the game, so their vision, their crystal ball is paying off. (WSPA)

In coal-related industries, we could see increased competition where the winners and losers have yet to be decided:

Companies like GE that have their IGCC technology are going around and saying “well if you are going to do carbon capture, you need to do IGCC. That is the cheapest way of doing it.” I am not exactly sure that is true, I’ve heard different things that it’s cheaper to do it on pulverized coal technology and we’ve had those companies tell us that. So I think you are going to see some interesting dynamics there, I think you are going to have pulverized coal technology fighting with the gasification technology manufacturers about who can do it. (PEW)

### *Public Perspective*

In general, most of the groups (Positive/Necessary and Negative/Necessary) believe that public awareness of both carbon sequestration and carbon sequestration as a way to mitigate climate change is low or non-existent. Most of the organizations believe that the general public is increasingly aware of climate change and is only just starting to think about potential solutions. When the public is made aware of carbon sequestration as a way to mitigate climate change, these groups believe that it will be greeted by the public with worry and skepticism. Many organizations believe that the public will be worried about carbon sequestration because it is a new technology, as with new technologies there are unknown risks:

It conjures up these images of inflating a big balloon underneath the earth and people think, “Oh geez, what if this thing explodes?” (NRDC, DC)

Most people when they first learn about [carbon sequestration] think, “Oh my God, you have to put how much underground? Five million tons/year? In this one place?” I mean when they think about how much volume that is, that it is Frankensteinian. (WRI)

More than worry, most organizations believe that carbon sequestration will be greeted by the public with skepticism because of past experience with other energy technologies such as nuclear. People will be “skeptical for all of the same reasons that people have opposed nuclear for years” (Environment California). Upon learning about carbon sequestration, another participant was “immediately skeptical because I thought it was in some way related to the government” (ED,CA). Furthermore, organizations believe that people will wonder why this is even being considered:

[People will] think, “Have we really come to this? Where this is not some other way to solve the problem, why can’t we build a lot of wind turbines?” (WRI)

I think that there will be the people who say, “Well, whatever happened to the renewables revolution?” (SEI)

### *Public Concerns*

All of the groups believe that there will be public concerns about the carbon sequestration with respect to Both the positively and negatively inclined groups believed that the public would be concerned about the safety of carbon sequestration sites and any subsequent impacts on human health. Many organizations emphasized that the public’s concerns will be based “more on their gut than any sort of factual issues” and recognized the importance of public concerns, “but, as we’ve seen that can be enough to kill something...” (ED, NY)

The interviews suggest that there will be concerns on two levels: (1) carbon sequestration and (2) coal-fired power plants with carbon sequestration. Positive/Necessary and Negative/Necessary in particular pointed to public concerns with respect to the technology itself and subsequent potential human health impacts. There were two main safety concerns, those that deal primarily with CO<sub>2</sub> leaking out from a sequestration site:

They are going to be very fearful of leaks, and they are not going to be worried about leaks the way we are in that they become a large source in the future, they are going to be worried about their kids playing in some abandoned lot that is suddenly flooded with CO<sub>2</sub>. (Greenpeace)

and those that have to do with how the CO<sub>2</sub> acts underground:

[People will wonder], “Can it gather up pressure and blow up underground? If it leaks out does the ground collapse?” (WSPA)

There are water risks, it can acidify water... (NCEP)

All of the negatively inclined organizations pointed to another level of concern, coal-fired power plants with carbon sequestration. They point to two types of concern, those dealing primarily with additional coal-fired power plants with carbon sequestration that could lead to an increase of criterion air pollutants, “there would still be the issue of building more coal plants that would contribute to pollution” (Environment California). Some organizations pointed to potential inequities with additional coal plants and explained that these facilities are likely to be located in socio-economically depressed areas:

I don’t think you are going to see these things built in Berkeley, they are going to be in the Ohio Valley, I have here this report that shows where the sites are but I think they are going to be in Kentucky and in Ohio, they are going to be in West Virginia. Poor people, I don’t know if they are going to be black, but they are going to be poor. (Greenpeace)

In Los Angeles for example, you could probably bet your house that it would not be Beverly Hills. It’d never even be considered. Probably not wealthier, upper middle-class and upper-class areas that is mostly white. So that is a problem, it’s that way because of the lack of economic clout and political clout that many of the low-income communities have, they’re often much more vulnerable to being the home for these CO<sub>2</sub> sequestration projects. (CBE)

One organization brought up BP’s plan for a carbon sequestration demonstration site that is supposed to go online in 2011:

That is the quintessential example of a cumulative impact of environmental injustice, they are (poor communities) a magnet for all different types of pollution, the ships, the cranes, the loading docks, they also happen to be surrounded by four different refinery sites, power plants, transmission lines, highways...so to have a CCS project you know pumping pollution underground in that type of community and they don’t know that any of it is going on...(ED, CA)

Tied to these issues is another primary concern that is the potential incentivization of coal:

There will be people who understand very well that geologic sequestration is the critical path to legitimizing the use of coal in the 21<sup>st</sup> century and because not just for climate reasons, but for all sorts of ideological reasons, people don’t want to see coal being used. (NRDC, NY)

### *Public Education*

All of the groups believe that some education of the public on carbon sequestration will be or is important. However, each of the groups have different reasons why they believe education should occur. Both the Positive/Necessary and Negative/Unnecessary believe that it is important that the “right” message about carbon sequestration is taught, the outcome for which the Positive/Necessary hopes will be public acceptance of carbon sequestration:



Industry has done a very good job from their perspective of drumming up the dangers of it and so there will probably need to be some education. (NRDC, CA)

And so what is going to be very important, in my opinion the most important element in the success of this technology is a huge education effort with everybody, the public, the media, academia because this will not happen if we don't get over the perception that there is some concern around [carbon sequestration]. (WSPA)

and the outcome for which the Negative/Unnecessary hopes will be public rejection of carbon sequestration:

