

# CRS Report for Congress

## Carbon Dioxide (CO<sub>2</sub>) Pipelines for Carbon Sequestration: Emerging Policy Issues

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Prepared for Members and  
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# Carbon Dioxide (CO<sub>2</sub>) Pipelines for Carbon Sequestration: Emerging Policy Issues

## Summary

Congress is examining potential approaches to reducing manmade contributions to global warming from U.S. sources. One approach is carbon capture and sequestration (CCS) — capturing CO<sub>2</sub> at its source (e.g., a power plant) and storing it indefinitely (e.g., underground) to avoid its release to the atmosphere. A common requirement among the various techniques for CCS is a dedicated pipeline network for transporting CO<sub>2</sub> from capture sites to storage sites.

In the 110<sup>th</sup> Congress, there has been considerable debate on the capture and sequestration aspects of carbon sequestration, while there has been relatively less focus on transportation. Nonetheless, there is increasing understanding in Congress that a national CCS program could require the construction of a substantial network of interstate CO<sub>2</sub> pipelines. S. 2144 and S. 2191 would require the Secretary of Energy to study the feasibility of constructing and operating such a network of pipelines. S. 2323 would require carbon sequestration projects to evaluate the most cost-efficient ways to integrate CO<sub>2</sub> sequestration, capture, and transportation. S. 2149 would allow seven-year accelerated depreciation for qualifying CO<sub>2</sub> pipelines. P.L. 110-140, signed by President Bush on December 19, 2007, requires the Secretary of the Interior to recommend legislation to clarify the issuance of CO<sub>2</sub> pipeline rights-of-way on public land.

That CCS and related legislation have been more focused on the capture and storage of CO<sub>2</sub> than on its transportation, reflects a perception that transporting CO<sub>2</sub> via pipelines does not present a significant barrier to implementing large-scale CCS. Notwithstanding this perception, and even though regional CO<sub>2</sub> pipeline networks already operate in the United States for enhanced oil recovery (EOR), developing a more expansive national CO<sub>2</sub> pipeline network for CCS could pose numerous new regulatory and economic challenges. There are important unanswered questions about pipeline network requirements, economic regulation, utility cost recovery, regulatory classification of CO<sub>2</sub> itself, and pipeline safety. Furthermore, because CO<sub>2</sub> pipelines for EOR are already in use today, policy decisions affecting CO<sub>2</sub> pipelines take on an urgency that is, perhaps, unrecognized by many. Federal classification of CO<sub>2</sub> as both a commodity (by the Bureau of Land Management) and as a pollutant (by the Environmental Protection Agency) could potentially create an immediate conflict which may need to be addressed not only for the sake of future CCS implementation, but also to ensure consistency of future CCS with CO<sub>2</sub> pipeline operations today.

In addition to these issues, Congress may examine how CO<sub>2</sub> pipelines fit into the nation's overall strategies for energy supply and environmental protection. If policy makers encourage continued consumption of fossil fuels under CCS, then the need to foster the other energy options may be diminished — and vice versa. Thus decisions about CO<sub>2</sub> pipeline infrastructure could have consequences for a broader array of energy and environmental policies.

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# Carbon Dioxide (CO<sub>2</sub>) Pipelines for Carbon Sequestration: Emerging Policy Issues

## Introduction

Congress has long been concerned about the impact of global climate change that may be caused by manmade emissions of carbon dioxide (CO<sub>2</sub>) and other greenhouse gases.<sup>1</sup> Congress is also debating policies related to global warming and is examining a range of potential initiatives to reduce manmade contributions to global warming from U.S. sources.<sup>2</sup> One approach to mitigating manmade greenhouse gas emissions is direct sequestration: capturing CO<sub>2</sub> at its source, transporting it via pipelines, and storing it indefinitely to avoid its release to the atmosphere.<sup>3</sup> This paper explores one component of direct sequestration — transporting CO<sub>2</sub> in pipelines.

Carbon capture and storage (CCS) is of great interest because potentially large amounts of CO<sub>2</sub> emitted from the industrial burning of fossil fuels in the United States could be suitable for sequestration. Carbon capture technologies can potentially remove 80%-95% of CO<sub>2</sub> 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<sub>2</sub> emissions from fossil fuels.

There are many technological approaches to CCS. However, one common requirement for nearly all large-scale CCS schemes is a system for transporting CO<sub>2</sub> from capture sites (e.g., power plants) to storage sites (e.g., underground reservoirs). Transporting captured CO<sub>2</sub> in relatively limited quantities is possible by truck, rail, and ship, but moving the enormous quantities of CO<sub>2</sub> implied by a widespread implementation of CCS technologies would likely require a dedicated interstate pipeline network.

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<sup>1</sup> This report does not explore the underlying science of climate change, nor the question of whether action is justified. See CRS Report RL33849, *Climate Change: Science and Policy Implications*, by Jane A. Leggett.

<sup>2</sup> For more information on congressional activities related to global warming, see CRS Report RL31931, *Climate Change: Federal Laws and Policies Related to Greenhouse Gas Reductions*, by Brent D. Yacobucci and Larry Parker; and CRS Report RL34067, *Climate Change Legislation in the 110th Congress*, by Jonathan L. Ramseur and Brent D. Yacobucci.

<sup>3</sup> This report does not address indirect sequestration, wherein CO<sub>2</sub> is stored in soils, oceans, or plants through natural processes. For information on the latter, see CRS Report RL31432, *Carbon Sequestration in Forests*, by Ross W. Gorte.

In the 110<sup>th</sup> Congress, there has been considerable debate on the capture and sequestration aspects of carbon sequestration, while there has been relatively less focus on transportation. Nonetheless, there is increasing understanding in Congress that a national CCS program could require the construction of a substantial network of interstate CO<sub>2</sub> pipelines. The Carbon Dioxide Pipeline Study Act of 2007 (S. 2144), introduced by Senator Coleman and nine cosponsors on October 4, 2007, would require the Secretary of Energy to study the feasibility of constructing and operating such a network of CO<sub>2</sub> pipelines. The America's Climate Security Act of 2007 (S. 2191), introduced by Senator Lieberman and nine cosponsors on October 18, 2007, and reported out of the Senate Environment and Public Works Committee in amended form on December 5, 2007, contains similar provisions (Sec. 8003). The Carbon Capture and Storage Technology Act of 2007 (S. 2323), introduced by Senator Kerry and one cosponsor on November 7, 2007, would require carbon sequestration projects authorized by the act to evaluate the most cost-efficient ways to integrate CO<sub>2</sub> sequestration, capture, and transportation (Sec. 3(b)(5)). The Coal Fuels and Industrial Gasification Demonstration and Development Act of 2007 (S.2149) introduced by Senator Dorgan on October 4, 2007, would allow accelerated depreciation for certain new CO<sub>2</sub> pipelines. The Energy Independence and Security Act of 2007 (P.L. 110-140) signed by President Bush, as amended, on December 19, 2007, requires the Secretary of the Interior to recommend legislation to clarify the appropriate framework for issuing CO<sub>2</sub> pipeline rights-of-way on public land (Sec. 714(7)).

Legislative focus on the capture and storage components of direct carbon sequestration reflects a perception that transporting CO<sub>2</sub> via pipelines does not present a significant barrier to implementing large-scale CCS. Even though regional CO<sub>2</sub> pipeline networks already operate in the United States for enhanced oil recovery (EOR), developing a more expansive national CO<sub>2</sub> pipeline network for CCS could pose numerous new regulatory and economic challenges. As one analyst has remarked,

Each of the individual technologies involved in the transport portion of the CCS process is mature, but integrating and deploying them on a massive scale will be a complex task. "The question is, how would the necessary pipeline network be established and evolve?"<sup>4</sup>

A thorough consideration of potential CCS approaches necessarily involves an assessment of their overall requirements for CO<sub>2</sub> transportation by pipeline, including the possible federal role in establishing an interstate CO<sub>2</sub> pipeline network.

