CARBON DIOXIDE SEQUESTRATION—TRANSPORTATION, STORAGE, AND OTHER INFRASTRUCTURE ISSUES

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I. INTRODUCTION: CARBON SEQUESTRATION—DRIVERS

Carbon sequestration is the storage of anthropogenic carbon dioxide in underground geologic formations. The excitement behind commercial-

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scale carbon sequestration lies at the intersection of two broad global trends: global climate change and increasing global demand for energy. Scientists have measured a rise in global surface temperatures of 1.4°F since the start of the twentieth century.[1] Climate change experts, such as the Intergovernmental Panel on Climate Change ("IPCC"), are projecting that average global surface temperatures will likely rise by an additional 2.0°–11.5°F by the year 2100.[2] These increases, according to most scientists, are due to human activities that have increased the amount of greenhouse gases in the atmosphere.[3] At the same time, global demand for energy, resulting in part from the emerging economies of China and India, as well as from continuing worldwide population growth, is on the rise. The source of most of the world's energy generation is fossil fuels, which produce greenhouse gases such as carbon dioxide when burned. According to the Department of Energy ("DOE"), fossil fuels account for about 82% of all greenhouse gases produced in the United States by human activity.[4]

Scientists and other researchers have been exploring carbon sequestration as an option to curb the release of carbon dioxide ("CO_2") from human sources into the atmosphere and to mitigate the global warming effects of burning fossil fuels for energy. According to the IPCC, a geologic storage site that is properly selected and managed could store CO_2 for millions of years and would likely retain over 99% of the injected CO_2 for at least a thousand years.[5] Notably, the United States has widespread geologic storage capacity for the sequestration of CO_2, and the storage capacity is frequently near large point-sources of CO_2 emissions, such as power plants.[6] With the promise of carbon sequestration to mitigate the carbon footprint of many of the large point

1. NAT'L ACAD. OF SCI. ET AL., UNDERSTANDING AND RESPONDING TO CLIMATE CHANGE: HIGHLIGHTS OF NATIONAL ACADEMIES REPORTS 2 (2008).

2. *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CARBON DIOXIDE CAPTURE AND STORAGE (2005), *available at* http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/SRCCS_WholeReport.pdf [hereinafter IPCC REPORT].

3. The primary greenhouse gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). When an excess of greenhouse gases accumulate in the earth's atmosphere, they trap heat and create a greenhouse effect, warming the earth's temperature.

4. Energy Info. Admin., Greenhouse Gases, Climate Change, and Energy (2008), *available at* http://www.eia.doe.gov/bookshelf/brochures/greenhouse/Chapter1.htm.

5. IPCC REPORT, *supra* note 2, at 14.

6. *See* NatCarb, http://www.natcarb.org (last visited Nov. 12, 2008) (online source provided by "a national look at carbon sequestration" displaying a map of stationary sources of CO_2 emissions and potential geologic repositories for CO_2). Also, a study from MIT concluded that the majority of coal-fired power plants are located in areas where there are high expectations that sequestration site are nearby. *See* PAUL PARFOMAK & PETER FOLGAR, CRS REPORT FOR CONGRESS: CO_2 PIPELINES OF CARBON SEQUESTRATION 6 (2007), *available at* http://ncseonline.org/NLE/CRSreports/07May/RL33971.pdf [hereinafter CO_2 PIPELINE REPORT].

sources of CO_2 emissions, the interest in carbon sequestration is prevalent.

In the United States, the drivers behind carbon sequestration are particularly strong. The United States has substantial coal reserves, particularly as compared to oil reserves, and by some estimates, the U.S. coal reserves could provide power generation for the country for more than 100 years and possibly for more than 200 years.[7] At the same time, CO_2 emissions from coal-fired electricity generation account for almost 80% of the total CO_2 emissions produced by electricity generation in the United States; the share of electricity generation from coal, however, is approximately 50%.[8] Should carbon sequestration become viable on a commercial scale, the impact of coal-fueled electric power generation on CO_2 emissions would be substantially decreased. According to some experts, the total capacity for storing captured CO_2 in geologic repositories in the United States and Canada is 1.2 to 3.6 trillion metric tons, which equates to a few hundred years' worth of CO_2 emissions.[9] To this end, the U.S. government is investing resources in carbon capture and sequestration. Under the Energy Independence and Security Act of 2007, Congress authorized substantial federal funding for studying and developing carbon capture and sequestration technologies and projects.[10] And, in July 2008, the DOE announced it will provide $36 million for fifteen projects with the goal of furthering the development of technologies for carbon capture from existing coal-fired power plants.[11]

Despite the excitement behind and the promise of carbon sequestration, hurdles remain. The regulatory framework is in its infancy as the federal and certain state governments are currently building legal regimes to regulate carbon sequestration. At the same time, there is still much uncertainty regarding how long-term liability will be apportioned