If we ever reach out to our membership it is to tell them to contact policymakers and tell them not to do this. We are very unlikely to ever reach out to our membership base and say, "You know, let's see if this works." Our membership isn't interested in that; our membership is interested in what we are doing to make the world a better place. (Greenpeace)

The Neutral/Necessary group is most interested in educating the public so that there is an open dialogue between policymakers, scientists, and the public on carbon sequestration:

There are political decisions and value decisions and long-term implications that need to be weighed in that the market doesn't typically weigh in. And so I think that there does need to be a political discussion that involves the public and brings in the stakeholders in a way that has sort of been incrementally and increasingly done over the years. (SEI)

The Negative/Necessary groups in educating the public to prepare them for the possible necessity of carbon sequestration in the future:

CCS is not something which I would like to campaign about, it is not something that goes to the heart, it something like disaster relief, can't win hearts and minds with CCS, you can only appeal to some rational acceptance and you have to make sure of course that CCS is accepted by the public as opposed to nuclear of course. (WWF)

All of the groups (with the exception of Neutral/Necessary) believe that education campaigns should be focused at the public. Positive/Necessary also believed it necessary to extend education campaigns to policymakers. In addition, this group believes it necessary to educate people on carbon sequestration in the near-term. The interviews suggest that these organizations will not specifically focus on carbon sequestration but it will be part of "the whole toolbox that we present to combat global warming" (NRDC, CA)

Many different potential strategies to educate the public were suggested such as reports, appearing at public venues (hearings, rulemakings, etc.), websites, scientific journals, advertisements, curricular in schools, and the press. However, only the negatively inclined organizations converged on two potential strategies they viewed as being most successful: public reports and the press. Negative/Necessary suggested that using the press to present carbon sequestration to the public may be the most fruitful approach. Negative/Unnecessary suggested that publishing reports may be the most fruitful approach.

*Appendix C*

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## Appendix C.1 Focus group demographics questionnaire

This information is being collected to help in the analysis of the discussions and will not be used to identify individuals. We are not requesting you to complete your name and address. Your responses to all questions, including these, are completely confidential.

1. Sex: (Please circle one)

Male                  Female

2. Age: (Please circle one)

18-45                  46-64                  65 or older

3. Do you have children under 18 years of age? (Please circle one)

Yes    No

4. How would you define your ethnicity? (Please circle all that apply):

Caucasian  
Asian  
African-American  
Hispanic/Latino  
Native American  
Other

5. What are your primary sources of information about local and national news? (Please circle all that apply):

Local newspaper  
National newspaper  
Radio  
TV  
Internet  
Other (please specify) \_\_\_\_\_

6. Do you recycle or take special precautions in disposing of the following materials in your home? (Please circle those that you do):

Newspaper  
Glass  
Plastic bottles  
Paint, paint thinners  
Used engine oil and coolant/antifreeze

7. In the past year, have you donated time or money to any environmental organization or groups? (Please circle one):

Yes No

8. In the past year, have you donated time or money to any industry or business-related organization or groups? (Please circle one):

Yes No

9. What is your highest level of education? (Please circle one):

- Grade school; high school diploma
- Some college (no degree)
- College degree (Associate or Bachelor)
- Advanced degree (Masters or Ph.D.)
- Technical training

Discussion Packet

Please Do Not Flip Page Until Instructed

Thank You!

Do you think global warming and climate change are really happening? If yes, why?

If yes, what is causing it?

[Please do not turn the page until prompted to do so]

## Terrestrial Sequestration

You can grow more trees to take CO<sub>2</sub> out of the atmosphere and store it in plants and soil – and this is called terrestrial sequestration. What is the first thing that comes to your mind when you think of terrestrial sequestration?

[Please do not turn the page until prompted to do so]

## Geological Sequestration

You can capture carbon that is produced in smokestacks and store it deep underground, sort of like how natural gas is stored naturally – and this is called geologic sequestration.

What is the first thing that comes to your mind when you think of geologic sequestration?

[Please do not turn the page until prompted to do so]



#### Safety Measure 1

The first is to pick an area that is good for geologic sequestration. The necessary level of geology is well understood across the country, and is similar to what is used to determine where to drill oil wells.

#### Safety Measure 2

A second safety measure is to work with regulators to obtain permits for both drilling and injection, and the permits would only be given if there was a detailed injection plan that says how the well needs to be designed and constructed and includes pressure and injection limitations.

#### Safety Measure 3

A third measure is the development of a monitoring plan. There are many ways to monitor for leaking CO<sub>2</sub> at the well site and further away. If a leak is detected, the engineers can either (1) stop injecting more CO<sub>2</sub> into the well, or (2) pump CO<sub>2</sub> out from the injection well and put it someplace.

#### Safety Measure 4

A fourth measure is to carry out the process of injection itself in a safe and careful manner. Regulators often inspect projects that are underway to ensure the operator is following the permit requirements and operators have numerous incentives to make sure they follow requirements and also operate their equipment safely.

Do these safeguards seem like enough? Please write down your first thoughts.