This report introduces key policy issues related to CO<sub>2</sub> pipelines which may require congressional attention. It summarizes the technological requirements for CO<sub>2</sub> pipeline transportation under a comprehensive CCS strategy. It characterizes these requirements relative to the existing CO<sub>2</sub> pipeline infrastructure in the United States used for EOR. The report summarizes policy issues related to CO<sub>2</sub> pipeline development, including uncertainty about pipeline network requirements, economic

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<sup>4</sup> John Douglas, "Expanding Options for CO<sub>2</sub> Storage," *EPRI Journal*, Electric Power Research Institute (Spring 2007): 24.

regulation, utility cost recovery, regulatory classification of CO<sub>2</sub> itself, and pipeline safety. The report concludes with perspectives on CO<sub>2</sub> pipelines in the context of the nation's overall energy and infrastructure requirements.

## Background

Carbon sequestration policies are inextricably tied to the function and availability of the necessary technologies. Consequently, discussion of CCS policy alternatives benefits from a basic understanding of the physical processes involved, and relevant experience with existing infrastructure. This section provides a basic overview of carbon sequestration processes overall, as well as specific U.S. experience with CO<sub>2</sub> pipelines.<sup>5</sup>

### Carbon Capture and Sequestration

Carbon capture and sequestration is essentially a three-part process involving a CO<sub>2</sub> source facility, a long-term CO<sub>2</sub> storage site, and an intermediate mode of CO<sub>2</sub> transportation.

**Capture.** The first step in direct sequestration is to produce a concentrated stream of CO<sub>2</sub> for transport and storage. Currently, three main approaches are available to capture CO<sub>2</sub> from large-scale industrial facilities or power plants:

- **pre-combustion**, which separates CO<sub>2</sub> from fuels by combining them with air and/or steam to produce hydrogen for combustion and CO<sub>2</sub> for storage,
- **post-combustion**, which extracts CO<sub>2</sub> from flue gases following combustion of fossil fuels or biomass, and
- **oxyfuel combustion**, which uses oxygen instead of air for combustion, producing flue gases that consist mostly of CO<sub>2</sub> and water from which the CO<sub>2</sub> is separated.<sup>6</sup>

These approaches vary in terms of process technology and maturity, but all yield a stream of extracted CO<sub>2</sub> which may then be compressed to increase its density and make it easier (and cheaper) to transport. Although technologies to separate and compress CO<sub>2</sub> are commercially available, they have not been applied to large-scale CO<sub>2</sub> capture from power plants for the purpose of long-term storage.<sup>7</sup>

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<sup>5</sup> More detailed information is available in CRS Report RL33801, *Direct Carbon Sequestration: Capturing and Storing CO<sub>2</sub>*, by Peter Folger.

<sup>6</sup> Intergovernmental Panel on Climate Change, Special Report: *Carbon Dioxide Capture and Storage, 2005* (2005): 22-23. (Hereafter referred to as IPCC 2005.)

<sup>7</sup> H. J. Herzog and D. Golumb, "Carbon Capture and Storage from Fossil Fuel Use," in C.J. Cleveland (ed.), *Encyclopedia of Energy* (New York, NY: Elsevier Science, Inc., 2004): (continued...)

**Transportation.** Pipelines are the most common method for transporting large quantities of CO<sub>2</sub> over long distances. CO<sub>2</sub> pipelines are operated at ambient temperature and high pressure, with primary compressor stations located where the CO<sub>2</sub> is injected and booster compressors located as needed further along the pipeline.<sup>8</sup> In overall construction, CO<sub>2</sub> pipelines are similar to natural gas pipelines, requiring the same attention to design, monitoring for leaks, and protection against overpressure, especially in populated areas.<sup>9</sup> Many analysts consider CO<sub>2</sub> pipeline technology to be mature, stemming from its use since the 1970s for EOR and in other industries.<sup>10</sup> Marine transportation may also be feasible when CO<sub>2</sub> needs to be transported over long distances or overseas; however, many manmade CO<sub>2</sub> sources are located far from navigable waterways, so such a scheme would still likely require pipeline construction between CO<sub>2</sub> sources and port terminals. Rail cars and trucks can also transport CO<sub>2</sub>, but these modes would be logistically impractical for large-scale CCS operations.

**Sequestration in Geological Formations.** In most CCS approaches, CO<sub>2</sub> would be transported by pipeline to a porous rock formation that holds (or previously held) fluids where the CO<sub>2</sub> would be injected underground. When CO<sub>2</sub> is injected over 800 meters deep in a typical storage formation, atmospheric pressure induces the CO<sub>2</sub> to become relatively dense and less likely to migrate out of the formation. Injecting CO<sub>2</sub> into such formations uses existing technologies developed primarily for oil and natural gas production which potentially could be adapted for long-term storage and monitoring of CO<sub>2</sub>. Other underground injection applications in practice today, such as natural gas storage, deep injection of liquid wastes, and subsurface disposal of oil-field brines, also provide potential technologies and experience for sequestering CO<sub>2</sub>.<sup>11</sup> Three main types of geological formations are being considered for carbon sequestration: (1) oil and gas reservoirs, (2) deep saline reservoirs, and (3) unmineable coal seams. The overall capacity for CO<sub>2</sub> storage in such formations is potentially huge if all the sedimentary basins in the world are considered.<sup>12</sup> The suitability of any particular site, however, depends on many factors, including proximity to CO<sub>2</sub> sources and other reservoir-specific qualities like porosity, permeability, and potential for leakage.

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<sup>7</sup> (...continued)  
277-287.

<sup>8</sup> IPCC 2005: 26.

<sup>9</sup> IPCC 2005: 181.

<sup>10</sup> CO<sub>2</sub> used in EOR enhances oil production by re-pressurizing geological formations and reducing oil viscosity, thereby increasing oil movement to the surface. CO<sub>2</sub> is used industrially as a chemical feedstock, to carbonate beverages, for refrigeration and food processing, to treat water, and for other uses.

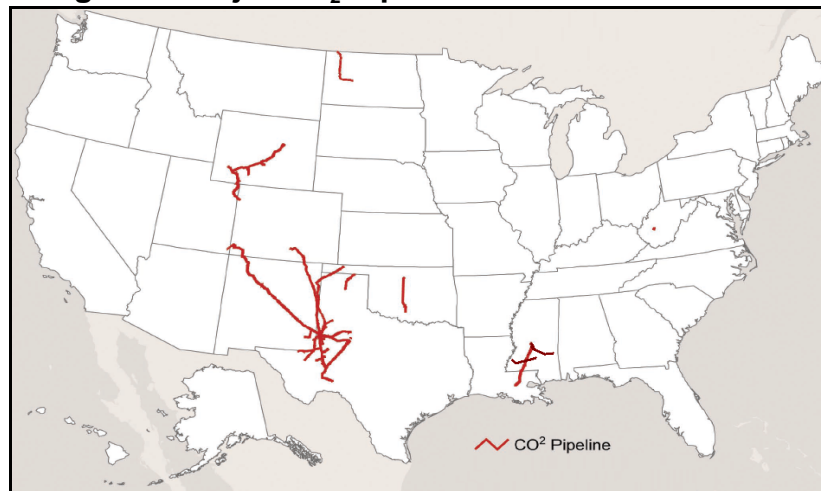
<sup>11</sup> IPCC 2005: 31.

<sup>12</sup> Sedimentary basins are large depressions in the Earth's surface filled with sediments and fluids.

