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Community Acceptance of Carbon Capture and Sequestration Infrastructure: Siting Challenges

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Community Acceptance of Carbon Capture and Sequestration Infrastructure: Siting Challenges

Summary

Congressional policy makers are becoming aware that a national program of carbon capture and sequestration could require an extensive new network of carbon-related infrastructure. Carbon capture and sequestration (CCS) is a three-part process involving a carbon dioxide (CO_2) source facility, CO_2 pipelines, and a permanent CO_2 sequestration site. A key consideration in the development of such infrastructure is community acceptance, which may ultimately determine whether, where, and how anticipated CCS projects may be built. Although the general public is still largely unfamiliar with CCS, there are early indications that community acceptance may prove a significant challenge to the siting of CCS infrastructure in the United States.

Recent federal statutes and legislative proposals related to CO_2 control have only obliquely addressed public acceptance of CO_2 infrastructure or related siting issues. The Energy Independence and Security Act of 2007 (P.L. 110-140) requires a report recommending procedures for "public review and comment" and protection of "the quality of natural and cultural resources" related to the siting of sequestration projects on public land. The Lieberman-Warner Climate Security Act of 2008 (S. 3036) would require a CCS construction feasibility study examining "any barrier or potential barrier ... including any technical, siting, financing, or regulatory barrier" relating to the development of CO_2 pipelines or geological sequestration sites for CCS. The Carbon Capture and Storage Technology Act of 2007 (S. 2323) would fund CCS demonstration projects in locations that "represent a range of population densities" and are "in close proximity to ... utilities and industrial settings."

Community acceptance studies in the United States and other developed countries are limited and based largely on hypothetical CCS scenarios and infrastructure choices. The research available suggests that the public is ambivalent towards CCS. At the policy level, this ambivalence may cause concern among legislators seeking to promote carbon control strategies that could impose significant costs on local communities or the U.S. economy overall. At the project level, this ambivalence may become outright opposition as community residents incorporate local considerations in their evaluation of a proposed CCS development.

If carbon control and associated CCS policies were narrowly targeted, or expected to have only marginal impacts on the U.S. energy sector, Congress might choose to defer consideration of community acceptance issues until CCS technologies were more mature and states had more time to work out CCS siting problems. But understanding public acceptance of CCS takes on greater urgency in light of proposals to curb CO_2 emissions quickly and the scale of CCS infrastructure required to do so. The most prominent CO_2 proposals in the 110th Congress seek reductions of nationwide CO_2 emissions to 1990 levels or lower by 2030. Given such goals for reducing U.S. emissions of CO_2, and the potential contribution of CCS to reaching them, the issue of community acceptance of CCS infrastructure may prove challenging.

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Community Acceptance of Carbon Capture and Sequestration Infrastructure: Siting Challenges

Introduction

Congress is considering policies to reduce U.S. emissions of carbon dioxide, a major contributor to global warming. These policies include promoting the capture and sequestration of carbon dioxide (CO_2) from manmade sources such as electric power plants and manufacturing facilities. Carbon capture and sequestration (CCS) is a three-part process involving a CO_2 source facility, an intermediate mode of CO_2 transportation (pipelines), and a permanent CO_2 sequestration site. CCS is of great interest because emerging technologies may be able to remove up to 95% of CO_2 emitted from an electric power plant or other industrial source. Power plants are the most likely initial candidates for CCS because they are predominantly large, single-point sources, and they contribute approximately one-third of U.S. CO_2 emissions from fossil fuels.

As U.S. carbon policies evolve, congressional policy makers are becoming aware that a national CCS program could require an extensive new network of CO_2-related infrastructure. In the 110th Congress, there has been considerable debate and legislative activity related to the technical, economic, and regulatory aspects of such infrastructure. Another key consideration, however, is public acceptance, which may ultimately determine whether, where, and how anticipated CCS projects may be constructed. Although the general public is still largely unfamiliar with CCS, there are early indications that — similar to the siting of other kinds of energy and industrial infrastructure — community acceptance may prove a significant challenge to the siting of CCS infrastructure in the United States.

Recent federal statutes and legislative proposals related to CO_2 control have only obliquely addressed public acceptance of CO_2 infrastructure or related siting issues. One provision in the Energy Independence and Security Act of 2007 (P.L. 110-140), for example, requires a report recommending procedures for "public review and comment" and protection of "the quality of natural and cultural resources" related to the siting of sequestration projects on public land (Sec. 714(b)(3)). The Lieberman-Warner Climate Security Act of 2008 (S. 3036) would require a CCS construction feasibility study examining "any barrier or potential barrier ... including any technical, siting, financing, or regulatory barrier" relating to the development of CO_2 pipelines or geological sequestration sites for CCS (Sec.

8003(b)(1)).[1] The Carbon Capture and Storage Technology Act of 2007 (S. 2323) would fund CCS demonstration projects in locations that "represent a range of population densities" and are "in close proximity to ... utilities and industrial settings" (Sec. 3(d)). Other legislative proposals for carbon control have no apparent provisions relating to public acceptance.

This report discusses the possible role public and community acceptance may play in the siting of CO_2 infrastructure for CCS. The report reviews what is known about public opinion of CCS as an overall strategy to combat climate change. The report examines community acceptance of CO_2 emissions controls, pipelines, and sequestration sites based on analogies, CO_2 experience, and focused research. It also discusses community acceptance issues related to selected alternatives to CCS policies, such as investment in renewable energy infrastructure and nuclear power. The report introduces key CCS policy considerations as Congress continues to evaluate opportunities and requirements for carbon control.

Background

Public acceptance has long posed challenges to energy infrastructure development in the United States. A lack of public acceptance is often cited, for example, as one reason why no oil refineries have been constructed in the United States since 1976, and no nuclear power plants have been ordered since 1973.[2] In 2001, a representative of the National Association of Regulatory Utility Commissioners (NARUC) testified before Congress that "the main impediment to siting energy infrastructure is the great difficulty getting public acceptance for needed facilities."[3] Likewise, the National Commission on Energy Policy (NCEP) stated in its 2006 report that energy-facility siting is "a major cross-cutting challenge for U.S. energy policy," largely because of public opposition to new energy projects and other major infrastructure.[4] In 2008, public acceptance remains an overriding concern in proposals by energy companies to site electric power transmission lines, liquefied natural gas (LNG) terminals, natural gas pipelines, wind farms, and other energy facilities in many parts of the country.

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[1] The Carbon Dioxide Pipeline Study Act of 2007 (S. 2144) also contains these provisions (Sec. 2(b)(1)).

[2] Jad Mouawad, "No New Refineries in 29 Years? There Might Well Be a Reason," *New York Times* (May 9, 2005); Marco Guigni, *Social Protest and Policy Change: Ecology, Antinuclear, and Peace Movements in Comparative Perspective*, Rowman and Littlefield, Lanham, MD (2004): 43-45.

[3] William M. Nugent, First Vice President, National Association of Regulatory Utility Commissioners, Testimony before the Senate Energy and Natural Resources Committee hearing on Federal, State, and Local Impediments to Siting Energy Infrastructure (May 15, 2001).

[4] National Commission on Energy Policy, *Siting Critical Energy Infrastructure: An Overview of Needs and Challenges*. (Washington, DC: June 2006): 1. (Hereafter referred to as NCEP 2006.)

Faced with substantial public opposition, many energy infrastructure projects viewed by policy makers to be in the national interest have been cancelled by developers or have failed to win state or local siting approval. Reacting to such failures over the years, Congress has occasionally enacted statutes intended to help developers overcome community opposition to energy projects. In 1947, for example, Congress amended the Natural Gas Act (P.L. 75-688) to grant federal eminent domain authority to interstate natural gas pipeline developers seeking to secure rights of way from unwilling landowners (15 U.S.C. § 717f(h)). The Trans-Alaska Pipeline Authorization Act of 1973 (P.L. 93-153) stopped regulatory and legal challenges to the Trans-Alaska Pipeline project brought by environmental, native American, and community opponents. The Energy Policy Act of 1992 (P.L. 102-486) streamlined the federal licensing process for new nuclear power plants, in part to ensure that community siting concerns would be addressed prior to plant construction (Sec. 2801, 2802). Most recently, Congress passed the Energy Policy Act of 2005 (P.L. 109-58), which increased federal authority to approve interstate electric transmission projects (Sec. 1221) and granted federal regulators "exclusive" authority to approve the siting of onshore LNG terminals (Sec. 311).

Notwithstanding federal siting legislation, community stakeholders retain many statutory and regulatory avenues to affect energy infrastructure siting decisions. These include public input to state permitting under federal statutes such as the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.), the Clean Air Act (42 U.S.C. 7401 et seq.), and the Federal Water Pollution Control Act (33 U.S.C. 251 et seq.), among others. Community groups also have a role in siting reviews such as those in P.L. 109-58 which require federal regulators to consult with governor-designated state agencies regarding state and local safety considerations prior to issuing LNG terminal permits (Sec. 311(d)). Local zoning and land use regulations, in particular, have been widely used by communities to influence or block energy infrastructure development.[5]

Since public acceptance has influenced the development of virtually every category of U.S. energy infrastructure, it is logical to consider how the public may view future infrastructure specifically associated with CCS. As one analyst has stated,

> [t]here is good reason to be concerned over public perception of CCS; lack of information will prevent a balanced evaluation of its costs and benefits. It may also create exaggerated perceptions of risk which can delay or stop implementation of this new technology.[6]

Consideration of this issue can be divided into two separate but related dimensions — public acceptance of CCS as an overall national policy, and public (or community) acceptance of specific CCS facilities.

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[5] See, for example: Michele Morgan Bolton, "Power Plant Fight Spreads," *The Boston Globe* (January 31, 2008).

[6] Jeffrey Logan, Andrea Disch, Kate Larsen, and John Venezia, "Building Public Acceptability for Carbon Capture and Sequestration" (World Resources Institute: October 2007): 2.