7. Not surprisingly, different organizations provide different estimates for the U.S. supply of coal. The American Coalition for Clean Coal Electricity ("ACCCE") provides an estimate of 200 or more years. *See Abundance of Coal for Electricity Generation*, AMERICAN COALITION FOR CLEAN COAL ELECTRICITY, 2008, http://www.cleancoalusa.org/docs/abundant. In a 2007 report, the National Academy of the Sciences stated that there is enough coal to meet U.S. needs for at least 100 years but that it is difficult to confirm whether there is sufficient coal for more than 200 years. Matthew L. Wald, *Science Panel Finds Fault with Estimates of Coal Supply*, N.Y. TIMES, June 21, 2007, at C2.

8. U.S. DEP'T OF ENERGY, CARBON DIOXIDE EMISSIONS FROM THE GENERATION OF ELECTRICITY IN THE UNITED STATES 3 (2000), *available at* http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2emiss.pdf.

9. CONG. BUDGET OFFICE, THE POTENTIAL FOR CARBON SEQUESTRATION IN THE UNITED STATES 2 (2007), *available at* http://www.cbo.gov/ftpdocs/86xx/doc8624/09-12-CarbonSequestration.pdf [hereinafter CBO REPORT].

10. Energy Independence and Security Act of 2007, 42 U.S.C.A. § 16293 (West 2008).

11. *DOE to Provide $36 Million to Advance Carbon Dioxide Capture*, U.S. DEP'T OF ENERGY, July 31, 2008, http://fossil.energy.gov/news/techlines/2008/08030-CO2_Capture_Projects_Selected.html.

among the stakeholders, and not all jurisdictions have clearly defined parameters regarding the ownership of the subsurface pore space into which the carbon dioxide is stored. Even so, most agree that federal climate-change legislation is forthcoming within the next two years, and the combination of the success of pilot projects and the emerging development of legal regimes suggests that carbon sequestration will in the future become a large-scale commercial enterprise.

II. INFRASTRUCTURE

Carbon sequestration is part of a process frequently termed "carbon capture and storage" ("CCS"). CCS involves three stages: (1) the capture of CO_2 from a point source (such as a coal- or gas-fired power plant) and then its compression into a fluid state for transportation; (2) the transportation of the liquid phase CO_2 through pipelines; and (3) the injection or storage of the CO_2 into underground geologic formations.

A. Capture

Before the CO_2 is transported and sequestered, it is captured from a point source and compressed into a liquid state. The main cost in CCS is capture.[12] It is anticipated that CO_2 will be captured from large power plants, but other potential point sources include industrial facilities for cement manufacturing, oil refining and natural gas processing, and iron and steel production.[13] Capture technology aims to produce a concentrated stream of CO_2 at high pressure that can be efficiently transported. There are three methods for capturing CO_2: (1) post-combustion systems; (2) pre-combustion systems; and (3) oxy-fuel combustion systems.

In post-combustion capture, the CO_2 is separated from the flue gases produced by combustion of the primary fuel (e.g., coal, natural gas) in air.[14] The CO_2 is typically separated by passing the CO_2-containing gas through a stripper system with chemical solvents to trap the CO_2.[15] Often the CO_2 concentration in the flue gas stream is relatively small (3 to 15% by volume).[16] Because post-combustion capture may be added onto an existing flue gas stream, this technology may be used for retrofitting

12. IPCC REPORT, *supra* note 2, at 11 (charting cost of CCS components). *See also* U.S. DEP'T OF ENERGY, CARBON SEQUESTRATION ATLAS OF THE UNITED STATES AND CANADA 5 (2007), *available at* http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlas/ATLAS.pdf [hereinafter SEQUESTRATION ATLAS] (stating that the DOE program is working to reduce the cost of capture technologies).

13. IPCC REPORT, *supra* note 2, at 112-13.

14. *Id*. at 109.

15. *Id*.

16. *Id*. at 25. Generally, when the CO_2 content of the flue gases is higher, then the process is less costly and less energy intensive.

existing facilities without major rebuilds.[17] Currently, post-combustion capture technologies are commercially available and used to capture CO_2 from coal-fired plants for use in the food and beverage industries.[18]

In pre-combustion capture, the primary fuel is processed in a reactor with oxygen or air and steam prior to combustion to produce a mixture of carbon monoxide and hydrogen known as "synthesis gas" or "syngas."[19] A second reactor is used to convert the carbon monoxide into carbon dioxide and additional hydrogen.[20] Then the carbon dioxide is separated, usually by a physical or chemical absorption process, leaving a hydrogen-rich fuel that can be used for combustion. The costs of the initial fuel conversion steps are higher in pre-combustion systems than in post-combustion systems, but the pre-combustion systems produce higher concentrations of CO_2 (15 to 60% by volume), which is more favorable for separation.[21] Pre-combustion capture is the most commercially-developed of the three options because numerous commercial facilities use coal or oil to manufacture hydrogen for ammonia fertilizer.[22] Pre-combustion capture is also well suited for integrated gasification combined cycle ("IGCC") power plants.