## Existing U.S. CO<sub>2</sub> Pipelines

The oldest long-distance CO<sub>2</sub> pipeline in the United States is the 225 kilometer Canyon Reef Carriers Pipeline (in Texas), which began service in 1972 for EOR in regional oil fields.<sup>13</sup> Other large CO<sub>2</sub> pipelines constructed since then, mostly in the Western United States, have expanded the CO<sub>2</sub> pipeline network for EOR. These pipelines carry CO<sub>2</sub> from naturally occurring underground reservoirs, natural gas processing facilities, ammonia manufacturing plants, and a large coal gasification project to oil fields. Additional pipelines may carry CO<sub>2</sub> from other manmade sources to supply a range of industrial applications. Altogether, approximately 5,800 kilometers (3,600 miles) of CO<sub>2</sub> pipeline operate today in the United States.<sup>14</sup>

**Figure 1. Major CO<sub>2</sub> Pipelines in the United States**



**Sources:** Denbury Resources Inc., “EOR: The Economic Alternative for CCS,” Slide presentation (October 2007). [[http://www.gasification.org/Docs/2007\\_Papers/25EVAN.pdf](http://www.gasification.org/Docs/2007_Papers/25EVAN.pdf)]; U.S. Dept. of Transportation, National Pipeline Mapping System, Official use only. (June 2005). [<https://www.npms.phmsa.dot.gov>]

The locations of the major U.S. CO<sub>2</sub> pipelines are shown in **Figure 1**. By comparison, nearly 800,000 kilometers (500,000 miles) of natural gas and hazardous liquid transmission pipelines crisscross the United States.<sup>15</sup>

<sup>13</sup> Kinder Morgan CO<sub>2</sub> Company, “Canyon Reef Carriers Pipeline (CRC),” web page (2007). [[http://www.kindermorgan.com/business/co2/transport\\_canyon\\_reef.cfm](http://www.kindermorgan.com/business/co2/transport_canyon_reef.cfm)]

<sup>14</sup> U.S. Dept. of Transportation, National Pipeline Mapping System database (June 2005). [<https://www.npms.phmsa.dot.gov>]

<sup>15</sup> Bureau of Transportation Statistics (BTS), National Transportation Statistics 2005 (Dec. 2005), Table 1-10. In this report *oil* includes petroleum and other hazardous liquids such as gasoline, jet fuel, diesel fuel, and propane, unless otherwise noted.



## Key Issues for Congress

Congressional consideration of potential CCS policies is still evolving, but so far initiatives have focused more on developing capture and sequestration technologies than on transportation. Specific legislative proposals in the 110<sup>th</sup> Congress reflect the current perception that CO<sub>2</sub> capture probably represents the largest technological hurdle to implementing widespread CCS, and that CO<sub>2</sub> transportation by pipelines does not present as significant a barrier. While these perceptions may be accurate, industry and regulatory analysts have begun to identify important policy issues related specifically to CO<sub>2</sub> pipelines which may require congressional attention.

### CO<sub>2</sub> Pipeline Requirements for CCS

Although any widespread CCS scheme in the United States would likely require dedicated CO<sub>2</sub> pipelines, there is considerable uncertainty about the size and configuration of the pipeline network required. This uncertainty stems, in part, from uncertainty about the suitability of geological formations to sequester captured CO<sub>2</sub> and the proximity of suitable formations to specific sources. One recent analysis concludes that 77% of the total annual CO<sub>2</sub> captured from the major North American sources may be stored in reservoirs directly underlying these sources, and that an additional 18% may be stored within 100 miles of additional sources.<sup>16</sup> If this were the case, the need for new CO<sub>2</sub> pipelines would be limited to onsite transportation and a relatively small number of long-distance pipelines (only a subset of which might need to be interstate pipelines).

Other analysts suggest that captured CO<sub>2</sub> may need to be sequestered, at least initially, in more centralized reservoirs to reduce potential risks associated with CO<sub>2</sub> leaks.<sup>17</sup> They suggest that, given current uncertainty about the suitability of various on-site geological formations for long-term CO<sub>2</sub> storage, certain specific types of formations (e.g., salt caverns) may be preferred as CO<sub>2</sub> repositories because they have adequate capacity and are most likely to retain sequestered CO<sub>2</sub> indefinitely. As geologic formations are characterized in more detail and suitable repositories identified, CO<sub>2</sub> sources can be mapped against storage sites with increasing certainty. The current uncertainty over proximity of sources to storage sites, however, implies a wide range of possible pipeline configurations and a wide range of possible costs.

Whether CCS policies ultimately lead to centralized or decentralized storage configurations remains to be seen; however, pipeline requirements and storage

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<sup>16</sup> R.T. Dahowski, J.J. Dooley, C.L. Davidson, S. Bachu, N. Gupta, and J. Gale, "A North American CO<sub>2</sub> Storage Supply Curve: Key Findings and Implications for the Cost of CCS Deployment," *Proceedings of the Fourth Annual Conference on Carbon Capture and Sequestration* (Alexandria, VA: May 2-5, 2005). The study addresses CO<sub>2</sub> capture at 2,082 North American facilities including power plants, natural gas processing plants, refineries, cement kilns, and other industrial plants.

<sup>17</sup> Jennie C. Stevens and Bob Van Der Zwaan, "The Case for Carbon Capture and Storage," *Issues in Science and Technology*, vol. XXII, no. 1 (Fall 2005): 69-76. (See page 15 of this report for a discussion of safety issues.)

configurations are closely related. A 2007 study at the Massachusetts Institute of Technology (MIT) concluded that “the majority of coal-fired power plants are situated in regions where there are high expectations of having CO<sub>2</sub> sequestration sites nearby.”<sup>18</sup> In these cases, the MIT study estimated the cost of CO<sub>2</sub> transport and injection to be less than 20% of total CCS costs. However, the study also stated that the costs of CO<sub>2</sub> pipelines are highly non-linear with respect to the quantity transported, and highly variable due to “physical ... and political considerations.”<sup>19</sup> Another 2007 study, at Duke University, concluded that “geologic sequestration is not economically or technically feasible within North Carolina,” but “may be viable if the captured CO<sub>2</sub> is piped out of North Carolina and stored elsewhere.”<sup>20</sup> There are also significant scale economies for large, integrated CO<sub>2</sub> pipeline networks that link many sources together rather than single, dedicated pipelines between individual sources and storage reservoirs.<sup>21</sup> As Congress considers CCS policies, it may examine the relationship between CO<sub>2</sub> reservoir sites and pipeline requirements.

## Economic Regulation

Economic regulation of interstate pipelines by the federal government is generally intended to ensure pipelines fulfill *common carrier* obligations by charging reasonable rates; providing rates and services to all upon reasonable request; not unfairly discriminating among shippers; establishing reasonable classifications, rules, and practices; and interchanging traffic with other pipelines or transportation modes.<sup>22</sup> If interstate CO<sub>2</sub> pipelines for carbon sequestration are ultimately to be developed, it will raise important regulatory questions in this context because federal jurisdiction over hypothetical interstate CO<sub>2</sub> pipeline siting and rate decisions is not clear. Based on their current regulatory roles, two of the more likely candidates for jurisdiction over interstate pipelines transporting CO<sub>2</sub> for purposes of CCS are the Federal Energy Regulatory Commission (FERC) and the Surface Transportation Board (STB).<sup>23</sup> However, both agencies have at some point expressed a position that interstate CO<sub>2</sub> pipelines are not within their purview, as summarized below.<sup>24</sup>

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<sup>18</sup> John Deutch, Ernest J. Moniz, et al., *The Future of Coal*. (Cambridge, MA: Massachusetts Institute of Technology: 2007): 58. (Hereafter referred to as MIT 2007.)

<sup>19</sup> MIT 2007: 58.

<sup>20</sup> Eric Williams, Nora Greenglass, and Rebecca Ryals, “Carbon Capture, Pipeline and Storage: A Viable Option for North Carolina Utilities?” Working paper prepared by the Nicholas Institute for Environmental Policy Solutions and The Center on Global Change, Duke University (Durham, NC: March 8, 2007): 4.

<sup>21</sup> MIT 2007: 58.