Public Acceptance of CCS Technology

One factor that determines whether community stakeholders accept a new energy technology is whether they view it as consistent with broad policy objectives they support. For example, residents of Searsburg, VT, have supported local wind farm development primarily because they believe wind power does not pollute the environment.[7] Community groups oppose a proposed coal gasification power plant in Edwardsport, IN, because they prefer investments in electricity conservation and renewable energy sources.[8] Other community groups oppose a proposed LNG terminal off the southern California coast, in part, because they believe it would increase U.S. dependence on foreign energy supplies.[9] In such cases, the nature of the proposed technology from a broad policy perspective has been a separate consideration from its particular location or operational characteristics.

Although the 110th Congress has been debating the need for carbon control, studies in the United States and other developed countries considering CCS policies shows that "the vast majority of the public is not aware of carbon capture and sequestration, and even fewer understand the technology and its risks."[10] Consequently, research on public acceptance of CCS is limited and based largely on hypothetical scenarios and infrastructure choices. Nonetheless, policy researchers have begun to identify likely attitudes among members of the public who learn about CCS technology. Their findings are mixed. A 2007 study in Australia found that, although most people believe it is very important to reduce greenhouse gas emissions at a national level, many are "neutral" towards CCS as a strategy to do so. This study found that approximately 40% of the public believes CCS would be "a quick fix that would not solve the greenhouse gas problem."[11] A 2007 study in France found only a 38% approval rate for CCS after presenting survey subjects with explanations of both CCS technology and its potential adverse consequences.[12] A 2006 study in the Netherlands reported that "after processing relevant information, people are likely to

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[7] J.F. Palmer, "Public Acceptance Study of the Searsburg Wind Power Project: Year One Post-Construction," Report No. EHWF-TC-5, prepared by Clinton Solutions (Fayetteville, NY: December 1977). [http://www.easthavenwindfarm.com/filing/high/ehwf-tc-5.pdf]

[8] Citizens Action Coalition of Indiana, "Public Opposition to Proposed Duke Coal-Fired Power Plant," (Indianapolis, IN: August 31, 2007). [http://www.citact.org/newsite/modules.php?op=modload&name=News&file=article&sid=245&mode=thread&order=0&thold=0].

[9] No Way on OceanWay Coalition, "Ten Reasons to Oppose LNG," Web page, (Santa Monica, CA: April 4th, 2008). [http://www.nowayonoceanway.org/2.html]

[10] Jeff Logan, et al.(World Resources Institute: October 2007): 2.

[11] Evonne Miller, Lorraine Bell, and Laurie Buys, "Public Understanding of Carbon Sequestration in Australia: Socio-Demographic Predictors of Knowledge, Engagement and Trust," *Australian Journal of Emerging Technologies and Society* (Vol.5, No. 1, 2007).

[12] Minh Ha-Duong, Alain Nadai, and Ana Sofia Campos, "A Survey on the Public Perception of CCS in France" (Centre International de Recherche sur l'Environnement et le Développement, Nogent-sur-Marne, France: December 21, 2007). [http://halshs.archives-ouvertes.fr/halshs-00200894]

agree with large scale implementation" of CCS.[13] A 2005 survey of the Canadian public reported that respondents overall were "slightly supportive" of CCS in Canada.[14] A 2004 study in the United States by Carnegie Mellon University found that people were significantly less willing to pay for CCS than for any other major option to reduce CO_2 emissions — including new nuclear power plants.[15] A 2004 study in the United Kingdom found "slight support" for CCS in concept, but also a belief that, as a stand-alone policy, "CCS might delay more far-reaching and necessary long-term changes in society's use of energy."[16] Other researchers report similarly mixed findings, although specific study methodologies differ so it is difficult to draw clear conclusions from the overall body of research to date.[17]

Public acceptance of CCS policies is complicated by public views of climate change as a global phenomenon. Notwithstanding recent science studies and public information campaigns about the effects of greenhouse gas emissions on climate change, parts of both the science community and the general population reject arguments that global warming is a problem requiring greenhouse gas mitigation.[18] For example, a 2006 survey by MIT found that only 61% of the U.S. public believed action should be taken to address global warming.[19] Another national survey in May, 2008, found that while 71% of Americans believe there is "solid evidence" of global warming, only 47% believe "the earth is warming because of human activity such

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[13] M. de Best-Waldhober and D. Daamen, *Public Perceptions and Preference Regarding Large-Scale Implementation of Six CO_2 Capture and Storage Technologies: Well-Informed and Well-Considered Opinions versus Uninformed Pseudo-Opinions of the Dutch Public* (Leiden University, Leiden, The Netherlands: 2006): p 249.

[14] Jacqueline Sharp, Mark Jaccard, and David Keith, "Public Attitudes Toward Geological Disposal of Carbon Dioxide in Canada," Report No. 384 (Simon Fraser University, Burnaby, BC, Canada: Fall 2005).

[15] Claire R. Palmgren, M. Granger Morgan, Wandi Bruine De Bruin, and David Keith, "Initial Public Perceptions of Deep Geological and Oceanic Disposal of Carbon Dioxide," *Environmental Science & Technology* (Vol. 38, No. 24, 2004): 6448.

[16] Simon Shackley, Carly McLachlan, and Clair Gough, "The Public Perceptions of Carbon Capture and Storage," (Tyndall Centre for Climate Change Research, Working Paper 44: January 2004): 2. [http://www.tyndall.ac.uk/publications/working_papers/wp44.pdf]

[17] See, for example: D.T. Reiner, M. de Figueiredo, H. Herzog, S. Ansolabehere, K. Itaoka, M. Akai, F. Johnsson, and M. Odenberger, "An International Comparison Of Public Attitudes Towards Carbon Capture and Storage Technologies," Presented at the 8th International Conference on Greenhouse Gas Control Technologies (Trondeim, Norway: June 19-22. 2006). [http://sequestration.mit.edu/pdf/GHGT8_Reiner.pdf]

[18] See, for example: Sharon Begley, "The Truth About Denial," *Newsweek* (Aug 13, 2007); Arthur B. Robinson, Noah E. Robinson, and Willie Soon, "Environmental Effects of Increased Atmospheric Carbon Dioxide," *Journal of American Physicians and Surgeons* (No. 12: 2007): 79-90; and Andrew C. Revkin, "Skeptics on Human Climate Impact Seize on Cold Spell," *New York Times* (March 2, 2008).

[19] T.E. Curry, S. Ansolabehere, and H. Herzog, "A Survey of Public Attitudes towards Climate Change and Climate Change Mitigation Technologies in the United States: Analysis of 2006 Results," MIT LFEE 2007-1-WP (Massachusetts Institute of Technology: April 2007): 16. [http://sequestration.mit.edu/pdf/LFEE_2007_01_WP.pdf]

as the burning of fossil fuels."[20] This survey further notes that "[o]pinions about the primary cause of global warming have remained stable in recent years."[21]

Taken together, the studies above suggest that the public is ambivalent towards CCS as an overall carbon control technology. At the policy level, this ambivalence may cause concern among legislators seeking to promote carbon control strategies that could impose significant costs on local communities or the U.S. economy overall. At the project level, this ambivalence may become outright opposition as community residents incorporate local considerations in their evaluation of a proposed CCS development. To the extent that members of the public reject assertions that human activity is responsible for a rise in global temperature, or that such a rise requires intervention by the United States, policy makers may face difficulty convincing communities that CCS is necessary to begin with. Project-specific considerations are further discussed in the following section.

Community Acceptance of CCS Infrastructure

Another factor influencing how public stakeholders may view an energy facility is their assessment of its potential negative community impacts (e.g., property values, environmental effects, safety) balanced against local benefits (e.g., jobs, tax revenues).[22] In the case of CCS, three main categories of facility may be involved: power plants with CO_2 capture technology, transportation pipelines, and underground sequestration sites. Although it is necessary to integrate these three types of infrastructure to implement CCS, they are physically distinct and so present different challenges related to siting and community acceptance. Unfortunately, there is almost no publicly available research about community attitudes towards these three infrastructure categories specifically in the context of CCS. Policy makers must, therefore, draw inferences about CCS infrastructure from experience with similar infrastructure in applications analogous to CCS. While not perfect comparisons, these analogies may offer valuable insights into the potential reactions of affected communities to the siting of CCS facilities.

Power Plants with CO_2 Controls

Community acceptance of electric power plants has been a concern of policy makers and plant developers for decades. As early as 1970, one legal analyst observed that "[e]lectric power projects across the nation have been attacked by a

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[20] Pew Research Center for the People & the Press, "An Increase in GOP Doubt About Global Warming Deepens Partisan Divide," Internet publication (May 8, 2008). [http://pewresearch.org/pubs/828/global-warming]

[21] Ibid.

[22] See, for example: "With Sparrows Point LNG Application in Hand, FERC Considers Project as Resistance Hardens," *Inside F.E.R.C.* (January 15, 2007).

worried and frustrated public."[23] Community scrutiny of, and opposition to, new power plant proposals has evolved since then, along with federal, state, and local policy approaches to address them. Detailing these approaches is beyond the scope of this report, but they have met with only limited success. Power plant projects, particularly coal-fired projects, throughout the United States continue to struggle for siting approval, in part because communities where they would be located often do not want them.[24]

If the public views CO_2 capture-capable power plants in the same way it has conventional power plants in the past, it seems likely that the former will face the same sorts of community acceptance barriers as the latter, and for many of the same reasons. The fact that CCS power plants are intended to be "cleaner" may not matter. As the National Commission on Energy Policy points out, "new technology alone will not alleviate siting problems."[25] Indications to date suggest that this is likely to be the case. For example, one prominent community group in Minnesota opposes the proposed Mesaba coal gasification power plant, which is intended to be CO_2 "capture-ready," because the group believes the facility would "degrade recreational lake country," would pollute air and water, would require environmentally harmful coal mining, would be subsidized with public funds, and would force private landowners to accept associated network infrastructure (i.e., electric transmission lines, railroad connections, pipelines and roads).[26] Whether these objections are justified or not, they are the same types of objections often raised against conventional coal-fired power plants.