## Appendix C.3 Focus group flipchart

5/6/11

- Crime
- Education
- The war on terrorism
- Healthcare
- Economy
- Energy Security
- Immigration
- Environment

PAGE 1

- Climate change
- Water pollution
- Air pollution
- Hazardous waste
- Solid waste or garbage
- Biodiversity

PAGE 2

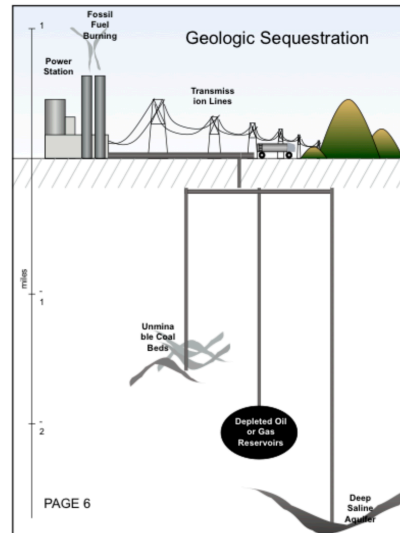
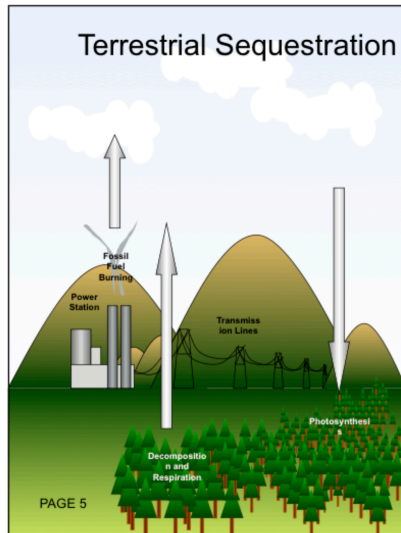
### Climate Change Science

1. Greenhouse Effect: Sun's rays enter atmosphere, like passing through glass walls of a greenhouse. They heat the surface and the heat is radiated back towards the glass. Some stays in the greenhouse and some passes through the glass. Earth's atmosphere acts like the glass. It allows sun's rays to heat the planet. Some heat is radiated back out of the atmosphere and some is trapped in our atmosphere and continues to warm the earth.
2. Greenhouse gases, like CO<sub>2</sub>, build up over time and start to trap more heat than they let through.
3. Man made CO<sub>2</sub> emissions mostly come from burning fossil fuels like coal, gas and oil. They have risen dramatically since the industrial revolution.
4. Many scientists say that dramatic cuts in CO<sub>2</sub> and other greenhouse gases will be needed to slow or stop global warming.

PAGE 3

- Your local community
- The US as a whole
- People all over the world
- You, your children and your grandchildren
- Non human nature – such as polar bears
- You are not especially concerned

PAGE 5



1. We should learn more about geologic and terrestrial carbon sequestration -- such as how much would it cost, and is it safe and effective -- and support more research on this topic.
  2. We should encourage landowners to increase the carbon stored in farmlands, forests and open spaces for terrestrial carbon sequestration.
  3. We should not support geologic and terrestrial carbon sequestration because we need to make a major shift away from using emission-causing fuels such as oil, coal and gas. Carbon sequestration will just delay that shift.
  4. Both geologic and terrestrial carbon sequestration should be encouraged as part of a larger strategy that includes more renewable energy, higher energy efficiency and other types of energy sources.
  5. We should encourage both geologic and terrestrial carbon sequestration because there is evidence to suggest that it will be difficult to transition away from our reliance on fossil fuels such as oil, gas and coal, and sequestration provides a way we can keep carbon out of the atmosphere as much as possible during a transition.
  6. We should support efforts to test and develop geologic sequestration because new technologies need to be tried before they can be adopted nationally.
  7. We should support geologic carbon sequestration because it is an approach that the US Dept of Energy and oil / gas / power companies are seriously looking at.
- PAGE 7

Terrestrial Sequestration		Geologic Sequestration	
Pros	Cons	Pros	Cons

PAGE 8

1. Pick a good site
2. Work with regulators
3. Monitor the project
4. Follow permit requirements

PAGE 9

- To adapt
- Changing our energy use
- Emissions management

PAGE 10

A

B

C

PAGE 11

## Appendix C.4 Focus group moderator guide

### DEMOGRAPHICS

This is to be done at discretion of moderator

Moderator says:

Moderator hands  
out demographics  
sheet and says:

Hi, my name is [STATE YOUR NAME], and I am a  
researcher at [STATE YOUR INSTITUTION].

[Insert up front or at the close of the interview at moderator's  
discretion] I would like to ask for some background  
information to help in our analysis of the discussions. It will  
not be used to identify individuals and your information will  
be completely confidential. For example, we are not  
requesting you to provide your name and address.

## DISCUSSION SESSION

### *Introduction*

Moderator says:

We are researchers from [STATE YOUR INSTITUTION] and we're interested in your views on new technologies and policies related to climate change or global warming. We believe that policy makers should be aware of, and take into account, how you, as members of the public, feel about these policies. We plan to take between one and half and two hours for the discussion. Although we'll focus on climate change, we are also interested in learning how this fits within the broader context of issues that are important to your community. There are no right or wrong answers. The purpose of the discussion is to learn more about how you all think about the topics we're going to discuss.

All of the information you provide to us is strictly confidential. We will combine information from all the discussions to prepare a report that reflects what we have found, but we will not be identifying individuals by name and will not attribute any statements or information to any person.

We will be recording this session, but everything you say will be treated confidentially. I will lead the discussion with 8 discussion topics over the course of the session, but I encourage all of you to engage in a free flowing discussion starting from each topic.

We have a fairly full agenda today, so I'll apologize in advance if I have to cut off the discussion at any point. I don't want to be impolite, but I may have to interrupt to bring us back to the main topic if we get too far a field. Or I may have to break in and move us along to the next topic so that we have enough time to get through all of them. If you have a cell phone or pager with you, please turn it off if possible. If you do have to leave it on, please leave the room if you have to take a call and return as quickly as you can.

Moderator in turn invites each participant to introduce themselves

Thank you for agreeing to participate in this focus group.

name is [YOUR NAME] and I am a researcher at [STATE  
YOUR INSTITUTION].