<sup>22</sup> General Accounting Office (now Government Accountability Office), *Surface Transportation: Issues Associated With Pipeline Regulation by the Surface Transportation Board*, RCED-98-99 (Washington, DC: April 21, 1998):3; and 49 U.S.C. § 155.

<sup>23</sup> The STB is the successor agency to the Interstate Commerce Commission (ICC) under the Interstate Commerce Commission Termination Act of 1995 (P.L. 104-88).

<sup>24</sup> For a more comprehensive discussion of CO<sub>2</sub> pipeline regulatory jurisdiction, see CRS Report RL34307, *Regulation of Carbon Dioxide (CO<sub>2</sub>) Sequestration Pipelines:* (continued...)

**Federal Jurisdiction over CO<sub>2</sub> Pipelines.** The Natural Gas Act of 1938 (NGA) vests in FERC the authority to issue “certificates of public convenience and necessity” for the construction and operation of interstate natural gas pipeline facilities.<sup>25</sup> FERC is also charged with extensive regulatory authority over the siting of natural gas import and export facilities, as well as rates for transportation of natural gas and other elements of transportation service. FERC also has jurisdiction over regulation of oil pipelines pursuant to the Interstate Commerce Act (ICA).<sup>26</sup> Although FERC is not involved in the oil pipeline siting process, as with natural gas, FERC does regulate transportation rates and capacity allocation for oil pipelines.<sup>27</sup> Jurisdiction over rate regulation for pipelines “other” than “water, gas or oil” pipelines resides with the STB, a decisionally independent regulatory agency affiliated with the Department of Transportation.<sup>28</sup> The STB acts as a forum for resolution of disputes related to pipelines within its jurisdiction. Parties who wish to challenge a rate or another aspect of a pipeline’s common carrier service must petition the STB for a hearing, however; there is no ongoing regulatory oversight.

Although CO<sub>2</sub> pipelines are not explicitly excluded from FERC jurisdiction by statute, FERC ruled in 1979 that they are not subject to the Commission’s jurisdiction because they do not transport *natural gas* for heating purposes.<sup>29</sup> Likewise, the ICC in 1980 concluded that Congress intended to exclude all types of gas, including CO<sub>2</sub>, from ICC regulation. After making the initial decision that it likely did not have jurisdiction over CO<sub>2</sub> pipelines, the ICC did conclude that the issue was “important enough to institute a proceeding and accept comments on the petition and our view on it.”<sup>30</sup> After the comment period the ICC confirmed its view that CO<sub>2</sub> pipelines were excluded from the ICC’s (and, therefore, the STB’s) jurisdiction.<sup>31</sup> Thus, the two federal regulatory agencies that, generally speaking, have jurisdiction over interstate pipeline rate and capacity allocation matters appear to have rejected explicitly jurisdiction over CO<sub>2</sub> siting and rates, and there is no legislative or judicial history to suggest that their rejections were improper at the time. Absent federal authority, CO<sub>2</sub> pipelines are regulated to varying degrees by the states.

**Potential Issues Related to ICC Jurisdiction.** Notwithstanding the ICC’s 1980 disclaimer of jurisdiction over CO<sub>2</sub> pipelines, other evidence indirectly suggests

<sup>24</sup> (...continued)

*Jurisdictional Issues*, by Adam Vann and Paul W. Parfomak.

<sup>25</sup> 15 U.S.C. 717f(c).

<sup>26</sup> 49 App. U.S.C. §1.

<sup>27</sup> Section 1801 of the Energy Policy Act of 1992 directed FERC to “promulgate regulations establishing a simplified and generally applicable ratemaking methodology” for oil pipeline transportation.

<sup>28</sup> 49 U.S.C. § 1-501(a)(1)(c).

<sup>29</sup> *Cortez Pipeline Company*, 7 FERC ¶ 61,024 (1979).

<sup>30</sup> *Id.*

<sup>31</sup> *Cortez Pipeline Company — Petition for Declaratory Order — Commission Jurisdiction Over Transportation of Carbon Dioxide by Pipeline*, 46 Fed. Reg. 18805 (March 26, 1981).

the possibility that interstate CO<sub>2</sub> pipelines could still be considered subject to STB jurisdiction. For example, an April 1998 report by the General Accounting Office (GAO)<sup>32</sup> stated that interstate CO<sub>2</sub> pipelines, as well as pipelines transporting other gases are subject to the board's oversight authority. The STB reviewed the GAO's analysis and, apparently, did not object to this jurisdictional classification.<sup>33</sup> Furthermore, although the STB is the successor to the now-defunct ICC, the STB conceivably could determine that its jurisdiction is not governed by the ICC's decision in the CO<sub>2</sub> matter. Indeed, the Supreme Court has ruled that federal agencies are not precluded from changing their positions on the issue of regulatory jurisdiction. According to the Court, "an initial agency interpretation is not instantly carved in stone. On the contrary, the agency, to engage in informed rulemaking, must consider varying interpretations and the wisdom of its policy on a continuing basis."<sup>34</sup> Accordingly, regulation of CO<sub>2</sub> pipelines for CCS purposes by the STB (or by FERC, for that matter) under existing statutes remains a possibility.

**Policy Implications for Rate Regulation.** If CCS technology develops to the point where interstate CO<sub>2</sub> pipelines become more common, and if FERC and the STB continue to disclaim jurisdiction over CO<sub>2</sub> pipelines, then the absence of federal regulation described above may pose policy challenges. In particular, with many more pipeline users and interconnections than exist today, complex common carrier issues might arise.<sup>35</sup> One potential concern, for example, is whether rates should be set separately for existing pipelines carrying CO<sub>2</sub> as a valuable commercial commodity (e.g., for EOR), versus new pipelines carrying CO<sub>2</sub> as industrial pollution for disposal. Furthermore, if rates are not reviewed prior to pipeline construction, it might be difficult for regulators to ensure the reasonableness of CO<sub>2</sub> pipeline rates until after the pipelines were already in service. If CO<sub>2</sub> pipeline connections become mandatory under future regulations, such arrangements might expose pipeline users to abuses of potential market power in CO<sub>2</sub> pipeline services, at least until rate cases could be heard. Presiding over a large number of CO<sub>2</sub> rate cases of varying complexity in a relatively short time frame might also be administratively overwhelming for state agencies, which may have limited resources available for pipeline regulatory activities.

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<sup>32</sup> Now known as the Government Accountability Office.

<sup>33</sup> Surface Transportation Board (STB), Personal communication, (December 2007). The STB Office of Governmental and Public Affairs informed CRS that the board recognizes the conflict between this GAO report and the ICC decision (as well as the wording of 49 C.F.R. § 15301 governing STB jurisdiction over pipelines other than those transporting "water, gas or oil"). However the office did not want to state an opinion as to the current extent of STB jurisdiction over CO<sub>2</sub> pipelines and suggested that the STB would likely not act to resolve this conflict unless a CO<sub>2</sub> pipeline dispute comes before it.

<sup>34</sup> *Chevron U.S.A. v. Nat. Res. Def. Council*, 467 U.S. 837, at 863-64 (1984).

<sup>35</sup> Beard Company 2000 annual report (10-k) filed with the U.S. Securities and Exchange Commission states that the company (with other plaintiffs) filed a lawsuit in 1996 against CO<sub>2</sub> pipeline owner Shell Oil Company and other defendants alleging, among other things, that the defendants "controlled and depressed the price of CO<sub>2</sub>" from a field partially owned by Beard and "reduc[ed] the delivered price of CO<sub>2</sub> while ... simultaneously inflating the cost of transportation." [<http://www.secinfo.com/dRxzp.424.htm#1fmr>]

**Siting Authority.** A company seeking to construct a CO<sub>2</sub> pipeline must secure siting approval from the relevant regulatory authorities and must subsequently secure rights of way from landowners along the pipeline right by purchasing easements or by eminent domain. However, since federal agencies claim no regulatory authority with respect to CO<sub>2</sub> pipeline construction, potential builders of new CO<sub>2</sub> pipelines do not require, and could not obtain, federal approval to construct new pipelines. Likewise, federal regulators claim no eminent domain authority for pipeline construction, and so cannot ensure that pipeline companies can secure rights of way to construct new pipelines. By contrast, companies seeking to build interstate *natural gas* 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.<sup>36</sup> A certificate of public convenience and necessity granted by FERC (15 U.S.C. § 717f(h)) confers eminent domain authority.