In addition to traditional considerations, the siting of power plants and CO_2 capture facilities under a CCS scheme may face new concerns stemming from changes in the physical configuration of power plants, or the processes they employ, to make carbon capture possible. While the ultimate characteristics of carbon-controlled power plants have yet to be determined because the capture technologies are still in development, new siting-related concerns are already apparent.

Plant Site Area. Power plants incorporating carbon capture may require a significantly larger site area than a conventional plant to accommodate the additional process facilities associated with CO_2 capture. Such facilities could include CO_2 compressors, scrubbers, oxygen production plants, or other carbon capture

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[23] Turner T. Smith, Jr., "Electricity and the Environment — The Generating Plant Siting Problem," *Business Law* (November 1970): 169.

[24] See, for example: David A. Fahrenthold, "Debating Coal's Cost in Rural Va.," *The Washington Post* (June 25, 2008); Michele Morgan Bolton, "Power Plant Will Figure in Campaigns," *Boston Globe* (May 1, 2008); Susan Moran, "Fight Against Coal Plants Draws Diverse Partners," *New York Times* (October 20, 2007).

[25] NCEP (2006): 2.

[26] Citizens Against the Mesaba Project (CAMP), "Mission Statement," Web page, (Grand Rapids, MN: June 2, 2008). [http://www.camp-site.info/about.html]

equipment.[27] Depending upon the capture technology employed, the site area required for the capture equipment may approach the size of the site area of the power generating plant itself.[28] This larger site requirement is a particularly important consideration for existing power plants. MIT researchers conclude that "additional space requirements for the CO_2 recovery and compression systems ... may cause difficulties for existing plants that do not have space readily available."[29] Furthermore, if net power production from the site must be maintained, construction of additional generating capacity on-site could be necessary to offset power losses in the capture process.[30] Power plant sites have expanded successfully in the past, for example, to add sulfur oxide (SO_x) control equipment (scrubbers). Nonetheless, to the extent an existing power plant would need to expand into adjacent communities or natural areas to add CO_2 equipment, such expansions could face community resistance.

Hazardous Materials. Certain carbon capture technologies may use or produce hazardous materials in large quantities. For example, a carbon capture demonstration project in Pleasant Prairie, WI, employs chilled ammonia to strip CO_2 from power plant combustion gases. At full scale, such a process would require tons of ammonia, which is listed as "highly hazardous" chemical under Occupational Safety and Health Administration (OSHA) regulations (29 C.F.R. 1910.119).[31] Ammonia in quantities exceeding 100,000 pounds (in aqueous solution), and therefore requiring risk management plans to be filed with the Environmental Protection Agency (EPA), is already found in nearly 300 U.S. power plants, where it is widely used in selective catalytic reduction (SCR) of nitrogen oxide (NO_x) emissions.[32] The Pleasant Prairie power plant itself has over a million tons of ammonia in its NO_x control equipment, unrelated to its CO_2 control demonstration equipment.[33] Furthermore, ammonia-based SCR may be required for any new coal-fired plants in order to meet federal clean air standards, with or without carbon capture. Nonetheless, perceived risks of an uncontrolled ammonia release from ammonia-based CO_2 capture facilities may increase opposition to the future siting of such facilities in populated areas. An early example of such opposition is a

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[27] R. Irons, G. Sekkapan, R. Panesar, J. Gibbins, and M. Lucquiaud, "CO_2 Capture Ready Plants," International Energy Agency, Report No. 2007/4 (May, 2007): ii.

[28] J. Gibbins, "Making New Power Plants 'Capture Ready'," Imperial College, Presentation to the 9th International CO2 Capture Network (London, England: June 16, 2006).

[29] Mark C. Bohm, Howard J. Herzog, John E. Parsons and Ram C. Sekar, "Capture-Ready Coal Plants — Options, Technologies and Economics," *International Journal of Greenhouse Gas Control* (Vol. 1, Issue 1: April 2007): 113-120.

[30] R. Irons, et al.(May, 2007): ii.

[31] The threshold quantity to be covered under this standard is 10,000 pounds.

[32] Risk management plans (RMPs) are required under the Clean Air Act, Section 112(r). The list of EPA hazardous chemicals and their threshold quantities is found at 40 CFR 68.130. Plant statistics are derived from CRS analysis of the EPA RMP*National Database (with off-site consequence analysis data), February 1, 2008. The EPA database is not publicly available.

[33] Ibid.

cogeneration power plant proposed in 1984 in Crockett, CA, but blocked by community groups, in part out of fear of ammonia release from the facility's SCR process.[34] Similar concerns about ammonia release are also reportedly among the reasons community groups currently oppose a new peaking power plant proposed in Billerica, MA.[35] There is at least one recent example of a community group formed specifically to oppose the use of a hazardous chemical (hydrogen fluoride) in the expansion of a local energy facility (a refinery).[36]

Amine-based CO_2 capture technologies, another post-combustion CO_2 capture option, may raise hazardous material concerns of a different kind. Amine-based systems may generate wastes in process chemical reclaimers which are "toxic to humans and the environment."[37] Among the chemicals found in such wastes are vanadium, antimony, and cyanide compounds — all listed as hazardous wastes by the Environmental Protection Agency (40 C.F.R. 261).[38] Amine-process hazardous wastes would need to be transported off-site by truck or rail and disposed of in suitable hazardous waste disposal facilities. Although process wastes are also generated by existing SO_x and NO_x emissions control systems, they are generally not classified as hazardous waste under federal regulation. Amine-process CO_2 capture plants may therefore face greater publicly scrutiny and opposition than SO_x and NO_x systems. Amine-based processes may ultimately not be the technology of choice for CCS, however, as they are potentially more expensive than ammonia-based or other CO_2 capture processes.

Chemicals Transportation. Power plants employing ammonia, amine, or other potentially hazardous chemicals as inputs to, or outputs from, their carbon capture processes may require new or substantially expanded transportation facilities to move those chemicals.

> These include product pipelines to get enormous volumes of ammonia, H_2S, and other chemical solvents to the new power plants for carbon separation. These are chemicals that have either never been used at power plants or never at this scale.... Like the creation of a national highway system for surface transportation of commodities and people, the new CCS technology at power plants will require a very sophisticated infrastructure of chemical products delivered by surface

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[34] Arthur O'Donnell, "NIMBY IV: Second Impressions About Crockett Cogeneration," *California Energy Markets* (October 9, 1992).

[35] Connie Paige, "Proposed Power Plant Faces Delays," *Boston Globe*, (February 21, 2008); Billerica Watchers Group, "!!Stop the Billerica Power Plant!!," Internet page (July 2, 2008). [http://stopthebillericapowerplant.org/]

[36] See, for example: Stacey Shepard, "Group Forms to Oppose Refinery Chemical," *The Bakersfield Californian* (Bakersfield, CA: April 8, 2008).

[37] B. Thitakamol, A. Veawab, and A. Aroonwilas, "Environmental Impacts of Absorption-based CO_2 Capture Unit for Post-combustion Treatment of Flue Gas from Coal-fired Power Plant," *International Journal of Greenhouse Gas Control* (Vol. 1:2007): 338; A.B. Rao and E. S. Rubin, "A Technical, Economic, and Environmental Assessment of Amine-based CO_2 Capture Technology for Power Plant Greenhouse Gas Control," *Environmental Science and Technology* (Vol. 36: 2002): 4467-4475.

[38] Ibid.

> shipping, barges and trains to CCS-equipped power plants. Some CCS plants may even require construction of chemical delivery pipelines that have traditionally only been constructed to serve refineries, natural gas production plants or other industrial facilities.[39]

While it is too soon to determine the specific nature and capacity of chemical transportation needs for future power plants with carbon capture capabilities, the safety and security of such transportation has been a prominent concern among the public.[40] Hazardous materials (HAZMAT) transportation security has also been a key concern of Congress, especially since the terror attacks of September 11, 2001. As the Senate Committee on Commerce, Science, and Transportation stated in a 2007 report, "[t]he majority of the over 2 billion tons of HAZMAT that move annually are transported by trucks, pipelines, and railroads, and such shipments present one of the most serious security concerns for the Nation."[41] Given these prominent and public concerns, the siting of chemicals transportation infrastructure for carbon-capture capable power plants may face potential opposition in communities where it is proposed.

CO_2 Pipelines for CCS

The energy industry has constructed nearly half a million miles of oil and gas transmission pipeline across the United States since the early 20th century.[42] Since the 1970s, the industry has also operated a limited CO_2 pipeline network in relatively remote areas of the Western United States, primarily to transport naturally-occurring CO_2 for use in underground injection for enhanced oil recovery (EOR). Experiences with natural gas pipelines are relevant to CCS because natural gas pipelines are similar in design to CO_2 pipelines, and therefore may be viewed in similar ways by the public with respect to siting. Furthermore, unlike the existing CO_2 pipeline network, natural gas pipelines are found throughout the country, including densely populated regions where new CO_2 pipelines may be needed for CCS. Experiences with CO_2 pipelines in EOR provide a record of siting in unpopulated areas, as well as statistics on network safety specific to CO_2.

As in the case of power plants, pipeline developers have faced local opposition to new pipeline development for many years. During the construction of the first major interstate oil pipeline in the United States (the Big Inch Pipeline) in 1942, developers had to acquire through eminent domain about 300 of the 7,500 properties

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[39] American Public Power Association, *APPA Comments to NERC on Reliability Impacts of Climate Change Initiatives* (July 16, 2008): 6.

[40] See, for example: *Citizens' Environmental Coalition, Toxic Trains and Public Safety in New York State: The Case for Urgent Action* (September 2007).

[41] Senate Committee on Commerce, Science, and Transportation, *Surface Transportation and Rail Security Act of 2007*, S.Rept. 110-29 (March 1, 2007): 8.