In oxy-fuel combustion systems, oxygen is used instead of air for combustion of the primary fuel to produce a flue gas that is mainly water vapor and CO_2.[23] The resulting flue gas stream has high concentrations of CO_2 (generally greater than 80% by volume).[24] The oxy-fuel combustion systems remove the water vapor by cooling and compressing the flue gas stream. Some elements of this process are in commercial use, but in general this is the least developed of the three options and has not been implemented for CO_2 capture on a large scale.[25] Additionally, although the overall energy requirements of this form of capture are lower than for post-combustion capture, the capital costs and power requirements of oxygen production may present a challenge for oxy-fuel combustion systems.[26]

17. CAL. ENERGY COMM'N & CAL. DEP'T OF CONSERVATION, GEOLOGIC CARBON SEQUESTRATION STRATEGIES FOR CALIFORNIA: REPORT TO THE LEGISLATURE 32 (2008), *available at* http://www.energy.ca.gov/2007publications/CEC-500-2007-100/CEC-500-2007-100-CMF.PDF [hereinafter CAL. JOINT REPORT].
18. CBO REPORT, *supra* note 9, at 11.
19. IPCC REPORT, *supra* note 2, at 25.
20. *Id*.
21. *Id*.
22. CAL. JOINT REPORT, *supra* note 17, at 32.
23. IPCC REPORT, *supra* note 2, at 109.
24. *Id*.
25. CAL. JOINT REPORT, *supra* note 17, at 34.
26. *Id*. at 35.

B. Transportation

CO_2 is compressed into a liquid state for efficient transport and is typically transported in pipelines. Compression of CO_2 utilizes mature gas compression technologies developed by the natural gas industry.[27] For pipeline transport, the CO_2 ideally is free of hydrogen sulfide to minimize pipeline corrosion.[28] Although pipelines are usually the preferred mechanism for transport, ships may be used for longer distances (e.g., overseas).[29]

Currently, CO_2 transport by pipeline operates as a mature technology because of the use of CO_2 in enhanced oil recovery ("EOR") operations. Kinder Morgan and BP Amoco, for example, are major operators of CO_2 pipelines that were constructed in the 1970s and 1980s.[30] In the United States, there are approximately 5,800 miles of pipelines for the transportation of CO_2 from natural and anthropogenic sources to oilfields for use in EOR.[31]

Even so, existing CO_2 pipeline infrastructure will have to be expanded significantly to implement a large-scale CCS market. Large point sources are not always situated over suitable carbon sequestration sites. As a result, there is the potential for a boom in pipeline construction. It is likely that, if CO_2 sequestration is to achieve a commercial scale, pipeline capacity will need to double over the next fifteen years. The existing infrastructure generally has been in areas of low population density, and it can be anticipated that safety issues may become more complex if new pipelines are laid in more densely populated areas.

C. Storage

Carbon sequestration is achieved by injecting the CO_2 in a dense liquid form into a geologic rock formation below the earth's surface. The density of the CO_2 increases as depth below the surface increases, and at a depth of about 800 meters, the CO_2 reaches a dense "supercritical" state.[32] Where the CO_2 can be injected to a sufficient depth and can achieve and maintain the supercritical state, the storage capacity of the geologic formation will be maximized because supercritical CO_2 occupies less pore space for a given quantity of CO_2.[33] The injection technology has been developed in the oil and gas industry for use of CO_2 for EOR,

27. *See generally* Ian J. Duncan, *From Power Plant to Back in the Ground: A Practical Example of Carbon Capture and Sequestration including EOR Applications*, 2008 CARBON AND CLIMATE CHANGE 5 (Univ. of Tex. Sch. of Law Continuing Legal Educ.).
28. IPCC REPORT, *supra* note 2, at 181.
29. *Id.*
30. CAL. JOINT REPORT, *supra* note 17, at 25.
31. CO_2 PIPELINE REPORT, *supra* note 6, at 4.
32. IPCC REPORT, *supra* note 2, at 6 n.9.
33. *Id*. at 21.

but well-drilling and injection technology and computer simulation of storage reservoir dynamics are being further developed for long-term geologic storage of CO_2.[34]