The state-by-state siting approval process for CO<sub>2</sub> pipelines may be complex and protracted, and may face public opposition, especially in populated or environmentally sensitive areas. As the National Commission on Energy Policy (NCEP) states in its 2006 report:<sup>37</sup>

Recent developments notwithstanding, most new energy projects are still regulated primarily at the state level and 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. At the same time — and despite recent moves toward consolidated oversight by FERC or other regulatory authorities — fragmented permitting processes, nonstandard permitting requirements, and interagency redundancy often still compound siting challenges.

Securing rights of way along existing easements for other infrastructure (e.g., natural gas pipelines, electric transmission lines) may be one way to facilitate the siting of new CO<sub>2</sub> pipelines. However, existing easements may be ambiguous as to the right of the easement holder to install and operate CO<sub>2</sub> pipelines. Questions may also arise as to compensation for landowners or easement holders for use of such easements, and as to whether existing easements can be sold or leased to CO<sub>2</sub> pipeline companies.<sup>38</sup> A related issue is whether state condemnation laws, which are often used to secure sites for infrastructure deemed to be in the public interest, allow for CO<sub>2</sub> pipelines to be treated as public utilities or common carriers. This issue also arises on federal lands managed by the Bureau of Land Management (BLM). New

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<sup>36</sup> 18 C.F.R. § 157.

<sup>37</sup> National Commission on Energy Policy, *Siting Critical Energy Infrastructure: An Overview of Needs and Challenges*. (Washington, DC: June 2006): 9. (Hereafter referred to as NCEP 2006.)

<sup>38</sup> Partha S. Chaudhuri, Michael Murphy, and Robert E. Burns, “Commissioner Primer: Carbon Dioxide Capture and Storage” (National Regulatory Research Institute, Ohio State Univ., Columbus, OH: Mar. 2006): 17.

CO<sub>2</sub> pipelines through BLM lands potentially may be sited under right of way provisions in either the Federal Land Policy and Management Act (FLPMA; 43 U.S.C. § 35) or the Mineral Leasing Act (MLA; 30 U.S.C. § 185). However, the MLA imposes a common carrier requirement while the FLPMA does not. Although the agency currently permits CO<sub>2</sub> pipelines for EOR under the MLA,<sup>39</sup> CO<sub>2</sub> pipeline companies seeking to avoid common carrier requirements under CCS schemes may litigate to secure rights of way under FLPMA.<sup>40</sup> Provisions in P.L. 110-140 require the Secretary of the Interior to recommend legislation to clarify the appropriate framework for issuing CO<sub>2</sub> pipeline rights-of-way on federal land (Sec. 714(7)).

Another complicating factor in the siting of CO<sub>2</sub> pipelines for CCS is the types of locations of existing CO<sub>2</sub> sources. Although a network of long-distance CO<sub>2</sub> pipelines exists in the United States today for EOR, these pipelines are sited mostly in remote areas accustomed to the presence of large energy infrastructure. However, many potential sources of CO<sub>2</sub>, such as power plants, are located in populated regions, many with a history of public resistance to the siting of energy infrastructure. If a widespread CO<sub>2</sub> pipeline network is required to support CCS, the ability to site pipelines to serve such facilities may become an issue requiring congressional attention. As the NCEP concluded, “In sum, it seems probable that the siting of critical infrastructure will continue to present a major challenge for policymakers.”<sup>41</sup>

## Commodity vs. Pollutant Classification

Under a comprehensive CCS policy, captured CO<sub>2</sub> arguably could be classified as either a commodity or as a pollutant. CO<sub>2</sub> used in EOR is considered to be a commodity, and is regulated as such by the states. Because captured CO<sub>2</sub> may be sold as a valuable commodity for EOR, and may have further economic potential for enhanced recovery of coal bed methane (ECBM), some argue that all CO<sub>2</sub> under a CCS scheme should be classified as a commodity.<sup>42</sup> However, it is unlikely that the quantities of CO<sub>2</sub> captured under a widely implemented CCS policy could all be absorbed in EOR or ECBM applications. In the long run, significant quantities of captured CO<sub>2</sub> will have to be disposed as industrial pollution, with negative economic value.<sup>43</sup> Furthermore, on April 2, 2007, the U.S. Supreme Court held that the Clean Air Act gives the U.S. Environmental Protection Agency (EPA) the authority to regulate greenhouse gas emissions, including CO<sub>2</sub>, from new motor vehicles.<sup>44</sup> The court also held that EPA cannot interpose policy considerations to

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<sup>39</sup> U.S. Dept. of the Interior, Bureau of Land Management, *Environmental Assessment for Anadarko E&P Company L.P. Monell CO<sub>2</sub> Pipeline Project*, EA #WY-040-03-035 (Feb. 2003): 71.

<sup>40</sup> Chaudhuri et al: 17.

<sup>41</sup> NCEP 2006: 9.

<sup>42</sup> IOGCC 2005: 41.

<sup>43</sup> S.M. Frailey, R.J. Finlay, and T.S. Hickman, “CO<sub>2</sub> Sequestration: Storage Capacity Guideline Needed,” *Oil & Gas Journal* (Aug. 14, 2006): 44.

<sup>44</sup> *Massachusetts v. EPA*; at [<http://www.supremecourtus.gov/opinions/06pdf/05-1120.pdf>].  
(continued...)

refuse to exercise this authority. While the specifics of EPA regulation under this ruling might be subject to agency discretion, it has implications for the regulation of CO<sub>2</sub> emissions from stationary sources, such as power plants.

Separately, EPA has also concluded that geologic sequestration of captured CO<sub>2</sub> through well injection meets the definition of “underground injection” in § 1421(d)(1) of the Safe Drinking Water Act (SDWA).<sup>45</sup> EPA anticipates protecting underground sources of drinking water, through its authority under the SDWA, from “potential endangerment” as a result of underground injection of CO<sub>2</sub> in anticipated CCS pilot projects. EPA’s assertion of authority under SDWA for underground injection of CO<sub>2</sub> during CCS pilot studies may contribute to uncertainty over future classification of CO<sub>2</sub> as a commodity or a pollutant.

Conflicting classification of captured CO<sub>2</sub> as either a commodity or pollutant has important implications for CO<sub>2</sub> pipeline development. For example, classifying all CO<sub>2</sub> as a pollutant not only would contradict current state and BLM treatment of CO<sub>2</sub> for EOR, but might also undermine an interstate commerce rationale for FERC regulation of CO<sub>2</sub> pipelines. On the other hand, classifying all CO<sub>2</sub> as a commodity would create other policy contradictions, for example, in regions like New England where EOR may be impracticable. Under either scenario, legislative and regulatory ambiguities would arise — especially for an integrated, interstate CO<sub>2</sub> pipeline network carrying a mixture of “commodity” CO<sub>2</sub> and “pollutant” CO<sub>2</sub>. Resolving these ambiguities to establish a consistent and workable CCS policy could likely be an issue for Congress.

## Pipeline Costs

If an extensive network of pipelines is required for CO<sub>2</sub> transportation, pipeline costs may be a major consideration in CCS policy. MIT estimated overall annualized pipeline transportation (and storage) costs of approximately \$5 per metric ton of CO<sub>2</sub>.<sup>46</sup> If CO<sub>2</sub> sequestration rates in the United States were on the order of 1 billion metric tons per year at mid-century, as some analysts propose, annualized pipeline costs would run into the billions of dollars. Furthermore, because most pipeline costs are initial capital costs, up-front capital outlays for a new CO<sub>2</sub> pipeline network would be enormous. The 2007 Duke study, for example, estimated it would cost approximately \$5 billion to construct a CO<sub>2</sub> trunk line along existing pipeline rights of way to transport captured CO<sub>2</sub> from North Carolina to potential sequestration sites in the Gulf states and Appalachia.<sup>47</sup> Within the context of overall CO<sub>2</sub> pipeline costs, several specific cost-related issues may warrant further examination by Congress.