[42] Bureau of Transportation Statistics (BTS), "National Transportation Statistics," February 2008. [http://www.bts.gov/publications/national_transportation_statistics/html/table_01_10.html]. In this report "oil" includes petroleum and other hazardous liquids such as gasoline, jet fuel, diesel fuel, and propane, unless otherwise noted.

required for the pipeline right-of-way.[43] Through the 1940s and 1950s unwilling landowners along proposed pipeline routes continued to be an obstacle to siting, although their influence was limited and their interests usually focused more on financial compensation for rights-of-way than broader community concerns. In the 1960s, however, public acceptance started to have a markedly greater influence on the siting of pipelines in parts of the United States, largely due to perceived impacts of pipeline construction on the environment.[44] The encroachment of cities on historically remote pipeline rights-of-way subsequently heightened concerns about public safety. While many communities, especially in energy-producing regions, continued to support local pipeline development during this period, a gas pipeline industry survey in 1991 found that over a third of the public would object to having a long-distance pipeline sited in their neighborhood.[45] Accidents such as the 2000 natural gas pipeline explosion which killed 12 campers near Carlsbad, NM, and the 2006 BP Alaska oil pipeline leaks, which temporarily halted North Slope oil production, have aggravated public concern about pipeline safety in recent years.[46]

Despite public concerns about environmental impacts and public safety, new natural gas and oil pipelines continue to be sited in many parts of the United States. Indeed, according to the Energy Information Administration (EIA), nearly 1,700 miles of natural gas pipeline in at least 50 separate projects were completed in the Lower 48 States in 2007, primarily to serve new gas production areas.[47] Nonetheless, one result of public opposition has been to prevent new pipeline siting in certain localities, and to increase pipeline development time and costs in others. In a 2006 report, for example, the EIA stated that "several major projects in the Northeast, although approved by FERC, have been held up because of public opposition or non-FERC regulatory interventions."[48] In the specific case of the Millennium Pipeline, proposed in 1997 to transport Canadian natural gas to metropolitan New York, developers did not receive final construction approval for nine years, largely

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[43] Louis Berger Group, Inc., *The Big Inch and Little Big Inch Pipelines*, Produced for Texas Eastern Transmission Corp. (Houston, TX: May 2000): 19.

[44] For an early example, see Federal Power Commission, *Manufacturers Light & Heat Co*., 39 F.P.C. 294 (1968): 302.

[45] Roper Organization, "Public Attitudes Toward Natural Gas and Interstate Pipelines," Prepared for the INGAA Foundation, Inc. (New York, NY: May 15, 1991): 20-23.

[46] See, for example: Janet Zink, "Fueling the Resistance," St. Petersburg Times, December 16, 2007; W. Loy, "Slope Mayor Questions Leak Detection," *Anchorage Daily News*, March 14, 2006; J. Nesmith and R. K. M. Haurwitz, "Pipelines: The Invisible Danger," *Austin American-Statesman* (July 22, 2001)

[47] Energy Information Admin., *Natural Gas Year-In-Review* (March 2008): 6.

[48] Energy Information Admin., *Additions to Capacity on the U.S. Natural Gas Pipeline Network: 2005* (August 2006): 11.

because of community resistance to the pipeline route.[49] Numerous other proposed pipelines, especially in populated areas, have faced similar community barriers.[50]

CO_2 Pipeline Safety. CO_2 pipelines are built in almost exactly the same way as natural gas pipelines, so public acceptance issues related to their construction would likely reflect gas industry experiences. With respect to public safety, however, CO_2 pipelines for CCS could present new or unfamiliar risks. Although it is not combustible like natural gas, and so poses virtually no risk of fire or explosion, CO_2 is an asphyxiant listed as a Class 2.2 (non-flammable gas) hazardous material under Department of Transportation regulations (49 C.F.R. § 172.101). Furthermore, unlike natural gas, CO_2 is heavier than air, so its potential to accumulate in low-lying or enclosed spaces like basements or tunnels is a safety concern — especially for CO_2 pipelines passing through cities. As the Deputy Administrator of the Pipeline and Hazardous Materials Safety Administration (PHMSA) has testified before Congress, "a large, sudden release of ... CO_2 could have catastrophic consequences in a populated area."[51] Accordingly, PHMSA applies nearly the same safety requirements to CO_2 pipelines as it does to pipelines carrying hazardous liquids such as crude oil, gasoline, and anhydrous ammonia (49 C.F.R. § 195).

Based on the limited sample of CO_2 incidents to date, analysts conclude that, mile-for-mile, CO_2 pipelines appear to be safer than the other types of pipeline regulated by the federal government.[52] Nonetheless, if the network of CO_2 pipelines expands under CCS policies, analysts suggest that "statistically, the number of incidents involving CO_2 should be similar to those for natural gas transmission."[53] Overall, then, although CO_2 poses a somewhat different type of risk, CO_2 pipelines may appear to the general public to pose a similar *level* of risk as the natural gas pipelines with which it may be more familiar.

CO_2 Pipeline Siting Opposition. In remarks during a March 2008 congressional briefing on carbon control, Senator Jeff Bingaman, Chairman of the Senate Energy and Natural Resources Committee, stated that the development of CO_2 pipeline infrastructure was among his top three concerns in developing CCS policy.

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[49] Federal Energy Regulatory Commission (FERC), "Commission Approves Revised $1 Billion Millennium Pipeline Project to Bring New Gas Service to the Northeast," Press release (December 21, 2006). See, for example: Randal C. Archibold, "Fighting Plans for a Gas Pipeline: Not Under My Backyard," *New York Times* (August 7, 2001).

[50] Samantha Santa Maria, " Energy Projects: Rockies Express Add-on Pipe Projects Face Several Obstacles to Building in US Northeast," *Inside F.E.R.C.* (October 22, 2007).

[51] Krista L. Edwards, Deputy Administrator, Pipeline and Hazardous Materials Safety Administration, Testimony before the Senate Committee on Energy and Natural Resources Hearing on Carbon Capture, Transportation, and Sequestration and Related Bills, S. 2323 and S. 2144 (January 31, 2008).

[52] John Gale and John Davidson, "Transmission of CO_2 — Safety and Economic Considerations," *Energy*, Vol. 29, Nos. 9-10 (July-August 2004): 1326.

[53] J. Barrie, K. Brown, P.R. Hatcher, and H.U. Schellhase, "Carbon Dioxide Pipelines: A Preliminary Review of Design and Risks," Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies (Vancouver, Canada: September 5-9, 2004): 2.

According to Senator Bingaman, "there is a big problem with [CO_2] transportation in this country."[54] Almost no research, however, examines public attitudes specifically concerning CO_2 pipelines used for CCS. One relevant study in 2007 found that CO_2 pipeline safety and routing both had the potential to be negative drivers of public opinion.[55] The study reported "a common perception across stakeholder groups that siting CCS facilities, including pipelines, will be a major challenge."[56] Energy industry experts have expressed similar concerns that CO_2 pipelines for CCS would face growing public opposition not only in affluent communities but across a wide range of socioeconomic groups.[57]

Faced with community or landowner opposition, pipeline developers typically rely on eminent domain authority to secure pipelines rights-of-way. In the case of natural gas, companies seeking to build interstate pipelines must first obtain certificates of public convenience and necessity from FERC under the Natural Gas Act (15 U.S.C. §§ 717, et seq.). Such certification may include safety and security provisions with respect to pipeline routing, safety standards and other factors.[58] A certificate of public convenience and necessity granted by FERC (15 U.S.C. § 717f(h)) confers eminent domain authority.

There is no federal siting authority for oil pipelines, so interstate oil pipeline developers must secure rights of way under various state statutes. Likewise, interstate CO_2 pipelines developed for EOR purposes have been constructed under state statutes because federal agencies claim no siting jurisdiction for CO_2 pipelines. The Federal Energy Regulatory Commission (FERC) and the Surface Transportation Board (STB), the two most logical candidates for administering federal CO_2 pipeline siting authority, disclaimed jurisdiction over CO_2 pipeline siting nearly 30 years ago.[59] It is unclear, however, to what extent state eminent domain authorities would extend to CO_2 pipelines for CCS if a nationwide network of such pipelines were required. The state-by-state siting approval process for CO_2 pipelines also could be complex and protracted, and could face public opposition, especially in populated or environmentally sensitive areas. Consequently, members of Congress have

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[54] Senator Jeff Bingaman, Chairman, Senate Energy and Natural Resources Committee, Remarks before the Center for Strategic and International Studies briefing "Making CCS Work: Economics and Critical Issues" (Washington, DC: March 31, 2008).

[55] International Energy Agency, *Public Perception of Carbon Dioxide Capture and Storage: Prioritised Assessment of Issues and Concerns: Summary for Policy-Makers* (March 23, 2007): 12.

[56] Ibid: 6.

[57] Joel Kirkland, "Expansive Energy Agenda Hangs on Treatment of Public Opposition, Regulatory Hurdles," *Inside F.E.R.C.* (March 10, 2008): 16.

[58] 18 C.F.R. § 157.

[59] Notwithstanding the ICC's 1980 disclaimer, other evidence indirectly suggests the possibility that interstate CO_2 pipelines could still be considered subject to STB jurisdiction. For further discussion, see CRS Report RL34307, *Regulation of Carbon Dioxide (CO2) Sequestration Pipelines: Jurisdictional Issues*, by Adam Vann and Paul W. Parfomak.

expressed concern that federal siting authority for CO_2 pipelines might be required in the future.[60]

Pipelines vs. Power Lines. In light of costs and siting requirements for CO_2 pipelines, some analysts anticipate that a CO_2 network for CCS will begin with relatively short pipelines from CO_2 sources located close to sequestration sites.[61] This development approach would place CO_2 capture-capable power plants, for example, directly atop the largest saline aquifers and would transmit electric power to distant urban centers. Such power plants would be conceptually similar to existing coal-fired plants located directly adjacent to coal mines ("mine-mouth" plants) scattered throughout U.S. coal-producing regions. It is debatable whether CO_2 pipeline costs would generally outweigh electricity transmission costs (including capital, operations, maintenance, and electric line losses) in new construction.[62] Nonetheless, any CCS project requiring the construction of extensive new transmission infrastructure from remote to populated areas could face concerted community opposition to the siting of those transmission lines. Public challenges to electric transmission projects have long been considered among the most serious and most intractable challenges in the U.S. energy sector.[63] Such challenges continue to delay or prevent new transmission development in some regions despite the provisions in P.L. 109-58 intended to encourage the siting of new transmission lines.