Now let's start by  
introducing ourselves  
with our first names  
and what we do for  
work. I'll start: my

## *Discussion Topic 1.A Pressing Community Issues*

Moderator turns to page 1 of flip chart that contains list and prepares to note any new ideas. Moderator says:

**FLIPCHART  
PAGE 1**

Moderator points to a person, says their name and asks:

If participant lists one, Moderator asks group:

If participant indicates something else, Moderator asks about that issue. Point is to move quickly and get people talking. Go through top 2-3 if necessary.

I'd like to ask you what you think are the

pressing issues facing your community.

[INSERT NAME] are any of these most important to your community?

Who else thinks XX is most important?



## *Discussion Topic 1.B Environmental Concerns*

Moderator flips to page 2 of flip chart with list of environmental issues and says:

**FLIPCHART  
PAGE 2**

Moderator notes any other topics that come up during the discussion

I'd like to focus on the environment, what are your top 3 concerns? [INSERT NAME of another participant] what do you think is the top environmental concern in your community?

How about the rest of you? Does anyone else think XX is the top concern in your community? OK, how about XX, and so on.

## *Discussion Topic 2.A Introducing Climate Change*

Moderator says:

I'd like to turn to climate change. Has anyone heard of it?

Moderator says:

There has been a lot of coverage of climate change in the media recently. Has anyone seen the Gore movie *An Inconvenient Truth* or one of the specials on TV or seen coverage in a magazine?

Pause, then say:

When I say climate change, what are the first images or words that come to your mind?

Pause, then say

Who has one in mind?

What is it?

Does anyone else think of that image/word?

*Discussion Topic 2.B Attitudes towards climate change*

Moderator says:

**FLIPCHART  
PAGE 3**

If group needs additional information turn to page 4 of the flipchart, moderator says:

**FLIPCHART  
PAGE 4**

Do you think global warming and climate change are happening? Please take a couple of minutes to jot down some thoughts on the second page of the hand-out. Just key words are enough. If you think it is happening, write down a few ideas on why it might be happening. Remember – this is not a test. We are just interested in knowing what you think off the top of your head.

Just to refresh your memories, climate change refers to the sorts of changes that might take place if the earth's atmosphere warms significantly.

### *Discussion Topic 3 Possible Impacts of Climate Change*

Moderator turns to page 5 of the flip chart and says:

**FLIPCHART  
PAGE 5**

Moderator reads each group and takes notes:

Moderator – if the answers are surprising or interesting, ask people about their reactions specifically.  
Otherwise say:

I'd like to know if you are concerned or not about the possible impacts of climate change or global warming on specific groups. I'll show you a list of some different groups and tell me what concerns, if any come to mind.

Does anyone care to comment on their thinking about the impacts on specific groups?

## *Discussion Topic 4 Addressing Climate Change through Carbon Sequestration*

Moderator introduces a shift in questions, says:

Moderator turns to page 6 of the flipchart. Reads aloud the following and points out on flipchart

**FLIPCHART  
PAGE 6**

Moderator pauses, waits a few moments, goes to page 7 on flip chart and then says:

**FLIPCHART  
PAGE 7**

One way to address climate change is to try to prevent it or slow it down by reducing CO<sub>2</sub> emissions. Another way is to manage the emissions that we are producing. For now I'd like to focus on one method that could be used to manage the emissions that come from using fossil fuels – presuming the world can't or won't stop using them anytime soon. The method for doing this is called carbon sequestration.

Terrestrial sequestration is the term used to describe the storage of carbon that takes place on land. Trees and plants take CO<sub>2</sub> out of the air, and carbon, the key ingredient of CO<sub>2</sub>, is stored in the leaves and tree-trunks. It also gets stored in the soil in which plants grow. So a lot of CO<sub>2</sub> could be removed from the atmosphere by replanting forests, changing farming practices, and by recovering land that has been disturbed say by mining or development.

I'd like you take a few seconds to collect your thoughts on terrestrial sequestration. Do you think it is a good idea? Do you think it would work? Or do you have any other reactions to it? [please turn to page 3]

OK, let's go on. There is another type of sequestration, called geologic sequestration that involves actually capturing the CO<sub>2</sub> emissions from large sources like electric power plants or manufacturing plants before it gets into the air, and then injecting it through a deep well a mile or more below the surface. Just like oil has been stored for centuries in similar rock formations, the CO<sub>2</sub> would be stored underground permanently. Initial research suggests that this method could be used to store the CO<sub>2</sub> from a large number of facilities such as power plants and cement manufacturing.

I'd like you to take a few seconds to collect your thoughts on geologic sequestration. Do you think it is a good idea? Do you think it would work? Or do you have any other reactions to it? [please turn to page 4]

## *Discussion Topic 5 Thinking about Geologic and Terrestrial Sequestration*

Moderator turns to page 7 in flip chart on which each statement is written but covered up so that you can go through them one at a time by removing a paper taped on top. Says:

**FLIPCHART  
PAGE 7**

Moderator points to each and asks for general reactions after each and then as a whole group:

OK, keep thinking about terrestrial

sequestration and geologic sequestration. There are several opinions about the role of geologic and terrestrial sequestration in our society. I'd like to share some of these and ask for your general reaction to them.

[This is what is on flip chart : 1. We should learn more about geologic and terrestrial carbon sequestration -- such as how much would it cost, and is it safe and effective – and support more research on this topic.

2. We should encourage landowners to increase the carbon stored in farmlands, forests and open spaces for terrestrial carbon sequestration.

3. We should not support geologic and terrestrial carbon sequestration because we need to make a major shift away from using emission-causing fuels such as oil, coal and gas. Carbon sequestration will just delay that shift.

4. Both geologic and terrestrial carbon sequestration should be encouraged as part of a larger strategy that includes more renewable energy, higher energy efficiency and other types of energy sources

geologic and terrestrial carbon sequestration because it will be difficult to transition away from our reliance on oil, gas and coal, and sequestration provides a way that we can keep carbon out of the atmosphere as much as possible.