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<sup>44</sup> (...continued)

For further information see CRS Report RL33776, *Clean Air Issues in the 110<sup>th</sup> Congress: Climate Change, Air Quality Standards, and Oversight*, by James E. McCarthy.

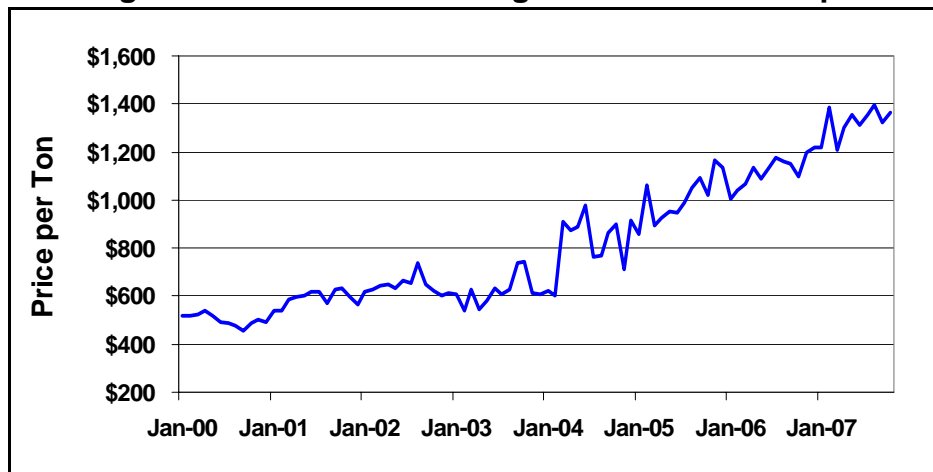
<sup>45</sup> U.S. Environmental Protection Agency, memorandum (July 5, 2006). Available at [[http://www.epa.gov/OGWDW/uic/pdfs/memo\\_wells\\_sequestration\\_7-5-06.pdf](http://www.epa.gov/OGWDW/uic/pdfs/memo_wells_sequestration_7-5-06.pdf)].

<sup>46</sup> MIT 2007: xi.

<sup>47</sup> Eric Williams et al. (2007): 20.

**Materials Costs.** Analysts commonly develop cost estimates for CO<sub>2</sub> pipelines based on comparable construction costs for natural gas pipelines, and to a lesser extent, petroleum product pipelines. In most cases, these comparisons appear appropriate since CO<sub>2</sub> pipelines are similar in design and operation to other pipelines, especially natural gas pipelines. A University of California (UC) study analyzing the costs of U.S. transmission pipelines constructed between 1991 and 2003 found that, on average, labor accounted for approximately 45% of the total construction costs. Materials, rights of way, and miscellaneous costs accounted for 26%, 22%, and 7% of total costs, respectively.<sup>48</sup> Materials cost was most closely dependent upon pipeline size, accounting for an increasing fraction of the total cost with increasing pipeline size, from 15% to 35% of total costs. The MIT study estimated that transportation of captured CO<sub>2</sub> from a 1 gigawatt coal-fired power plant would require a pipe diameter of 16 inches.<sup>49</sup> According to the UC analysis, total construction costs for such a pipe between 1991 and 2003 averaged around \$800,000 per mile (in 2002 dollars), although the study stated that costs for any individual pipeline could vary by a factor of five depending its location.<sup>50</sup>

**Figure 2. U.S. Prices for Large Diameter Steel Pipe**



**Source:** *Preston Pipe & Tube Report*. Pipe prices represent average transaction price (by weighted average value) for double-submerged arc-welded pipe > 24" diameter, combining domestic and import shipments. Prices are reported through October 2007.

Since pipeline materials make up a significant portion of CO<sub>2</sub> pipeline construction costs, analysts have called attention to rising pipeline materials costs,

<sup>48</sup> N. Parker, "Using Natural Gas Transmission Pipeline Costs to Estimate Hydrogen Pipeline Costs," UCD-ITS-RR-04-35, Inst. of Transportation Studies, Univ. of California (Davis, CA: 2004): 1. [<http://hydrogen.its.ucdavis.edu/people/ncparker/papers/pipelines>]; see, also, G. Heddle, H. Herzog, and M. Klett, "The Economics of CO<sub>2</sub> Storage," MIT LFEE 2003-003 RP (Laboratory for Energy and the Environment, MIT, Cambridge, MA: Aug. 2003). [[http://lfec.mit.edu/public/LFEE\\_2003-003\\_RP.pdf](http://lfec.mit.edu/public/LFEE_2003-003_RP.pdf)]

<sup>49</sup> MIT 2007: 58.

<sup>50</sup> N. Parker (2004): Fig. 23.



especially steel costs, as a concern for policymakers.<sup>51</sup> Following a period of low steel prices and company bankruptcies earlier in the decade, the North American steel industry has returned to profitability and enjoys strong domestic and global demand.<sup>52</sup> Now, higher prices resulting from both strong demand and increased production costs for carbon steel plate, used in making large-diameter pipe, may alter the basic economics of CO<sub>2</sub> pipeline projects and CCS schemes overall. As **Figure 2** shows, the price of large-diameter pipe was generally around \$600 per ton in late 2001 and early 2002. By late 2007, the price of pipe was approaching \$1,400 per ton. Analysts forecast carbon steel prices to decline over the next two years, but only gradually, and to a level still more than double the price early in the decade.<sup>53</sup>

If some form of CCS is effectively mandated in the future, a surge in demand for new CO<sub>2</sub> pipe, in competition with demand for natural gas and oil pipelines, may exacerbate the trend of rising prices for pipeline materials, and could even lead to shortages of pipe steel from North American sources. As a consequence, the availability and cost of pipeline steel to build such a CO<sub>2</sub> pipeline network for CCS may be a limiting factor for widespread CCS implementation.

**Cost Recovery.** In states where traditional rate regulation exists, construction and operation of CO<sub>2</sub> pipelines for CCS could raise questions about cost recovery for electric utilities under state utility regulation. If, for example, a CO<sub>2</sub> pipeline is constructed for the exclusive use of a single power plant for on-site (or nearby) CO<sub>2</sub> sequestration, and is owned by the power plant owners, it logically could be considered an extension of the plant itself. In such cases, the CO<sub>2</sub> pipelines could be eligible for regulated returns on the invested capital and their costs could be recovered by utilities in electricity rates. Alternatively such a CO<sub>2</sub> pipeline could be owned by third parties and considered a non-plant asset providing a transportation service for a fee. In the latter case, the costs could still be recovered by the utility in its rates as an operating cost.

Two complications arise with respect to pipeline cost recovery. First, because utility regulation varies from state to state (e.g., some states allow for competition in electricity generation, others do not),<sup>54</sup> differences among states in the economic regulation of CO<sub>2</sub> pipelines could create economic inefficiencies and affect the attractiveness of CO<sub>2</sub> pipelines for capital investment. Second, if CO<sub>2</sub> transportation infrastructure is intended to evolve from shorter, stand-alone, *intrastate* pipelines into a network of interconnected *interstate* pipelines, pipeline operators wishing to link CO<sub>2</sub> pipelines across state lines may face a regulatory environment of daunting complexity. Without a coherent system of economic regulation for CO<sub>2</sub> pipelines, whether as a commodity, pollutant, or some other classification, developers of

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<sup>51</sup> IPCC 2005: 27.

<sup>52</sup> See CRS Report RL32333, *Steel: Price and Policy Issues*, by Stephen Cooney.