Carbon Sequestration Sites

Carbon sequestration sites are similar in many ways to natural gas and oil production sites — only operating in reverse. Rather than extracting an underground resource, operators of sequestration sites inject CO_2 underground using technologies originally developed for the oil and gas industries and adapted for long-term sequestration and monitoring of CO_2. As stated earlier in this report, some oil fields already employ CO_2 injection to increase oil production. These injections are limited in scale and focused on the oil resource, but they may achieve substantial levels of permanent CO_2 sequestration as a by-product of the oil production process. A key difference is that enhanced oil recovery removes and recycles injected CO_2 by design, whereas a CCS project developed strictly for carbon control would not. Other underground injection applications in practice today, such as natural gas storage, deep injection of liquid wastes, and subsurface disposal of oil-field brines, may share similar characteristics with sequestering CO_2.

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[60] Senator Lisa Murkowski, Remarks during the Senate Committee on Energy and Natural Resources Hearing on Carbon Capture, Transportation, and Sequestration and Related Bills, S. 2323 and S. 2144 (January 31, 2008).

[61] John Deutch, Ernest J. Moniz, et al., *The Future of Coal*. (Cambridge, MA: Massachusetts Institute of Technology: 2007): 59.

[62] Jeffrey M. Bielicki and Daniel P. Schrag, "On the Influence of Carbon Capture and Storage on the Location of Electric Power Generation," Harvard University, Belfer Center for Science and International Affairs, Working paper (2006).

[63] Shalini P. Vajjhala, "Siting Difficulty and Transmission Investment,"*IAEE Energy Forum* (International Association for Energy Economics: 2nd Quarter 2008): 5-7; North American Electric Reliability Council, *2006 Long-Term Reliability Assessment* (October 2006): 22-23.

Oil and Gas Property Rights. The aspect of oil and gas field development — and, by extension, sequestration site development — which most significantly depends upon community acceptance is the acquisition of property rights. If an oil or natural gas deposit lies beneath private property, developers may need to lease mineral rights from hundreds, or even thousands, of landowners distributed across a large geographic area in order to produce oil or gas from that deposit.[64] Historically, most private landowners have been willing to lease their oil or natural gas rights in return for production royalties. As the American Association of Petroleum Geologists has stated, "[p]rivate lands have been largely explored and produced."[65] Consequently, some CCS proponents expect that private owners would be similarly inclined to lease "pore space" under their property for the purposes of permanent carbon sequestration.[66] Early indications, however, suggest that this may not generally be the case. For example, as the National Commission on Energy Policy (NCEP) states in its 2006 report,

> public opposition remains inextricably intertwined with local concerns, including environmental and ecosystem impacts as well as, in some cases, complex issues of property rights and competing land uses.... In some cases, upstream or downstream infrastructure requirements — such as the need for ... underground carbon sequestration sites ... may generate as much if not more opposition than the energy facilities they support.[67]

As with other CCS infrastructure, empirical research specifically about community attitudes towards sequestration sites is limited. The 2007 French study found that approximately 40% of survey subjects "would be afraid if CCS was to be used near their community."[68] A 2007 survey of citizens living near a potential sequestration site in the Netherlands found that "[p]eople judge the idea of storage in general as slightly positive, but when the technology enters peoples daily lives, as in storage nearby, the attitude becomes more negative."[69] A 2006 role-playing workshop by the World Resources Institute simulating a public hearing about a proposed sequestration site found that community members "were reluctant to be a 'guinea pig'" and reached a "consensus ... that the risks outweighed the benefits in

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[64] In "split-estates" mineral rights are legally separate from surface property rights and may be held by the federal or state government on lands with private surface owners.

[65] Lee C. Gerhard and Carl J. Smith, American Association of Petroleum Geologists (AAPG), "An Energy Policy for the United States of America," Final report of the AAPG President's Energy Policy Summit, (Army Navy Club, Washington DC: April 23, 2001). [http://dpa.aapg.org/testimonies/2001/010423_energysummit.cfm]

[66] Who owns pore space (i.e., sequestration rights) has not been established in most states. Wyoming statute H.B. 89 which passed in March 2008 assigns pore space ownership to the surface landowner.

[67] NCEP 2006: 9.

[68] Evonne Miller, et al. (2007).

[69] Nicole M.A. Huijts, Cees J.H. Midden, Anneleos L. Meijnders, "Social Acceptance of Carbon Dioxide Storage," *Energy Policy*, (Vol. 35 (5): May 2007): 2788.

the scenario presented."[70] The workshop also reported that "[i]t was clear some community representatives perceived CO_2 as a waste from the start," casting an overall negative light on the hypothetical carbon sequestration project.[71]

A few cases in the United States involving actual sequestration projects or related legislation have also demonstrated significant public opposition. In 1998, the Natural Energy Laboratory of Hawaii Authority abandoned an experiment to sequester CO_2 in the deep ocean, in part due to strong public outcry against the project.[72] Focus groups in 2007 in two California communities where actual sequestration sites were considered raised familiar concerns about community participation in siting decisions, along with fears that the sequestration projects may "risk ... carbon dioxide release, may lower property values, may 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 [would be] expensive."[73]

Notwithstanding the community resistance examples described above, some sequestration sites in the United States have secured sufficient community approval to begin development, at least for the purposes of technology demonstration. For example, prior to its restructuring in January 2008, the Department of Energy's (DOE) FutureGen demonstration project in Tuscola, IL, had acquired through voluntary agreement contiguous property rights from 42 private landowners in Illinois to develop a one square mile sequestration site for the project.[74] Some analysts caution, however, that the Tuscola sequestration site, while adequate for a demonstration project, is perhaps 10 to 100 times smaller than a full-scale, commercial sequestration site might need to be to serve a single large coal-fired power plant (emitting over 10 million metric tons of CO_2 annually).[75] Furthermore, compensation for these rights, at $1000 per acre of surface land, was at a premium and based on existing surface property values rather than a valuation factor linked to

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[70] World Resources Institute, "Carbon Capture and Storage Project Siting Role Play Scenario Workshop," Meeting notes (October 20, 2006): 4. [http://pdf.wri.org/ccs_siting_workshop_summary_110806.pdf]

[71] Ibid: 5.

[72] Mark A. de Figueiredo, *The Hawaii Carbon Dioxide Ocean Sequestration Field Experiment: A Case Study in Public Perceptions and Institutional Effectiveness*, Master's thesis, (Massachusetts Institute of Technology, Laboratory for Energy and the Environment: June 2003). [http://sequestration.mit.edu/pdf/defig_thesis.pdf]

[73] Gabrielle Wong-Parodi, Isha Ray, and Alex Farrell, "Community Perceptions of CCS in California's Central Valley," Unpublished memorandum to CRS (Energy and Resources Group, Univ. of California, Berkeley: April 8, 2008). This study did not report quantitative measures of support or opposition to the proposed sequestration sites.

[74] Alta Long, Treasurer and Brian Moody, Office of Economic Development, City of Tuscola, Illinois, Personal communication (July 9, 2008). The original concept for the FutureGen project was subsequently canceled by the Department of Energy for costs reasons.

[75] See CRS Report RL34316, *Pipelines for Carbon Dioxide (CO2) Control: Network Needs and Cost Uncertainties*, by Paul W. Parfomak and Peter Folger.

CO_2 or pore space value. Some analysts have also indicated that local property owners were eager to sign pore space contracts in part to ensure the development of the power plant complex in their community, which they believed would provide direct benefits to community members apart from sequestration payments.[76] Due to these factors, it is unclear whether the Tuscola sequestration site acquisition would be representative of sequestration site development in commercial operations.

Compulsory Unitization. Oil and gas production reservoirs, and other geologic formations into which CO_2 might be injected, are typically continuous bodies of porous rock that extend beneath large geographic areas deep (1,000 feet or more) underground. In addition to the issue of landowners' willingness to lease sequestration rights, developers must also be concerned about the physical configuration of the rights they must acquire. The most economically efficient, and least environmentally impactful, way to produce oil from a large natural deposit is to do so by means of a single operator treating that deposit as a geophysical whole, rather than as artificially independent fragments delineated by property boundaries. Where an oil deposit is spread out beneath multiple parcels of private land, an energy company may therefore seek to acquire the rights to *all* (or nearly all) such parcels to form a contiguous production "unit." The acquisition and development of a deposit in this way is called "unitization," and has been practiced in the oil industry since the 1940s.[77]

Unitization agreements are typically negotiated as private, voluntarily agreements between an operator and multiple minerals rights owners.[78] However, nearly all oil- and natural gas-producing states also have compulsory unitization laws requiring unwilling landowners to join a production unit if a sufficient percentage of other potential unit members voluntarily do so.[79] The minimum percentage required may range from 51% to 80% of unit property owners, depending upon the state.[80] Compulsory unitization laws facilitate the establishment of production units over property owner objections, although they do not guarantee them. According to some analysts, even with such statutes, "unitization is still an arduous, if not impossible,

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[76] R. Lee Gresham, Carnegie Mellon Univ., Dept. of Engineering and Public Policy, Personal communication (June 24, 2008).

[77] Steven N. Wiggins and Gary D. Libecap, "Oil Field Unitization: Contractual Failure in the Presence of Imperfect Information," *The American Economic Review*, Vol. 75, No. 3 (June 1985): 368. "Pooling" is a similar arrangement of combining mineral interests for production efficiency, but it does not necessarily take into account the geophysical configuration of the oil deposit.

[78] Andrew B. Derman, Thomas & Knight, L.L.P., "Unitization," FindLaw Library (2003). [http://library.findlaw.com/2003/Jan/30/132512.html]

[79] One exception is Texas.