6. We should support efforts to test and develop geologic sequestration because new technologies need to be tried before they can be adopted nationally.

7. We should support geologic carbon sequestration because it is an approach that the US Dept of Energy and oil / gas / power companies are seriously looking at.]]

5. We should encourage both

*Discussion Topic 6 Advantages and Disadvantages of Carbon Sequestration*

Moderator flips to page 8 on flip chart – matrix with pro/con and terre/geo and says:

FLIPCHART  
PAGE 8

Do you think terrestrial sequestration and geologic sequestration could have some advantages or benefits? Do you think they could have some disadvantages or risks? I'd like to do a little brainstorming to what you think might be pros and cons of both approaches.



## *Discussion Topic 7 Risks and Safeguards*

Moderator says:  
And Moderator  
turns to page 10 on  
flip chart – which  
reads:

1. Pick a good site
2. Work with regulators
3. Monitor the project
4. Follow permit requirements

Moderator says:

**FLIPCHART  
PAGE 10**

Moderator says,  
and prepares to jot

notes on the flip chart:

Scientists understand that there are some risks associated with geologic sequestration, such as leaks. They plan to use at least four safeguards to reduce these risks and believe that with these safeguards in place, the risks are manageable or even preventable.

The first is to pick an area that is good for geologic sequestration. The necessary level of geology is well understood across the country, and is similar to what is used to determine where to drill oil wells.

The second safety measure is to work with regulators to obtain permits for both drilling and injection, and the permits would only be given if there was a detailed injection plan that says how the well needs to be designed and constructed.

The third measure is the development of a monitoring plan. If a leak is detected, the engineers can either (1) stop injecting more CO<sub>2</sub> into the well, or (2) pump CO<sub>2</sub> out from the injection well and put it someplace else.

A fourth measure is to carry out the process of injection itself in a safe and careful manner. Regulators often inspect projects that are underway to ensure the operator is following the permit requirements

What do you think of these safeguards? [please turn to page 5]

Do these safeguards seem like enough? Do they make you feel comfortable enough to support CCS research?

## *Discussion Topic 8 Other Approaches to Addressing Climate Change*

Moderator says:

**FLIPCHART  
PAGE 10**

Moderator takes  
notes on flip chart  
page 11:

Moderator says and  
takes notes under  
A:

**FLIPCHART  
PAGE 12**

Earlier I mentioned  
that there are other

options for addressing climate change. I can group them into three broad approaches and it's likely that some combination of all three may be needed.

The three approaches include:

1. Adapt. This means we adjust to the impacts of climate change by for example moving away from coastal areas because of sea level rise or changing farming practices because of changes in weather and rain patterns.
2. Change the way we make and use energy. This means using more sorts of energy that does not emit CO<sub>2</sub>, such as nuclear energy or renewable energy like wind, solar or biomass; or, increasing energy efficiency and auto efficiency.
3. Manage CO<sub>2</sub> emissions by e.g. terrestrial sequestration and geologic sequestration.

Overall, after considering all we have discussed, what role do you think each of these approaches should play in any future climate policy the US? To what degree and why?

Presuming that some geologic sequestration projects would be needed, what additional information would you want to know if one of these were proposed in your community?

Moderator says and takes notes under C:

Moderator says and  
takes notes under  
B:

Given what you heard today, how would you feel about having a geologic sequestration project in your community or near your house?

Given that large-scale projects could last up to 25 years, how would you feel about having a geologic sequestration project in your community or near your house?

Given that large-scale projects would also involve developing a pipe-line infrastructure similar to today's oil industry, how would you feel about having a geologic sequestration project in your community or near your house?

## **CONCLUDING REMARKS**

Thank you for participating in this focus group interview today. I appreciate your time and input. If any of you would like further information on this study, my contact information is on this information handout sheet.

## **Appendix C.5 Focus group information sheet**

### Focus Group Information Sheet

Thank you for participating in our focus group!

If you have any questions about this research, please do not hesitate to contact me. I may be reached by telephone at (510) 316-1631 or via email at [gwongpar@berkeley.edu](mailto:gwongpar@berkeley.edu). If you have any question regarding your treatment or rights as a participant in this research project, please contact the University of California at Berkeley's Committee for the Protection of Human Subjects at (510) 642-7461 or [subjects@berkeley.edu](mailto:subjects@berkeley.edu).

If you would like to know more about our graduate group please visit our website at <http://socrates.berkeley.edu/erg>.

## Appendix C.6 Interview instrument

Section 1 – interviewer asks questions about participant’s views on climate change, knowledge of technologies to mitigate technology. Interviewer presents climate science and CCS technology (both geologic and terrestrial) – hopefully 10 minutes

Section 2 – substantive questions

1. What do you think will be the effects of this technology?
  - a. On human health?
  - b. On the air?
  - c. On agriculture?
  - d. How large do you think the risks are?
  - e. On related natural disasters (i.e. earthquakes)?
2. Where do you think these projects will be sited?
  - a. Why?
  - b. Where do you think these projects should be sited?
3. If you have concerns, who would you like to talk to?
  - a. Do you think your concerns will be heard?
  - b. Do you think that your concerns matter?
  - c. How much power do you think you have to influence the opinion of the government, of oil/gas/electricity companies?
4. What role should the community near these sites play?
  - a. What should the forum look like?
5. What is most important and how should they be reconciled?
  - a. Does the community near the project support the CCS project?
  - b. Do you support actions to mitigate climate change?
6. Who should pay for this technology?
  - a. What should the property structure of this technology look like?
7. In California we live with risk (i.e. earthquakes and flooding), given the scale of risk, how much does the additional risk of CCS matter?
8. How should we attack the problem of climate change?
  - a. Why do you think that DOE is interested in this technology?
  - b. What role, if any, should CCS play?
  - c. What other things should we be doing?
9. Are there any other places where we should be getting our information about CCS?
  - a. What would you need to know about the technology to feel comfortable accepting and adopting the technology?