Three types of geologic formations have been identified as the most viable repositories for carbon sequestration: (1) deep saline formations, (2) depleted oil and gas reservoirs, and (3) unmineable coal beds.[35] Saline formations are sedimentary rocks saturated with formation waters containing high concentrations of salts.[36] Due to the high salt content, the waters are not suitable for agriculture or human consumption.[37] The CO_2 is injected into deep saline formations (800 meters below the surface or deeper) capped by a layer of impermeable rock.[38] More widespread than the other options, saline formations present the largest capacity for CO_2 storage.[39] By some estimates, deep saline formations account for 80% of the low-end estimate of geologic storage capacity in the United States and Canada (919 billion metric tons out of 1.2 trillion).[40]

Depleted oil and gas reservoirs are viewed as viable candidates for CO_2 storage. The geologic structure of oil and gas fields has been extensively studied by the oil and gas industry, and computer models have been developed to predict the movements and behaviors of hydrocarbons.[41] Carbon dioxide is already injected into mature fields for EOR, and the infrastructure in place may be used for injecting CO_2 for long-term storage. As with deep saline formations, storage of CO_2 in depleted oil and gas reservoirs will generally take place at depths below 800 meters, although storage may be technically feasible in more shallow reservoirs.[42] By some estimates, oil and gas reservoirs, including those in production and those that are and will be abandoned, account for approximately 7% of the low-end estimate of geologic storage capacity in the United States and Canada (82 billion metric tons).[43]

Unmineable coal beds also present a possible storage option for CO_2 due to the fractures in the coal that impart some permeability.[44] Coal permeability varies widely, and it generally decreases with increasing depth.[45] When CO_2 is injected into the coal bed, it adheres to the surface

34. *Id*. at 6-7.
35. *Id*. at 31-36.
36. *Id.* at 3, fn. 3.
37. *Id.*
38. *Id*. at 197.
39. SEQUESTRATION ATLAS, *supra* note 12, at 15.
40. CBO REPORT, *supra* note 9, at 12.
41. IPCC REPORT, *supra* note 2, at 215.
42. *Id*.
43. CBO REPORT, *supra* note 9, at 12.
44. IPCC REPORT, *supra* note 2, at 217.
45. *Id*.

of the coal (it is adsorbed).[46] By some estimates, unmineable coal beds account for approximately 13% of the low-end estimate of geologic storage capacity in the United States and Canada (156 billion metric tons).[47] Some field tests have explored the use of CO_2 to recover coalbed methane, such as in the San Juan basin of New Mexico.[48] Use of CO_2 to recover methane from coalbeds faces some technological obstacles, however, due to the fact that coal seams that are not receptive to mining have low permeability, which can make it difficult to inject a compressed gas such as CO_2.[49]

Siting a carbon sequestration project requires significant surface and subsurface characterization and may be limited by available data and cost.[50] Most believe that deep saline formations below underground sources of drinking water present the greatest storage potential,[51] and pilot studies are underway to explore this potential. For example, the Frio Brine Pilot Project is exploring CO_2 injection into a brine-bearing sandstone formation beneath the Texas Gulf Coast.[52] The site is part of a large area that is a likely target for large-volume storage because of the extensive sandstone underlying several large industrial-point sources of CO_2 emissions. The project is being implemented in several phases and is funded by the DOE.[53] The government will continue to fund similar projects because, following the passage of the Energy Independence and Security Act of 2007, the DOE is authorized to expend funds to study viable CCS technologies.[54]

III. REGULATORY CONTROL

A. Federal

On July 25, 2008, the Environmental Protection Agency ("EPA") published a proposed rulemaking to regulate the injection and geologic sequestration of CO_2.[55] The rules are not expected to become final until 2010 or 2011. The proposed regulations were developed under the

46. *Id*.
47. CBO REPORT, *supra* note 9, at 14.
48. *Id.*
49. *Id*.
50. CAL. JOINT REPORT, *supra* note 17, at 39.
51. *See* IPCC REPORT, *supra* note 2, at 22.
52. Tim Green, *Experiment Seeks Answers on Burying Carbon Dioxide Deep Underground*, THE U. OF TEX. AT AUSTIN, http://www.utexas.edu/research/features/story.php?item=/2006/01/frio16.xml (last visited Nov. 6, 2008).
53. Id.
54. Energy Independence and Security Act of 2007, 42 U.S.C.A. § 16293 (West 2008)
55. Federal Requirements under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,492 (July 25, 2008) (to be codified at 40 C.F.R. §§ 144 and 146).