[80] Interstate Oil and Gas Compact Commission, *IOGCC Model Statute and Fieldwide Unitization References* (1999): 9. [http://www.iogcc.state.ok.us/Websites/iogcc/docs/iogcc_model_statute_and_fieldwide_unitization_references.pdf]

task" in states with high threshold percentages.[81] Reaching agreement on unit contracts, therefore, can be a complex and protracted process, with negotiations taking years and often failing to achieve the most efficient unit sizes.[82]

Oil and gas industry experience with compulsory unitization is important in the CCS context because analysts anticipate "that a similar unitization process will need to be developed prior to large-scale injection of CO_2 for sequestration in geological formations."[83] An Interstate Oil and Gas Compact Commission task force examined this issue in proposing model CCS regulations in 2007.

> The Task Force concluded that control of the reservoir and associated pore space used for CO_2 storage is necessary to allow for the orderly development of a storage project.... The Model General Rules and Regulations propose the required acquisition of these storage rights and contemplates use of state natural gas storage eminent domain powers or oil and gas unitization processes to gain control of the entire storage reservoir.[84]

A unitization requirement for CO_2 may stem from sequestration efficiency considerations, CO_2 trespass concerns, or the co-location of pore space and natural gas or oil. Trespass may be important because CO_2 injected underground could spread in unanticipated ways through a geological formation with no way to prevent its entering the pore space of any particular landowner located within that formation. In locations where a subset of relevant landowners is unwilling to lease its pore space, for example, disputes about subterranean CO_2 trespass could hamper sequestration field development.[85] The presence of oil or gas may be important because it may require a site to be developed in compliance with long-standing mineral statutes, including mineral resource unitization statutes, along with CO_2 statutes. The New Mexico Energy, Minerals, Natural Resources Department's Oil Conservation Division (OCD) has identified these issues as potential barriers to carbon sequestration site development.

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[81] Jacqueline Lang Weaver and David F Asmus, "Unitizing Oil and Gas Fields Around the World: A Comparative Analysis of National, Laws and Private Contracts," *Houston Journal of International Law* (March 22, 2006).

[82] Gary B. Libecap, "Unitization," *The New Palgrave Dictionary of Economics and the Law* (Peter Newman, Ed.), Macmillan Press (London: 1998).

[83] Plains CO_2 Reduction (PCOR) Partnership, *Plains CO_2 Reduction (PCOR) Partnership (Phase I) Final Report/July — September 2005 Quarterly Report* (January 2006): 34. [http://www.undeerc.org/PCOR/products/pdf/finalreport.pdf]

[84] The Interstate Oil and Gas Compact Commission (IOGCC), Task Force on Carbon Capture and Geologic Storage, *Storage of Carbon Dioxide in Geologic Structures: A Legal and Regulatory Guide for States and Provinces*, (September 25, 2007): 4. [http://www.eei.org/meetings/nonav_2007-10-18-km/CCS_IOGCClegalregulGuideExecSumm.pdf]

[85] For legal discussion of CO_2 trespass and related property issues, see Mark A. de Figueiredo, "Property Interests and Liability of Geologic Carbon Dioxide Storage," (MIT Carbon Sequestration Initiative: September 2005). [http://sequestration.mit.edu/pdf/deFigueiredo_Property_Interests.pdf]

> This may prove an unacceptable means of blocking planned sequestration projects, as minority interests could refuse to ratify unitization orders, making operation of the unit as a sequestration field difficult. Nonunitized interests may have available to them legal remedies such as nuisance and trespass actions for any provable interference with their mineral production.[86]

A further challenge associated with a unitization requirement for CO_2 sequestration sites is the applicability of state compulsory unitization statutes to CCS. Because such statutes typically have been enacted specifically for oil and natural gas extraction, it is unclear to what extent they could be applied to CO_2 injection into formations not associated with oil or natural gas, such as deep saline aquifers. For example, New Mexico's oil and gas statutes cover the production of "natural gas" or "gas" defined as "any combustible vapor composed chiefly of hydrocarbons occurring naturally in a pool."[87] This definition would not seem to apply to CO_2. Accordingly, New Mexico regulators have concluded that "there exists no clear authority for the state to regulate anthropogenic CO_2 injection for sequestration purposes alone, nor does it have general authority to regulate injection/sequestration of CO_2 ... into reservoirs other than those that produce oil and gas."[88]

By comparison, West Virginia's statutes apply to "natural gas and all other fluid hydrocarbons not defined as oil," without defining "natural gas" in a way which clearly excludes CO_2.[89] The state's unitization statute applies to a "pool," defined as "an underground accumulation of petroleum or gas in a single and separate natural reservoir."[90] The statute appears ambiguous as to whether CO_2 is a covered "gas" and whether a sequestration site is a "natural reservoir." In states without any unitization statutes, or where existing unitization statues do not clearly apply to CO_2, community opponents of sequestration projects may therefore litigate to prevent the voluntary or compulsory unitization of pore space rights necessary for site development.

Eminent Domain for Natural Gas Storage. Another potential analog to CO_2 sequestration is underground natural gas storage used by the natural gas industry to manage seasonal variations in natural gas demand. Most natural gas storage occurs in underground reservoirs. Developers have constructed over 400 such storage sites in the lower 48 states, primarily in depleted natural gas fields in Appalachia and the south-central states, as well is in aquifers in the Midwest.[91] Like other categories of energy infrastructure, some proposed natural gas storage projects

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[86] New Mexico Energy, Minerals, Natural Resources Department, Oil Conservation Division "A Blueprint for the Regulation of Geologic Sequestration of Carbon Dioxide in New Mexico," (December, 2007): 36.

[87] New Mexico Administrative Code § 19.15.1.7 N.(1)

[88] New Mexico Energy, Minerals, Natural Resources Department (December, 2007): 5.

[89] West Virginia Code § 22C-9-2(a)(8).

[90] West Virginia Code § 22C-9-2(a)(9).

[91] Energy Information Administration, *U.S. Underground Natural Gas Storage Developments: 1998-2005* (October 2006): 1.

have faced determined community opposition, which has prevented their construction or added years to their development time.[92]

Although gas storage developers may encounter community opposition, they, nonetheless, continue to open new storage facilities throughout the country. According to the EIA, at least 26 new storage sites began operation over the last 10 years.[93] Developers have been aided in these efforts by eminent domain statutes at the federal or state levels which authorize the taking of private property needed for a storage project if regulators deem it in the public interest. For projects involving interstate gas trade, eminent domain authority resides with the Federal Energy Regulatory Commission, which approves the siting of natural gas storage facilities under Section 7 of the Natural Gas Act.[94]

Some analysts have proposed applying existing eminent domain statutes to secure privately-owned pore space for sequestration sites. However, eminent domain is often perceived negatively by the general public, and thus might undermine public support for CCS in general if widely invoked.

> Use of 'public utility' classifications and eminent domain to ensure construction on behalf of unregulated profit-making entities raises significant issues of fairness and process. Even in cases where property owners come to terms with developers, the community as a whole or other individuals may suffer uncompensated and persistent impacts.[95]

Furthermore, as in the case of compulsory unitization, it is unclear to what extent statutes enacted to support natural gas storage siting could be applied to CO_2 sequestration sites. Ambiguity in state statutes about eminent domain authority for CCS projects could lead to costly and time-consuming litigation by community opponents.

Key Policy Issues for Congress

Congressional consideration of potential CCS policies is still evolving, but so far initiatives have focused more on CCS technology and economic mechanisms for

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[92] See, for example: Patrick Courreges, "Lake Peigneur Residents Celebrate," *The Baton Rouge Advocate* (June 19, 2008): 1BA; Avondale — Glen Elder Neighborhood Assoc., *Application of Sacramento Natural Gas Storage, LLC, for a Certificate of Public Convenience and Necessity for Construction and Operation of Gas Storage Facilities and Requests for Related Determinations, Protest of Avondale — Glen Elder Neighborhood Association,* Before the Public Utilities Commission of the State of California, Application No. 07-04-013 (January 24, 2008). [http://docs.cpuc.ca.gov/efile/ST/83384.pdf]

[93] Energy Information Administration, *U.S. Underground Natural Gas Storage Developments: 1998-2005* (October 2006): 1.

[94] 15 U.S.C. § 717; Application of this statute to natural gas storage is affirmed in *Columbia Gas Transmission Corp. v. An Exclusive Gas Storage Easement,* 776 F.2d 125, 129 (1985).

[95] Chris Deisinger, "The Backlash against Merchant Plants and the Need for a New Regulatory Model," *The Electricity Journal* (Vol 13, Issue 10: December 2000): 57.

carbon capture than on public acceptance and siting issues. Specific legislative proposals in the 110th Congress appear to reflect a perception that CO_2 capture represents the largest physical hurdle to implementing widespread CCS, and that CO_2 siting may not present as significant, or immediate, a barrier. While these perceptions may be accurate, experience with the siting of other energy infrastructure in the United States suggests that, sooner or later, potential community opposition to CCS projects may become a factor. Industry and regulatory analysts have already identified several key policy issues related specifically to pubic acceptance of CCS infrastructure which may require congressional attention.

Community Acceptance and State Statutory Changes

Under current statutes, the federal government has limited authority to compel the siting of CCS infrastructure should the development of such infrastructure be hindered by community opposition. The siting of power plant facilities, pipelines, and sequestration sites required for CCS is principally under state jurisdiction. In many states, however, the applicability of existing oil, gas, and electric power siting statutes (especially public review, eminent domain, and compulsory unitization provisions) to CO_2 sequestration projects is unclear. Consequently, a congressionally-mandated CO_2 control policy which involves CCS may be critically dependent upon state legislatures to enact new CCS statutes in its support unless federal siting authorities are significantly expanded (see section on federal siting authority below).