<sup>53</sup> Michael Cowden, "A Profusion of New Pipeline Projects and Profits... for Now," *American Metal Market* (January 2008): 18; Global Insight, *Steel Industry Review* (2nd Qtr. 2006), tabs. 1.11-1.12; and *American Metal Market*, "West Sees More Steel Plate But Prices Holding Ground" (Aug. 31, 2006).

<sup>54</sup> In market-based states, cost recovery may affect electricity markets.

interstate CO<sub>2</sub> pipelines may need to negotiate or litigate repeatedly issues such as siting, pipeline access, terms of service, and rate “pancaking” (the accumulation of transportation charges assessed by contiguous pipeline operators along a particular transportation route). It is just these kinds of issues which have complicated and impeded the integration of individual utility electric transmission systems into larger regional transmission networks.<sup>55</sup>

**CO<sub>2</sub> Pipeline Incentives.** Oil industry representatives frequently point to EOR as offering a market-based model for profitable CO<sub>2</sub> transportation via pipeline. It should be noted, however, that much of the existing CO<sub>2</sub> pipeline network in the United States for EOR has been established with the benefit of federal tax incentives. Although current federal tax law provides no special or targeted tax benefits specifically to CO<sub>2</sub> pipelines, investments in CO<sub>2</sub> pipelines *do* benefit from tax provisions targeted for EOR. They also benefit from accelerated depreciation rules, which apply generally to any capital investment including petroleum and natural gas (non-CO<sub>2</sub>) pipelines. For example, the Internal Revenue Code provides for a 15% income tax credit for the costs of recovering domestic oil by one of nine qualified EOR methods, including CO<sub>2</sub> injection (I.R.C. § 43).<sup>56</sup> Also, extraction of naturally occurring CO<sub>2</sub> may qualify for percentage depletion allowance under I.R.C. § 613(b)(7). Prior federal law, both tax and nontax, also provided various types of incentives for EOR which stimulated investment in CO<sub>2</sub> pipelines. In particular, oil produced from EOR projects was exempt from oil price controls in the 1970s. Development of CO<sub>2</sub> pipeline infrastructure in the 1980s benefitted from tax advantages to EOR oil under the crude oil windfall profits tax law, which was in effect from March 1980 to August 1988.

Although there were never incentives explicitly for CO<sub>2</sub> pipelines under federal tax and price control regulation in the 1970s and 1980s, it is clear that CO<sub>2</sub> pipeline infrastructure development benefitted from these regulations. In a CCS environment where some captured CO<sub>2</sub> is a valuable commodity, but the remainder is not, establishing similar regulatory incentives for CO<sub>2</sub> pipelines becomes complex. One initial proposal in S. 2149 would allow seven-year accelerated depreciation for qualifying CO<sub>2</sub> pipelines constructed after enactment (Sec. 4). As debate continues about the economics of CO<sub>2</sub> capture and sequestration generally, and how the federal government can encourage CCS infrastructure investment, Congress may seek to understand the implications of CCS incentives specifically on CO<sub>2</sub> pipeline development.

**Cost Implications for Network Development.** In light of the overall costs associated with CO<sub>2</sub> pipelines, including the uncertainty about future materials costs and cost recovery, some analysts anticipate that a CO<sub>2</sub> network for CCS will begin with shorter pipelines from CO<sub>2</sub> sources located close to sequestration sites. Larger CO<sub>2</sub> trunk lines are expected to emerge to capture substantial scale economies in

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<sup>55</sup> For further information of electric transmission regulation, see CRS Report RL33875, *Electric Transmission: Approaches for Energizing a Sagging Industry*, by Amy Abel.

<sup>56</sup> Unfortunately for EOR investors, while this tax credit is part of current federal tax law, its phaseout provisions mean that presently it is not available — the credit is zero — due to high crude oil prices.

long-distance pipeline transportation. According to the 2007 MIT report, “it is anticipated that the first CCS projects will involve plants that are very close to a sequestration site or an existing CO<sub>2</sub> pipeline. As the number of projects grow, regional pipeline networks will likely evolve.”<sup>57</sup> It is debatable, however, whether piecemeal growth of a CO<sub>2</sub> pipeline network in this way, presumably by individual facility operators seeking to minimize their own costs, would ultimately yield an economically efficient and publically acceptable CO<sub>2</sub> pipeline network for CCS. Weaknesses and failures in the North American electric power transmission grid, which was developed in this manner, may be one example of how piecemeal, uncoordinated network development may fail to satisfy key economic and operating objectives.

As an alternative to piecemeal CO<sub>2</sub> pipeline development, some analysts suggest that it may be more cost effective in the long run to build large trunk pipelines when the first sites with CO<sub>2</sub> capture come on line with the expectation that subsequent users could fill the spare capacity in the trunk line. In addition to lower per-unit transport costs for CO<sub>2</sub>, such an arrangement would smooth out potentially intermittent CO<sub>2</sub> flows from individual capture sites (especially discontinuously operated power plants), provide a greater buffer for overall CO<sub>2</sub> supply fluctuations, and generally allow for more operational flexibility in the system.<sup>58</sup> Planning and financing such a CO<sub>2</sub> trunk line system would present its own challenges, however. As another analysis points out, “implementation of a ‘backbone’ transport structure may facilitate access to large remote storage reservoirs, but infrastructure of this kind will require large initial upfront investment decisions.”<sup>59</sup> How a CO<sub>2</sub> network for CCS would be configured, and who would configure it, may be issues for Congress.<sup>60</sup>

## CO<sub>2</sub> Pipeline Safety

CO<sub>2</sub> occurs naturally in the atmosphere, and is produced by the human body during ordinary respiration, so it is commonly perceived by the general public to be a relatively harmless gas. However, at concentrations above 10% by volume, CO<sub>2</sub> may cause adverse health effects and at concentrations above 25% poses a significant asphyxiation hazard. Because CO<sub>2</sub> is colorless, odorless, and heavier than air, an uncontrolled release may accumulate and remain undetected near the ground in low-lying outdoor areas, and in confined spaces such as caverns, tunnels, and basements.<sup>61</sup> Exposure to CO<sub>2</sub> gas, as for other asphyxiates, may cause rapid “circulatory

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<sup>57</sup> Ibid., MIT. (2007): 59.

<sup>58</sup> John Gale and John Davidson, “Transmission of CO<sub>2</sub> — Safety and Economic Considerations,” *Energy*, Vol. 29, Nos. 9-10 (July-August 2004): 1326.

<sup>59</sup> IPCC 2005: 190.

<sup>60</sup> For further discussion see CRS Report RL34316, *Pipelines for Carbon Dioxide (CO<sub>2</sub>) Control: Network Needs and Cost Uncertainties*, by Paul W. Parfomak and Peter Folger.

<sup>61</sup> 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: Sept. 5-9, 2004): 2.

insufficiency,” coma, and death.<sup>62</sup> Such an event occurred in 1986 in Cameroon, when a cloud of naturally-occurring CO<sub>2</sub> spontaneously released from Lake Nyos killed 1,800 people in nearby villages.<sup>63</sup>

The Secretary of Transportation has primary authority to regulate interstate CO<sub>2</sub> pipeline safety under the Hazardous Liquid Pipeline Act of 1979 as amended (49 U.S.C. § 601). Under the act, the Department of Transportation (DOT) regulates the design, construction, operation and maintenance, and spill response planning for CO<sub>2</sub> pipelines (49 C.F.R. § 190, 195-199). The DOT administers pipeline regulations through the Office of Pipeline Safety (OPS) within the Pipelines and Hazardous Materials Safety Administration (PHMSA).<sup>64</sup> Although CO<sub>2</sub> is listed as a Class 2.2 (non-flammable gas) hazardous material under DOT regulations (49 C.F.R. § 172.101), the agency applies nearly the same safety requirements to CO<sub>2</sub> pipelines as it does to pipelines carrying hazardous liquids such as crude oil, gasoline, and anhydrous ammonia (49 C.F.R. § 195).