Underground Injection Control ("UIC") Program pursuant to the Safe Drinking Water Act. The rules would create a new category of underground injection wells, Class VI wells, specifically for the injection and long-term storage of CO_2.[56] The proposed rules identify "deep saline formations, depleted oil and gas reservoirs, un-minable coal seams, and other formations" as the target formations with the most viable CO_2 storage capacity.[57]

Currently, there are five classes of injection wells regulated by the UIC program: Class I wells are used to inject industrial non-hazardous liquids, municipal wastewater, or hazardous wastes beneath the lowermost underground source of drinking water ("USDW").[58] Class II wells are used to inject fluids in connection with conventional oil or natural gas production, enhanced oil and gas production, and the storage of hydrocarbons that are liquid at standard temperature and pressure.[59] Notably, under the proposed rulemaking, the injection of CO_2 for the purposes of enhanced oil and gas recovery will continue to be permitted under the Class II program, and those wells will retain this regulatory designation as long as production is occurring. Class III wells are used to inject fluids associated with the extraction of minerals or energy, including the mining of sulfur and solution mining of minerals.[60] Class IV wells are used to inject hazardous or radioactive wastes into or above a formation containing a USDW, and, with certain exceptions, are banned.[61] Class V wells are shallow wells that inject non-hazardous fluids into or above formations that contain USDWs, and Class V wells include all injection wells that are not included in Classes I-IV.[62] Class V wells include experimental technology wells,[63] such as those being used for carbon sequestration pilot projects, including the Frio Brine Pilot well in Texas.

In the rulemaking, the EPA proposes to create a new class of wells (Class VI) for CO_2 injection and to develop rules for the long-term storage of CO_2.[64] The rule clarifies that geologic sequestration is the

56. *Id*. at 43,535.
57. *Id*. at 43,502.
58. *Id*. A USDW is "an aquifer or portion of an aquifer that supplies any public water system or that contains a sufficient quantity of groundwater to supply a public water system, and currently supplies drinking water for human consumption, or that contains fewer than 10,000 mg/l total dissolved solids and is not an exempted aquifer." *Id*. at 43,494. The EPA has promulgated regulations for the Underground Injection Control Program at 40 C.F.R. §§ 144-149.
59. Classification of Wells, 40 C.F.R. § 144.6(b) (2007).
60. *Id.* § 144.6(c).
61. *Id*. § 144.6(d); Prohibition of Class IV Wells, 40 C.F.R. § 144.13 (2007).
62. 40 C.F.R. § 144.6(e).
63. Does This Subpart Apply to Me?, 40 C.F.R. § 144.81(14) (2007).
64. Federal Requirements under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,492, 43,502 (July 25,

"long-term containment of a gaseous, liquid or supercritical carbon dioxide stream in subsurface geologic formations."[65] The rulemaking also limits the operation of Class VI injection wells to formations beneath the lowermost formation containing a USDW.[66] Additionally, Class VI wells must utilize certain enhanced construction techniques that vary from other UIC wells. Continuous internal mechanical integrity testing is required, and an operator must make annual demonstrations of external mechanical integrity.[67] Operators also must prepare and implement a testing and monitoring plan to ensure the injection is not endangering USDWs.[68]

In setting the period for post-injection site care, the EPA proposes a combination of a fixed timeframe (50 years) and a performance standard (that post-injection site care will continue until the plume is stabilized and cannot endanger USDWs).[69] The rules propose that the 50-year post-injection period may be shortened or lengthened depending upon performance of the site.[70] For financial responsibility, the EPA proposes that owners or operators of Class VI wells be required to demonstrate and maintain financial responsibility and have the resources for activities related to closing and remediating sequestration sites, including emergency and remedial response.[71] The proposed rules require periodic updates of the cost estimates for well plugging, post-injection site care, and site closure to account for any amendments to the plugging and abandonment plan, the post-injection site care, or the site closure plan.[72]

Consistent with the current UIC program, EPA proposes to allow delegation of the Class VI well program to states (or tribes) that adopt rules that are at least as stringent as, and may be more stringent than, the proposed minimum federal requirements.[73] Delegation of the program facilitates flexibility for states to enforce customized policies that address local concerns. The proposed rules grant discretion to the permitting authority to grandfather construction requirements for existing Class I, Class II, or Class V wells that may be converted to Class VI wells, provided the applicant is able to demonstrate that the wells would not endanger USDWs.[74] By granting discretion to the permitting authorities to tailor regulatory requirements, the EPA is allowing local permitting

2008) (to be codified at 40 C.F.R. §§ 144 and 146).

65. *Id*. at 43,535.
66. *Id*. at 43,534.
67. *Id*. at 43,540.
68. *Id*. at 43,536-37.
69. *Id*. at 43,540-41.
70. *See id.*
71. *Id*. at 43,537.
72. *Id*.
73. *Id*. at 43,523.
74. *Id*. at 43,535.

authorities flexibility to make appropriate decisions based on specific proposals for individual projects.