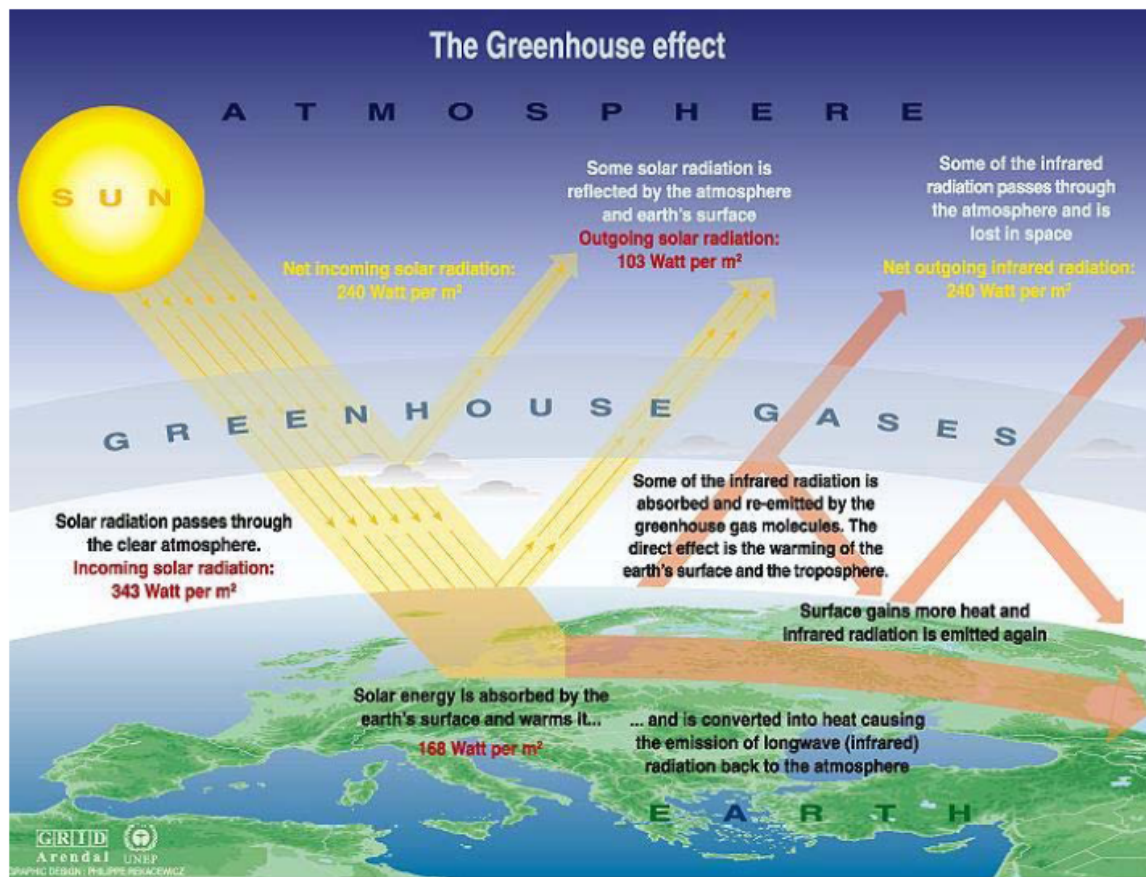
10. The communities most directly affected by these projects, should they be compensated with jobs, money, services, etc?
  - a. Who should pay for this?
11. What would you say the advantages and disadvantages are of CCS (both geologic and terrestrial sequestration)
12. How would you feel about having this technology near your home? (both terrestrial and geologic)
13. How would you feel about these projects lasting 25-50 years? (specifically geologic)

Section 3 – concluding remarks and debriefing

## Climate Change Science

Greenhouse Effect: Sun's rays enter atmosphere, like passing through glass walls of a greenhouse. They heat the surface and the heat is radiated back towards the glass. Some stays in the greenhouse and some pass through the glass. Earth's atmosphere acts like the glass. It allows sun's rays to heat the planet. Some heat is radiated back out of the atmosphere and some is trapped in our atmosphere and continues to warm the earth.