To date, CO<sub>2</sub> pipelines in the United States have experienced few serious accidents. According to OPS statistics, there were 12 leaks from CO<sub>2</sub> pipelines reported from 1986 through 2006 — none resulting in injuries to people. By contrast, there were 5,610 accidents causing 107 fatalities and 520 injuries related to natural gas and hazardous liquids (excluding CO<sub>2</sub>) pipelines during the same period.<sup>65</sup> It is difficult to draw firm conclusions from these accident data, because CO<sub>2</sub> pipelines account for less than 1% of total natural gas and hazardous liquids pipelines, and CO<sub>2</sub> pipelines currently run primarily through remote areas. Based on the limited sample of CO<sub>2</sub> incidents, analysts conclude that, mile-for-mile, CO<sub>2</sub> pipelines appear to be safer than the other types of pipeline regulated by OPS.<sup>66</sup> Additional measures, such as adding gas odorants to CO<sub>2</sub> to aid in leak detection, may further mitigate CO<sub>2</sub> pipeline hazards. Nonetheless, as the number of CO<sub>2</sub> pipelines expands, analysts suggest that “statistically, the number of incidents involving CO<sub>2</sub> should be similar to those for natural gas transmission.”<sup>67</sup> If the nation’s CO<sub>2</sub> pipeline network expands significantly to support CCS, and if this expansion includes more pipelines near populated areas, more CO<sub>2</sub> pipeline accidents are likely in the future.<sup>68</sup>

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<sup>62</sup> Airco, Inc., “Carbon Dioxide Gas,” *Material Safety Data Sheet* (Aug. 4, 1989). [<http://www2.siri.org/msds/f2/byd/bydjl.html>]

<sup>63</sup> Kevin Krajick, “Defusing Africa’s Killer Lakes,” *Smithsonian*, v. 34, n. 6. (2003): 46—55.

<sup>64</sup> PHMSA succeeds the Research and Special Programs Administration (RSPA), reorganized under P.L. 108-246, which was signed by the President on Nov. 30, 2004.

<sup>65</sup> Office of Pipeline Safety (OPS), “Distribution, Transmission, and Liquid Accident and Incident Data,” (2007). OPS has not yet released 2007 incident statistics. Data files available at [<http://ops.dot.gov/stats/IA98.htm>].

<sup>66</sup> John Gale and John Davidson. (2004): 1322.

<sup>67</sup> Barrie et al. (2004): 2.

<sup>68</sup> Gale and Davidson (2004): 1321.

**Criminal and Civil Liability.** There are no special provisions in U.S. law protecting the CO<sub>2</sub> pipeline industry from criminal or civil liability. In January 2003, the Justice Department announced over \$100 million in civil and criminal penalties against Olympic Pipeline and Shell Pipeline resolving claims from a fatal gasoline pipeline fire in Bellingham, WA, in 1999.<sup>69</sup> In March 2003, emphasizing the environmental aspects of homeland security, Attorney General John Ashcroft reportedly announced a crackdown on companies failing to protect against possible terrorist attacks on storage tanks, transportation networks, industrial plants, and pipelines.<sup>70</sup>

Even if no federal or state regulations are violated, CO<sub>2</sub> pipeline operators could still face civil liability for personal injury or wrongful death in the event of an accident. In the Bellingham accident, the pipeline owner and associated defendants reportedly agreed to pay a \$75 million settlement to the families of two children killed in the accident.<sup>71</sup> In 2002, El Paso Corporation settled wrongful death and personal injury lawsuits stemming from a natural gas pipeline explosion near Carlsbad, NM, which killed 12 campers.<sup>72</sup> Although the terms of those settlements were not disclosed, two additional lawsuits sought a total of \$171 million in damages.<sup>73</sup> The MIT study concluded that operational liability for CO<sub>2</sub> pipelines, as part of an integrated CCS infrastructure, “can be managed within the framework that has been successfully used for decades by the oil and gas industries.”<sup>74</sup> Nonetheless, as CCS policy evolves, Congress may seek to ensure that liability provisions for CO<sub>2</sub> pipelines are adequate and consistent with liability provisions in place for other CO<sub>2</sub> infrastructure.

## Other Issues

In addition to the issues discussed above, additional policy issues related to CO<sub>2</sub> pipelines may arise as CCS policy evolves. These may include addressing technical transportation problems related to the presence of other pollutants, such as sulfuric and carbonic acid, in CO<sub>2</sub> pipelines. Some have also suggested the use or conversion of existing non-CO<sub>2</sub> pipelines, such as natural gas pipelines, to transport CO<sub>2</sub>.<sup>75</sup>

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<sup>69</sup> “Shell, Olympic Socked for Pipeline Accident,” *Energy Daily* (Jan. 22, 2003).

<sup>70</sup> John Heilprin, “Ashcroft Promises Increased Enforcement of Environmental Laws for Homeland Security,” *Assoc. Press*, Washington dateline (Mar. 11, 2003).

<sup>71</sup> Business Editors, “Olympic Pipe Line, Others Pay Out Record \$75 Million in Pipeline Explosion Wrongful Death Settlement,” *Business Wire* (April 10, 2002).

<sup>72</sup> National Transportation Safety Board, *Pipeline Accident Report*, PAR-03-01. (Feb. 11, 2003).

<sup>73</sup> El Paso Corp., *Quarterly Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934*, Form 10-Q, Period ending June 30, 2002. (Houston, TX: 2002). The impact of these lawsuits on the company’s business is unclear, however; the report states that “our costs and legal exposure ... will be fully covered by insurance.”

<sup>74</sup> MIT 2007: 58.

<sup>75</sup> An example is the Gwinville, MS-Lake St. John, LA natural gas pipeline purchased by (continued...)

Coordination of U.S. CO<sub>2</sub> pipeline policies with Canada, with whom the United States shares its existing pipeline infrastructure, may also become a consideration. Finally, the potential impacts of CO<sub>2</sub> pipeline development overseas on the global availability of construction skills and materials may arise as a key factor in CCS economics and implementation.

## Conclusion

Policy debate about the mitigation of climate change through some scheme of carbon capture and sequestration is expanding quickly. To date, debate among legislators has been focused mostly on CO<sub>2</sub> sources and storage sites, but CO<sub>2</sub> pipelines are a vital connection between the two. Although CO<sub>2</sub> transportation by pipeline is in some respects a mature technology, there are many important unanswered questions about the socially optimal configuration, regulation, and costs of a CO<sub>2</sub> pipeline network for CCS. Furthermore, because CO<sub>2</sub> pipelines for EOR are already in use today, policy decisions affecting CO<sub>2</sub> pipelines take on an urgency that is, perhaps, unrecognized by many. It appears, for example, that federal classification of CO<sub>2</sub> as both a commodity (by the BLM) and as a pollutant (by the EPA) potentially could create an immediate conflict which may need to be addressed not only for the sake of future CCS implementation, but also to ensure consistency between future CCS and today's CO<sub>2</sub> pipeline operations.

In addition to these issues, Congress may examine how CO<sub>2</sub> pipelines fit into the nation's overall strategies for energy supply and environmental protection. The need for CO<sub>2</sub> pipelines ultimately derives from the nation's consumption of fossil fuels. Policies affecting the latter, such as energy conservation, and the development of new renewable, nuclear, or hydrogen energy resources, could substantially affect the need for and configuration of CO<sub>2</sub> pipelines. If policy makers encourage continued consumption of fossil fuels under CCS, then the need to foster the other energy options may be diminished — and vice versa. Thus decisions about CO<sub>2</sub> pipeline infrastructure could have consequences for a broader array of energy and environmental policies.

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<sup>75</sup> (...continued)

Denbury Resources, Inc. in 2006 and converted to CO<sub>2</sub> transportation for EOR in 2007.