The EPA is seeking comments on these proposed rules and specifically notes certain areas of interest. For instance, under the rules, the Class VI wells are required to be drilled below the lowermost formation containing a USDW, but this requirement may preclude the viable use of coal bed seams.[75] Also, the EPA has solicited comment on whether CO_2 injection for EOR purposes should still be regulated as a Class II well and whether hazardous waste should be permitted to be injected into Class VI wells.[76] Financial responsibility requirements were also identified as an area in which EPA would like to receive comments.[77] Finally, it is worth noting that the proposed rules specify that the owner or operator of a CO_2 injection well must continue monitoring the site following closure for 50 years, unless the owner or operator can demonstrate that the site no longer endangers USDWs.[78] The 50-year time frame is significantly longer than the 10-year period proposed by the IOGCC (discussed below). As with all rulemakings, the EPA is soliciting public input, and the agency seems to be anticipating that the regulated community will modify or improve upon the rules during the public comment period.[79]

B. States

1. Interstate Oil and Gas Compact Commission

The Interstate Oil and Gas Compact Commission ("IOGCC") was founded in 1935 by six states with the goal of creating a multi-state government agency to help regulate and advocate on behalf of sound management of domestic oil and gas production. Today the IOGCC is an interstate compact representing governors of 30 member states and 7 associate member states. In 2002, the IOGCC created the "Geological CO_2 Sequestration Task Force" to examine technical, policy, and regulatory issues related to carbon sequestration.

In a 2005 report, the Task Force concluded that states had the greatest expertise in the regulation of oil and natural gas production and natural gas storage: critical analogues to the effective regulation of CO_2 storage.[80]

75. *Id*. at 43,534.
76. *Id*. at 43,502.
77. *Id*. at 43,522.
78. *Id*. at 43,540.
79. *Id*. *passim*.
80. *See* INTERSTATE OIL & GAS COMPACT COMM'N, TASK FORCE ON CARBON CAPTURE AND GEOLOGIC STORAGE, STORAGE OF CARBON DIOXIDE IN GEOLOGIC STRUCTURES: A LEGAL AND REGULATORY GUIDE FOR STATES AND PROVINCES 3 (2007), http://iogcc.publishpath.com/Websites/iogcc/PDFS/2008-CO2-Storage-Legal-and-Regulatory-Guide-for-States-Full-Report.pdf [hereinafter IOGCC REPORT] (discussing the 2005 report).

Thus, according to the Task Force, the states would be the most logical regulators of CO_2 storage, although the regulatory frameworks would likely require modification.[81] Importantly, the Task Force also advocated that CO_2 be treated not as a waste, but as a commodity.[82] The Task Force observed that regulating CO_2 under resource management frameworks would better take into account the legal complexities of CO_2 storage, including environmental protection, ownership of pore space, long term liability, and maximization of storage capacity.[83] The Task Force recognized that additional study was necessary and, under the sponsorship of the DOE, began further research.[84]

In 2007 the Task Force published a *Legal and Regulatory Guide for States and Provinces*.[85] The document was composed of two principal sections: (1) a Model CO_2 Storage Statute with Model Rules and Regulations; and (2) an analysis of property rights related to underground storage space. Aspects of the IOGCC analysis of property rights are included under Section IV of this article.

The Task Force emphasized that the states are in the best position to manage a storage site from "cradle to grave."[86] Accordingly, the Model Statute is drafted in broad terms and grants the state regulatory agency jurisdiction over "all persons and property necessary to administer and enforce effectively the provisions of this article concerning the geologic storage of carbon dioxide."[87] The Model Statute grants permitting authority to the state regulatory agency for the purpose of regulating the facility and protecting against CO_2 pollution or migration.[88] Notably, the Model Statute also empowers a storage operator, after obtaining approval from the state regulatory agency, to exercise the right of eminent domain in order to acquire all surface and subsurface rights necessary for the operation of the storage facility.[89] In the report, the Task Force underscored that the amalgamation of property rights is necessary for the proper operation and permitting of a storage facility and that the most likely legal mechanism for this purpose is eminent domain.[90] The Task Force noted that, for some states, unitization would serve the same purpose.[91] The Model Rules include provisions for permit

81. *Id*.
82. *Id*. at 4.
83. *Id*. at 5.
84. *Id*. at 3.
85. *Id*.
86. *Id*. at 12.
87. *Id*. at 32.
88. *Id.* at 33.
89. *Id*. at 33-34.
90. *Id*. at 33.
91. *Id*. at 28.

amendments, storage site operational standards, and reporting and closure requirements.[92]

The Task Force proposed the establishment of a Carbon Dioxide Storage Facility Trust Fund and a two-stage Closure Period and Post-Closure Period to address long-term monitoring and liability issues.[93] Under the Model Statute, the trust fund would be funded by a tax or fee on storage operators and would be utilized by the state regulatory agency for the long-term monitoring of the storage site.[94] Under the Model Rules, the Closure Period is defined as the period of time (ten years, unless modified by the state regulatory agency) after the plugging of the injection well has been completed and until the expiration of the performance bond.[95] At the end of the Closure Period, the operational bond is released, and the liability for ensuring a secure storage site is transferred to the state.[96] The Trust Fund would provide the financial resources during the Post-Closure Period for a state (or state-contracted) entity to engage in future monitoring, verification, and remediation activities.[97] The Trust Fund would assume all management of the storage site during the Post-Closure Period.[98]