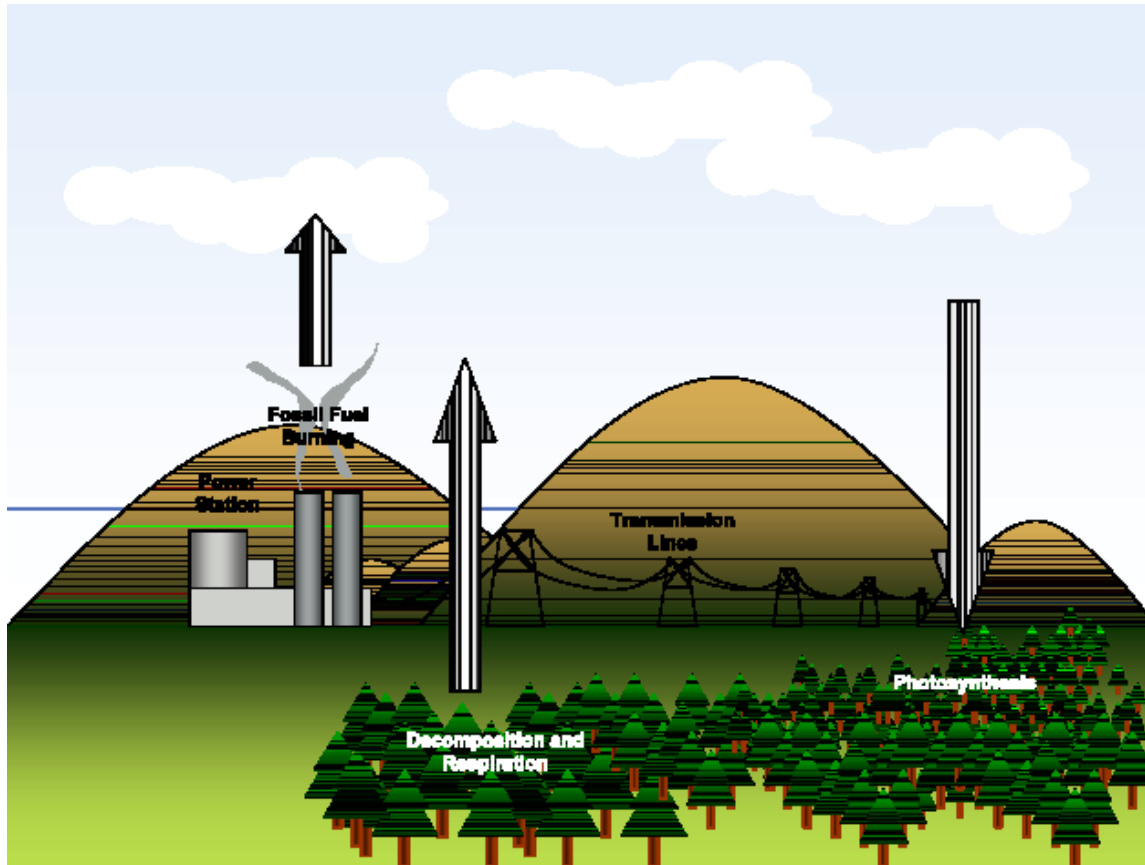
Greenhouse gases, like CO<sub>2</sub>, build up over time and start to trap more heat than they let through. Man made CO<sub>2</sub> emissions mostly come from burning fossil fuels like coal, gas and oil. They have risen dramatically since the industrial revolution. Many scientists say that dramatic cuts in CO<sub>2</sub> and other greenhouse gases will be needed to slow or stop global warming.





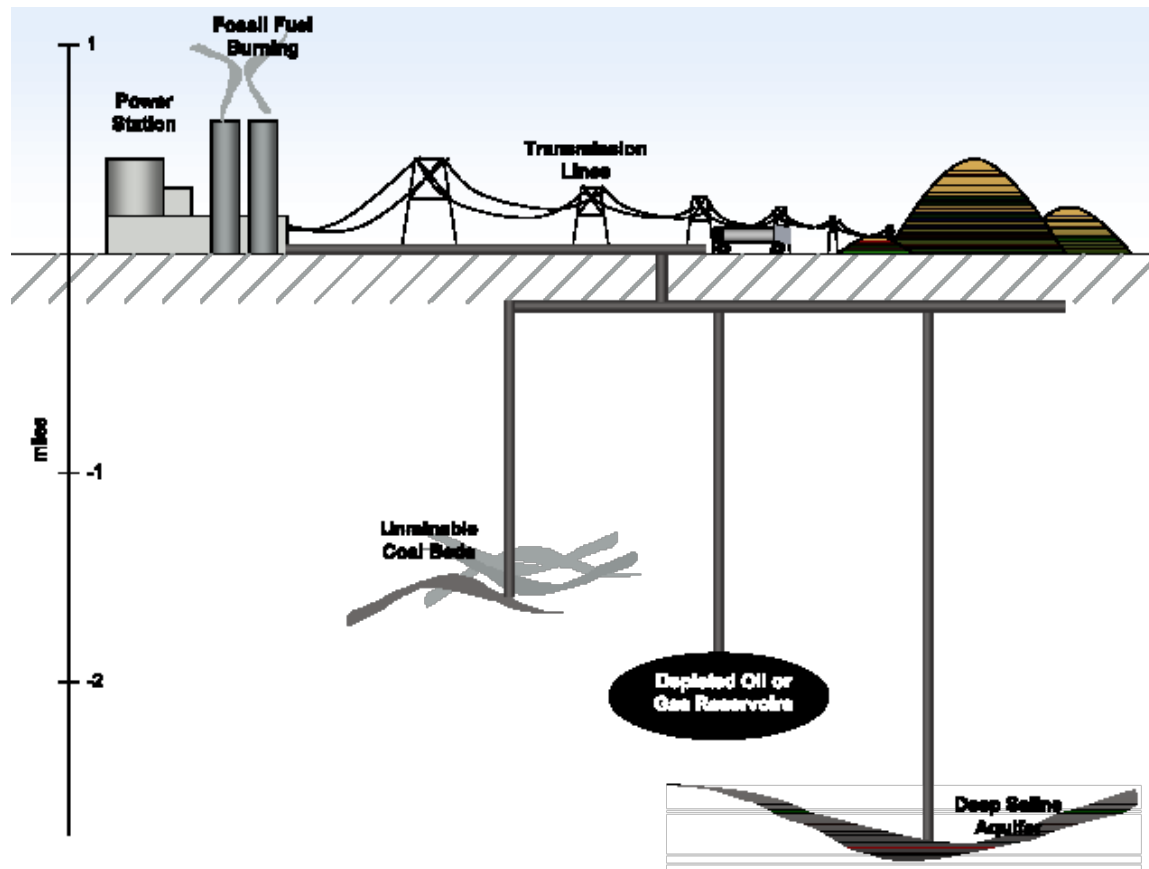
## Terrestrial Sequestration

Terrestrial sequestration is the term used to describe the storage of carbon that takes place on land. Trees and plants take  $\text{CO}_2$  out of the air, and carbon, the key ingredient of  $\text{CO}_2$ , is stored in the leaves and tree-trunks. It also gets stored in the soil in which plants grow. So a lot of  $\text{CO}_2$  could be removed from the atmosphere by replanting forests, changing farming practices, and by recovering land that has been disturbed say by mining or development.