Although many state policy makers have indicated a willingness to advance CCS, there are questions about how quickly, uniformly, or aggressively they will do so — in part due to community acceptance concerns. One state that has considered comprehensive CCS legislation is California. Proposed in 2007, California Assembly Bill 705 would have required the state to develop standards and regulations for geologic carbon sequestration. The bill was defeated largely due to opposition from citizens groups that asserted that sequestration policies under the bill could result in underprivileged communities inequitably bearing the environmental costs of carbon control (by being forced to accept local sequestration sites).[96] In March 2008, Wyoming began to establish a statutory framework for CO_2 injection and sequestration with the enactment of two carbon sequestration statutes (H.B. 89 and H.B. 90). The Wyoming statutes passed without significant public opposition — but they do not address property rights issues which are potentially contentious. Wyoming state legislators subsequently have rejected drafting legislation on eminent domain for CCS and have expressed reservations about provisions for "forced pooling" of sequestration sites.[97] Washington state has issued the nation's first

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[96] California State Assembly, Committee on Natural Resources, Hearing on Assembly Bill 705, Geologic Carbon Sequestration (Sacramento, CA: April 23, 2007): 6; Jane Williams, Executive Director, California Communities Against Toxics, "Carbon Sequestration: Injection of Toxic Gases into Poor Communities or the Salvation of the Fossil Fuel Industry, or Both?," *California Progress Report*, Internet publication (April 22, 2007). [http://www.californiaprogressreport.com/2007/04/carbon_sequestr.html]

[97] Wyoming State Legislature, Joint Judiciary Interim Committee meeting minutes (June 2-3,

(continued...)

regulatory standards for carbon sequestration sites (under existing environmental statutes), but they do not address property rights either.[98]

As the examples above show, community acceptance considerations may make the passage of state CCS statutes more complicated and potentially contentious than they might be otherwise. These complications may be exacerbated when they involve regional sequestration projects where CO_2 from one state would be transported through, or sequestered in, another. Some experts suggest that local constituencies, and the government officials representing them, could be less supportive of siting and eminent domain policies where in-state communities may bear CO_2 risks for the benefit of distant populations.[99] As Congress continues to refine U.S. policies for carbon control, it may wish to consider how community concerns may influence the ability of states to pass CCS legislation, and how such state legislative processes fit into a possible federal timetable for national CO_2 control.

Affecting Public Acceptance of CCS

Because the general public is still largely unfamiliar with CCS, there may be opportunities to influence public opinion in a way that could moderate community opposition to the siting of CCS infrastructure projects. Numerous commentators and stakeholders have called for proactive programs of public education and outreach to establish positive public views of CCS while opinions are still being formed. Consistent with this view, the seven regional partnerships in the Department of Energy's Regional Carbon Sequestration Partnerships (RCSP) initiative have each, to varying degrees, directed activities towards public acceptance of carbon sequestration. As one of these partnerships has stated, "[t]he limited public awareness of carbon capture and storage (CCS) offers ... an opportunity ... for introducing and presenting the issues related to CCS in a constructive, problem-solving mode."[100] To this end, the partnerships have used community web broadcasts, focus groups, fact sheets, town hall meetings, and a television documentary to convey the science behind carbon sequestration technologies to

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[97] (...continued)
2008). [http://legisweb.state.wy.us/2008/interim/Jud/MINUTES/min0602.htm]

[98] Doug Obey, "Washington Rule May Set State Benchmark For Underground CO2 Storage," *InsideEPA*, (July 9. 2008).
[http://insideepa.com/secure/docnum.asp?docnum=792008_washington&f=epa_2001.ask]

[99] For a discussion in the context of electric transmission siting, see Ashley C. Brown and Damon Daniels, "Vision Without Site; Site Without Vision," The Electricity Journal (Vol. 16, Issue 8: October 2003): 23-34.

[100] Battelle, *The Midwest Regional Carbon Sequestration Partnership (MRSCP): Phase I Final Report*,(December 2005): 214.
[http://216.109.210.162/userdata/Phase%20I%20Report/MRCSP_Phase_I_Final.pdf]

public stakeholders.[101] Some of these partnerships have developed specific public outreach recommendations as part of their CCS public outreach pilot programs.[102]

Some analysts argue that the nature of CCS regulatory frameworks can influence the degree of public acceptance or opposition towards the technology.[103] The Environmental Protection Agency (EPA) is pursuing policies within its jurisdiction with such considerations in mind. In proposed rules for underground injection of CO_2 under the Safe Drinking Water Act, the EPA includes requirements for the public notice of pending sequestration site permitting actions via newspaper advertisements, postings, or mailings and providing a fact sheet or statement that describes the planned injection operation and the principal facts and issues considered in preparing the draft permit. The proposed rules would also require permitting authorities to provide a 30-day comment period for public hearings on specific sequestration projects, and a responsiveness summary for the public record.[104] In announcing its proposed rules, the EPA also "encourages permit applicants and permit writers to use the Internet and other available tools to explain potential [geologic sequestration] projects; describe the technology; and post information on the latest developments including schedules for hearings, briefings, and other opportunities for involvement."[105]

While policy makers may agree as to the importance of public outreach in winning public acceptance of CCS, doing so in support of national carbon policies may be problematic because different communities may have markedly different points of view on CCS infrastructure.

> [T]he task of increasing awareness and knowledge among multiple "publics"... who have different degrees of interest, concerns, levels of awareness, and desired levels of involvement presents a challenge. An additional challenge is that of engaging the public in the topic of CCS when the issues are generic and abstract — yet, as the history of facility siting has shown, this situation is likely to change when the issues become immediate and close to home....[106]

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[101] J.T. Litynski, S. Plasynski, H.G. McIlvried, C. Mahoney, and R.D. Srivastava, "The United States Department of Energy's Regional Carbon Sequestration Partnerships Program Validation Phase," *Environment International* (Vol. 34: 2008): 133.

[102] Sallie E. Greenberg, "Midwest Geological Sequestration Consortium Outreach Working Group: Pilot Study Update," Presentation at the U.S. EPA - Region 5 Midwest Regional Sequestration Conference (Angola, IN: March 2007). [http://sequestration.org/publish/greenberg_pilot_update_mar07.pdf]

[103] Hiranya Fernando, John Venezia, Clay Rigdon, and Preeti Verma, *Capturing King Coal: Deploying Carbon Capture and Storage Systems in the U.S. at Scale*, (World Resources Institute: May, 2008): 25.

[104] Environmental Protection Agency (EPA), *Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells*, Proposed Rule, RIN 2040-AE98 (July 16, 2008):137.

[105] Ibid: 138.

[106] Battelle, *The Midwest Regional Carbon Sequestration Partnership (MRSCP): Phase I Final Report*,(December 2005): 214.

(continued...)

In many cases, public education about CCS concepts and analogies may, indeed, be enough to win community support for CCS projects. Officials in Tuscola, IL, for example, have credited the Midwest Geologic Sequestration Consortium's extensive public outreach efforts with securing community support for the proposed Futuregen CCS project — including power plant, pipeline, and sequestration sites.[107] In other cases, however, some argue that the best way to facilitate broad public acceptance of CCS projects may be to prove their safety through near-term demonstration projects.[108] This appears to be a key motivation for the DOE's RCSP initiative. Nonetheless, according to some research, even successful technology demonstration projects may not completely alleviate community concerns about the potential negative impacts of CCS.

> Whether focused on risks to the environment, public health, property values, or other impacts, scientific assessments of potential risks and impacts are often challenged by a lack of trust in both the data and the institutions that develop them. Distrust of regulators, lack of confidence in experts, and the possibility of accidents caused by human error all contribute to a high level of public concern, even in light of low levels of assessed risk.[109]

Consequently, even given the history of safe CO_2 injection for enhanced oil recovery, and even with successful RCSP or other demonstrations, some segments of the public may remain skeptical and unsupportive of CCS infrastructure development in their communities. Furthermore, a focus on technology demonstrations to win public approval carries significant risks if the these demonstrations do not perform as expected. An MIT report assessing analogs to CCS infrastructure concluded that "significant problems in the early years of a technology's development affected public perceptions and produced regulatory regimes and political battles that took decades to reform or resolve."[110]

As federal CCS policies continue to develop, Congress may seek to identify a range of options to influence community attitudes toward CCS infrastructure. Congress may ensure that the positive operational experiences of federally supported CCS demonstrations are communicated transparently and effectively to public audiences beyond scientific and regulatory stakeholders. Congress may seek to establish structured initiatives for public outreach beyond technology demonstrations,

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[106] (...continued)
[http://216.109.210.162/userdata/Phase%20I%20Report/MRCSP_Phase_I_Final.pdf]

[107] Alta Long, Treasurer and Brian Moody, Office of Economic Development, City of Tuscola, Illinois, Personal communication (July 9, 2008). The Futuregen project was subsequently canceled by the Department of Energy for costs reasons.

[108] Gregory R. Singleton, *Geologic Storage of Carbon Dioxide: Risk Analyses and Implications for Public Acceptance*, Master's thesis, Engineering Systems Division and Department of Political Science, Massachusetts Institute of Technology (June 2007): 97.

[109] Carissa Schively, "Siting Geologic Sequestration: Problems and Prospects," in *Carbon Capture and Sequestration: Integrating Technology, Monitoring, Regulation*, Elizabeth Wilson and David Gerard, editors (Blackwell Publishing, Oxford: 2007): 228.

[110] D.M. Reiner and H.J. Herzog, "Developing a Set of Regulatory Analogs for Carbon Sequestration," *Energy* (Vol. 29 Nos.9-10: 2004): 1561-1570.

taking into account social, economic, and geographic differences among communities near potential CCS infrastructure sites. As part of this effort, Congress may explore potential partnerships with state or local agencies that have relevant siting responsibilities and established relationships with potential CCS community members. Congress may also seek to evaluate how public education and community outreach may affect the timing, scale, and chances of success for future commercial CCS proposals.