The Model Statute specifically states that the provisions do not apply to EOR operations, and it authorizes the state regulatory agency to adopt rules to permit the conversion of an EOR injection well into a storage injection well.[99] Additionally, consistent with the IOGCC's advocacy that carbon dioxide should be regulated as a commodity and not as a waste, geologic storage is defined as "permanent or short-term underground storage of carbon dioxide in a reservoir."[100] By contrast, in the proposed EPA rule-making, geologic sequestration is defined to limit sequestration to "long-term containment."[101] That the Task Force rules contemplate short-term storage suggests that the commission views CO_2 as a commodity that has possible uses beyond the storage period. The Task Force explained that it viewed regulations for natural gas storage and oil and gas injection wells as analogues for the majority of its proposed Model Rules and Regulations.[102]

92. *Id*. at 28-29.
93. *Id*. at 29, 34.
94. *Id*. at 34.
95. *Id*. at 29.
96. *Id*. at 11, 29.
97. *Id*.
98. *Id*.
99. *Id*. at 35.
100. *Id*. at 32.
101. Federal Requirements under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,492, 43,493-94 (July 25, 2008) (to be codified at 40 C.F.R. §§ 144 and 146).
102. *Id*. at 43,512-16.

2. Selected States—Wyoming

In March 2008, the Wyoming governor signed into law two bills directly addressing the regulation of carbon sequestration. One bill, House Bill 90, authorized the Wyoming Department of Environmental Quality ("WDEQ") to regulate carbon capture and sequestration and to develop rules related to the regulation. The second bill, House Bill 89, addressed the ownership of subsurface pore space. Both acts became effective July 1, 2008.

House Bill 90 designated the WDEQ as the regulatory authority for permitting carbon sequestration.[103] The bill also allows the WDEQ to issue temporary permits for pilot-scale testing of technologies based upon current rules and regulations.[104] House Bill 90 provides that rules and standards should be developed for, inter alia:

(1) the creation of subclasses of wells within the existing UIC program to allow for the permitting of carbon sequestration;
(2) requirements for the contents of permit applications;
(3) requirements for the operator to provide immediate verbal notice after any migration (termed "excursion" in the bill) of CO_2 is discovered, followed by written notice to all surface owners, mineral owners, and owners of record of subsurface interests; and
(4) procedures for the termination or modification of the applicable UIC permit if the migration of CO_2 cannot be controlled or mitigated.[105]

Regarding the application for a permit, the bill specifies numerous requirements, including:

(a) a characterization of the injection zone and aquifers that may be affected,
(b) plans and procedures for environmental surveillance and detection of migrating CO_2,
(c) a site and facilities description with documentation that the applicant has the legal right to sequester carbon dioxide,
(d) proof of minimum construction standards, as set forth by the WDEQ and the Wyoming Oil and Gas Conservation Commission,
(e) a plan for mechanical integrity testing,
(f) proof of financial assurance for the construction, operation and closure of the storage site,
(g) a detailed plan for post-closure monitoring, verification, maintenance, and mitigation, and

103. WYO. STAT. ANN. § 35-11-313(a) (Supp. 2008).
104. *Id.* § 35-11-313(d).
105. *Id.* § 35-11-313(f).

(h) proof of notice to surface owners, mineral owners and other owners of record of subsurface interests.[106]

The bill does not specify what entity is liable if sequestered carbon migrates beyond the permitted parameter, only stating that the regulations cannot be construed "to create any liability by the state for failure to comply with this section."[107]

House Bill 90 specifically carves out jurisdiction for the WDEQ over carbon sequestration.[108] The bill provides that the injection of CO_2 for enhanced recovery of oil or other minerals is not governed by the new law.[109] However, pursuant to the law, should an oil and gas operator convert CO_2 injection from EOR to geologic sequestration, the regulation of the storage facility will be transferred from the Wyoming Oil and Gas Conservation Commission to the WDEQ.[110] If a CO_2 injection well used for EOR purposes is subsequently plugged and abandoned (and not converted to geologic sequestration), jurisdiction remains with the Commission.[111] Importantly, the bill provides that the Wyoming Oil and Gas Conservation Commission shall have jurisdiction over "any subsequent extraction of sequestered carbon dioxide that is intended for commercial or industrial purposes."[112] The Wyoming statute clearly contemplates that the CO_2 will, in some cases, have use as a commodity following sequestration.