## Geologic Sequestration1

Geologic sequestration involves actually capturing the CO<sub>2</sub> emissions from large sources like electric power plants or manufacturing plants before it gets into the air, and then injecting it through a deep well a mile or more below the surface. Just like oil has been stored for centuries in similar rock formations, the CO<sub>2</sub> would be stored underground permanently. Initial research suggests that this method could be used to store the CO<sub>2</sub> from a large number of facilities such as power plants and cement manufacturing.



## Appendix C.7 Focus group summary results

### SECTION 1: Pressing community issues

Concerns in both communities center on growth and development, education, and healthcare. Town T cited several additional issues facing the community which are crime, immigration, migration, and basic survival of community members. Town R also cited several additional issues which are quality and level of community services, economy, energy security, and local youth.

### SECTION 2: Environmental concerns

Both Town R and Town T see air pollution and water pollution as environmental concerns facing their communities. In particular, participants in Town T are concerned about biodiversity and climate change. Participants in Town R are also concerned about hazardous waste and local parks.

### SECTION 3: Attitudes toward climate change

Participants displayed varying levels of knowledge about climate change and its causes. Many participants expressed their confusion and frustration with the perceived climate change debate taking place in the media. When asked about how to solve the climate change problem, many participants shared a wide range of solutions from nuclear power to conservation measures. The participants see obstacles to the implementation some of these solutions from lack of encouragement from the government to the difficulty in admitting that climate change is a real threat. When asked about the Department of Energy's (DOE) interest in climate change solutions, many participants expressed skepticism regarding DOE's motives. Both Town R and Town T expressed concern about potential local and national impacts of climate change, especially those that impact water (e.g, flooding, water quality, droughts, etc.).

### SECTION 4: Attitudes toward carbon sequestration

#### *Advantages and Disadvantages*

Overall, for both communities, the primary positive quality of geologic sequestration is that it removes carbon dioxide from the atmosphere. Furthermore, this technology is seen as both technologically feasible and has the potential to create local jobs. However, both communities cited a number of negative qualities that include: high tech, technological knowledge may be low, risk of carbon dioxide release, could lower property values, could increase the likelihood of natural disasters such as earthquakes, may change the "character" of the town, would involve the construction of a pipeline infrastructure, and expensive.

Both communities view a number of positive advantages to terrestrial sequestration that include: low tech, co-benefits (e.g., use wood to build houses, paper, etc.), enhance biodiversity, enhance neighborhoods, etc. Some negative qualities are: takes a long time, would likely involve a large number of trees, may impact land development, and may involve large quantities of water.

#### *Effects of technology*

Overall, participants did not see any negative human health impacts (a small chance of a sudden release of carbon dioxide), air quality or agriculture. However, a wide range of opinions were expressed regarding the impact of geologic sequestration on related natural disasters such as

earthquakes or volcanic activity where some participants believed the risk is low or non-existent while others perceived the risk to be a real possibility. When asked about the magnitude of that risk, most participants believed the possibility to be low. Furthermore, participants expressed a wide range of opinions as to whether this additional risk matters, from not at all to greatly.

#### *Location of projects*

The participants expressed a wide range of opinions as to where these projects should take place, from locations close to where the emissions are occurring to low population density areas such as the desert.

#### *If concerned, who to talk to?*

Most participants agreed that if they were concerned about the technology that they would like to talk to local government, scientific experts or those in charge of the project. Participants believed that as individuals they would be unlikely to influence the opinion of government or the oil/gas/electricity companies. However, in larger numbers (e.g., the whole community) they might be able to exert influence.

#### *Role of the community*

Participants believed that the community should be actively involved in the project by either being employed at the project site, or through the involvement of elected officials.

#### *Pay/ own project*

Participants expressed a wide range of opinions as to who should pay for carbon sequestration, from tax payers to those energy companies. In addition, a wide range of opinions were given for who should own the project, from the public to government to private companies.

#### *Information about carbon sequestration*

Participants want to get information about carbon sequestration from many different sources: non-profits, Universities and private companies. However, many participants did not want to get their information from governmental sources. Participants want to get their information in a wide variety of different formats from media sources: newspapers, websites, and television. Participants want the information provided in a “straight-forward” manner without a lot of jargon. A number of measures could be taken to make the public feel comfortable about carbon sequestration: demonstrate safety measures, cost, feasibility, regulation, and how the community will be compensated.

#### *Compensation*

Most of the participants believe that community where a carbon sequestration project will be taking place should be compensated. Some items that the participants would like to see: parks, royalties, jobs, upgrade schools, and community services. A range of opinions were expressed about who should pay for this compensation from taxpayers to the company that is in charge of the project.

#### *Proximity/ Duration/ Infrastructure*

When asked about having a carbon sequestration project near home, some participants did not mind having a geologic sequestration or terrestrial sequestration nearby while others did. When told that the projects would last on the order of 25-50 years, none of the participants minded. Some participants stated that they would be concerned if the projects didn't last a long time. A range of

opinions were expressed concerning the construction of a pipeline infrastructure, from concern about the degradation of the landscape to no concern at all.

### **SECTION 5: Contact information**

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Thank you for participating in our study!

If you have any questions about this research, please do not hesitate to contact me. I may be reached by telephone at (510) 316-1631 or via email at [gwongpar@berkeley.edu](mailto:gwongpar@berkeley.edu). If you have any question regarding your treatment or rights as a participant in this research project, please contact the University of California at Berkeley's Committee for the Protection of Human Subjects at (510) 642-7461 or [subjects@berkeley.edu](mailto:subjects@berkeley.edu).

If you would like to know more about our graduate group please visit our website at <http://socrates.berkeley.edu>