Federal Siting Authority for CCS

If Congress takes action on CO_2 reduction, and if states are not able to site CCS infrastructure in accord with those federal carbon control policies, Congress may find itself facing proposals to strengthen federal siting authorities for CCS. As indicated earlier in this report, there are existing models of federal siting authority for energy infrastructure offering Congress a range of options to consider for CO_2 infrastructure. The telecommunications, transportation, and waste disposal industries offer additional models. For some CCS infrastructure projects, such as CO_2 pipelines, existing analogies suggest fairly clear directions for a federal role. Other types of CCS projects may require innovative approaches. It is beyond the scope of this report to examine the applicability of any existing federal siting models to CCS, but they are a source of both legal precedent and siting experience which may be helpful in identifying promising approaches to spur CCS deployment. Additional policy tools to encourage siting, such as federal economic incentives for communities with CCS projects, may also warrant evaluation.

Apart from the details of potential federal siting authority for CCS projects, a general policy question concerns *when* Congress may need to consider the need for such federal authority. In the case of LNG infrastructure, Congress legislated the "exclusive" federal LNG siting authority in P.L. 109-58 approximately three years after the Hackberry LNG terminal siting application — the first such application in 25 years — by which time it was already apparent that community and state opposition would create significant barriers to a national resurgence in LNG terminal development.[111] By contrast, Congress has not enacted broad federal siting authority for interstate oil pipelines, although the federal government does regulate the rates and operations of oil pipelines.

In the specific context of siting authority for CCS infrastructure, the need for federal involvement may be driven fundamentally by Congressional expectations for infrastructure deployment. As the FERC chairman testified before Congress in 2008 with regard to pipelines,

> looking at what Congress did on gas pipeline siting, it started off with state siting, and at some point it failed. In the views of Congress, they concluded, state siting had failed.... And then Congress came in and changed the law, exclusive and federal preemptive siting was the rule. The state siting has worked for CO_2 pipelines up to this point. But the network is much smaller than the oil and gas pipeline networks.... So it really relates to, if this is the path the country

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[111] "Congress Begins Debate on FERC's Jurisdiction over LNG Terminal Siting," *Inside F.E.R.C.'s Gas Market Report* (April 8, 2005): 13.

goes down, how big of a CO_2 pipeline network are we going to need, and how quickly are we going to need it.[112]

Given the legal and regulatory complexities, and taking into consideration public ambivalence toward CCS projects, at least some states are likely to struggle with the details of state CCS siting authority. Congress may, therefore, seek to understand how public acceptance may influence the nature and timing of CCS infrastructure regulation by the states and whether state siting efforts are likely to satisfy possible Congressional objectives in terms of CCS scale and scope. If it appears that state efforts are unlikely to do so, then Congress may examine the possibility of a stronger federal role in CCS siting approval. Such a policy could be controversial, however, and still might not guarantee success for CCS infrastructure siting, as demonstrated by the challenges faced in interstate natural gas pipeline siting which has been under federal jurisdiction for over 60 years. As a NARUC official has stated, "no matter where siting responsibility falls, with State government or the Federal government, siting energy infrastructure will not be easy and there will be no 'quick fix' to this situation."[113]

Siting Challenges for CCS Alternatives

If public acceptance becomes a significant barrier to CCS infrastructure, Congress may consider promoting more aggressively other energy sources — such as solar, wind, geothermal, and nuclear power — to meet future energy needs within the confines of CO_2 emissions limits. Research has shown that parts of the general public may prefer some of these power generation options over CCS projects. Nonetheless, these other energy sources may still face public acceptance barriers of their own. Although the number of renewable energy projects successfully sited in the United States has grown significantly, some proposals have been delayed or abandoned because local communities have rejected them.[114] The Cape Wind Project off Cape Cod, MA, is a nationally prominent example of such a project which faces concerted community opposition and related litigation nearly eight years after it was proposed — and has yet to receive siting approval.[115] Nuclear power plants likewise face community opposition. The National Commission on Energy Policy has stated that "no electricity generating technology is likely to face more formidable challenges to the siting of new facilities than nuclear power."[116] Although solar power plants appear to face less community opposition than other types of renewable power plants, community groups have fought against the electric transmission projects required to

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[112] The Honorable Joseph T. Kelliher, Chairman, Federal Energy Regulatory Commission, Testimony before the Senate Committee on Energy and Natural Resources Hearing on Carbon Capture, Transportation, and Sequestration and Related Bills, S. 2323 and S. 2144 (January 31, 2008).

[113] William M. Nugent (May 15, 2001).

[114] Robert D. Kahn, "Siting Struggles: The Unique Challenge of Permitting Renewable Energy Power Plants," *The Electricity Journal* (Vol. 13, No. 2, March 2000): 21-33.

[115] See, for example: Audra Parker, "It's Time to Deny Cape Wind, Find Better Alternative," *Marblehead Reporter* (Marblehead, MA: June 15, 2008).

[116] NCEP (2006): 26.

bring solar power from remote generation sites to urban centers of electricity demand.[117]

Although the specific types and locations of CCS, renewable, and nuclear energy projects may differ, they present interrelated challenges and opportunities with respect to siting and public acceptance. Indeed, the 2004 Carnegie Mellon University study suggests that the U.S. public may exhibit a "strong desire to frame decisions" about CCS in the context of other carbon control strategies, such as developing renewable energy resources or investing in nuclear power.[118] Consequently, it may be constructive for congressional policy makers to consider CCS siting as part of a broader, integrated policy debate, including the siting of other energy technologies which may help to satisfy national CO_2 management objectives. It follows that federal siting policies pursued for CCS infrastructure may have implications for the siting of other energy infrastructure.

Community Acceptance of CCS in Perspective

Some analysts assert that community opposition to CCS siting may be the single most important consideration in carbon control policy: "the gravest threat," "the overriding issue," or "a potential show stopper."[119] While drawing needed attention to the issue, such pronouncements are, perhaps, too extreme. First, while promoting CCS as a potentially important means by which to reduce U.S. greenhouse gas emissions, it is only one of several policy measures with the potential to do so. Congress is also considering policies to promote energy conservation, renewable energy, nuclear power, and hydrogen fuel — any of which could also yield major reductions in CO_2 emissions. Second, while the community acceptance barriers to energy infrastructure in the United States are significant, they are also complex, and not really amenable to "show stopper" characterizations. The more likely reality is that new CCS infrastructure projects, if they are ultimately constructed, will be distributed on a continuum of public acceptability, along with other types of energy and industrial infrastructure projects. The key question for Congress is not whether communities will accept CCS project siting at all, but where and to what degree, relative to other energy infrastructure options. So far, there is little research or CCS project experience in the United States offering specific insight into these questions

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[117] See for example: Community Alliance for Sensible Energy (CASE), *Before the Public Utilities Commission Of the State of California, In the Matter of the Application of San Diego Gas & Electric Company Application (U-902) for a Certificate of Public Convenience and Necessity for the Sunrise Powerlink Transmission Project, Pre-hearing Comments of Community Alliance for Sensible Energy (CASE),* Application No. 06-08-010 (September 7, 2006). [http://docs.cpuc.ca.gov/hottopics/1energy/phc.2.final.pdf]

[118] Claire R. Palmgren, M. Granger Morgan, Wandi Bruine De Bruin, and David Keith, "Initial Public Perceptions of Deep Geological and Oceanic Disposal of Carbon Dioxide," *Environmental Science & Technology* (Vol. 38, No. 24, 2004): 6448.

[119] United Kingdom, House of Commons, Science and Technology Committee, *Meeting UK Energy and Climate Needs: The Role of Carbon Capture and Storage*, Vol. 1 Report HC 578-II, (February 1, 2006): 41. [http://www.publications.parliament.uk/pa/cm200506/cmselect/cmsctech/578/57808.htm]

from a comprehensive, national perspective. Consequently, legislators must rely on siting analogies and their own judgment to develop policy perspectives on community acceptance and CCS infrastructure needs.

If carbon control and associated CCS policies were narrowly targeted, or expected to have only marginal impacts on the U.S. energy sector, Congress might choose to defer consideration of community acceptance issues until CCS technologies were more mature and states had more time to work out CCS siting problems. But understanding public acceptance of CCS may take on greater urgency in light of proposals to curb CO_2 emissions quickly. The most prominent CO_2 proposals in the 110th Congress seek reductions of nationwide CO_2 emissions to 1990 levels or lower by 2030.[120] Some expect CCS, along with conservation, renewables, and other energy alternatives, to make a significant contribution to meeting these goals. Even with complete public support, however, it would be a challenge to commercialize carbon capture technology, establish comprehensive CCS standards and regulations, design and finance CCS projects, secure numerous regulatory approvals, and physically construct a CCS network of sufficient size to meet such CO_2 emissions reductions targets. Community opposition could complicate and delay each element of CCS implementation, potentially adding years to a national CCS deployment. Alternatively, community concerns could lead to a national patchwork of CCS projects constructed only in publicly acceptable geographies (or on public lands), creating inter-regional disparities and failing to meet congressional objectives. If Congress sets goals for reducing U.S. emissions of CO_2, the potential influence of public acceptance on reaching them suggest that a more proactive approach to addressing the latter might be in order.

An advantage of being in the early stages of CCS policy formation is that Congress may have the opportunity to manage public acceptance issues before they become intractable.

> *While [community opposition] is a frequent impediment to siting, it is not insurmountable.* Strategies that offer concrete benefits or promote trust in affected communities and that remove legitimate arguments as camouflage for self-interest can overcome public goods problems. Committing to compensation, openness, information sharing, monitoring and enforcement can help diffuse legitimate grievances. This strategy will add to the costs and lead to delays, but so too will a permitting process where the public feels disenfranchised.[121]

As Congress considers CO_2 policies going forward it may find significant benefits in fully understanding the role of communities in the implementation of those policies. Although efforts to do so may require added resources and attention in the near term, they may be preferable to waiting for siting failures, as some have suggested, and expending far greater effort to address them at a later time.

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[120] World Resources Institute, "Comparison of Legislative Climate Change Targets," (Washington, DC: June 18, 2008): 3.

[121] D.M. Reiner and H.J. Herzog, "Developing a Set of Regulatory Analogs for Carbon Sequestration," *Energy*, (Vol. 29 Nos.9-10: 2004): 1561-1570.