House Bill 89 grants ownership of the subsurface pore space to surface owners.[113] The bill also provides that ownership of pore space may be conveyed as provided by law for the transfer of mineral interests in real property; however, any agreement that conveys mineral interests underlying the surface does not also convey ownership of pore space, unless the agreement explicitly conveys the pore space interest.[114] The bill provides that any agreements that purport to transfer the rights to pore space must describe the scope of any right to use the surface estate.[115] Additionally, under the bill, the owner of the surface estate has the option to nullify the transfer of pore space rights if the transfer instrument does not contain a specific description of the location of the pore space being transferred, such as a geologic or seismic survey.[116] Finally, the bill provides that it does not alter or diminish any rights to

106. *Id.*
107. *Id.* § 35-11-313(m).
108. *See id.* § 35-11-313(a).
109. *Id* § 35-11-313(b).
110. *Id.* § 35-11-313(c).
111. *See id.*
112. *Id.* § 35-11-313(k).
113. *Id.* § 34-1-152(a).
114. *Id.* § 34-1-152(b).
115. *Id.* § 34-1-202(e).
116. *Id.* § 34-1-152(g).

pore space that were acquired before the bill's effective date, July 1, 2008.[117] Under the bill, the primacy of the mineral estate is not altered. The Wyoming governor has called the two bills "works in progress," acknowledging that the provisions likely will be amended in the future as federal regulations are enacted.[118]

3. Selected States—Washington

The state of Washington passed legislation in April 2007 setting an emissions performance standard for base load power generation that limits electric utilities' ability to sign new or renewed long-term contracts with power plants whose greenhouse gas emissions exceed certain thresholds. New facilities can meet the standard by sequestering CO_2 emissions, and the legislation directed the Washington Department of Ecology to promulgate regulations for carbon sequestration.[119] Under the legislation, the rules were to be adopted by June 30, 2008.[120]

At the end of June, the Washington Department of Ecology's Water Quality Program amended Chapter 173-218 of the Washington Administrative Code ("WAC"), related to the UIC program, to address carbon sequestration. Under the Washington UIC program, most of the UIC wells are authorized "by rule," meaning that they do not require an individual permit.[121] Under the new regulations, Class V wells used for carbon sequestration are not authorized by rule and do require an individual permit under the State Waste Discharge Permit Program.[122] Pursuant to WAC Chapter 173-216 and Chapter 173-226, state waste discharge permits govern the discharge of waste materials in state surface or ground waters.[123] The new rules list extensive requirements for the waste discharge permit application for a CO_2 sequestration injection well, including (1) a project description, with map; (2) a comprehensive technical evaluation; (3) the predicted extent of the injected CO_2 plume and the projected response and storage capacity of the geologic containment system; (4) a leak detection and monitoring plan; (5) a risk assessment identifying and quantifying hazards, probabilities, and features that may adversely impact public health or the environment; (6) a closure and post-closure plan; and (7) a designated financial assurance

117. *Id.* § 34-1-152(h).
118. Brodie Farquhar, *Legislature Passes Bills On Carbon Sequestration*, WYOFILE.COM, Mar. 3, 2008, http://www.wyofile.com/carbon_capture_sequestration_pore_ownership.htm.
119. *Adopting New Rules, Washington Continues Leadership in Limiting Climate Change*, WASH. STATE DEP'T OF ECOLOGY, June 30, 2008, http://www.ecy.wa.gov/news/2008news/2008-180.html.
120. *Id*.
121. WASH. ADMIN. CODE § 173-218-115-1-a (2008).
122. *Id.* § 173-218-115-2.
123. *See id.* § 173-407-110.

mechanism.[124] In addition to the usual conditions of the state waste discharge permit program, the new rules require additional terms and conditions for the permit when it applies to CO_2 sequestration, including demonstrating that the geologic structure will provide "permanent sequestration."[125] Permanent sequestration is defined as "the retention of greenhouse gases in a containment system using a method that [complies with regulations and] that creates a high degree of confidence that substantially ninety-nine percent of the greenhouse gases will remain contained for at least one thousand years."[126]

The new rules in Washington also contain provisions for closure, post-closure care, financial assurance, and a mitigation plan that identifies corrective action should the geologic containment system fail.[127] Although the regulations do not directly address the issue of long-term liability, the post-closure requirements provide that the operator is obligated to be covered under the permit and to continue all monitoring until the Department determines that the monitoring and modeling demonstrate that conditions at the storage site indicate that there is little or no risk of future environmental impacts.[128] The post-closure period is complete only after the operator receives written notice from the Department confirming that all post-closure requirements have been satisfied.[129] If the operator cannot complete post-closure activities, the Department will utilize the financial assurance account to complete the activities on the operator's behalf.[130] In other words, under the Washington regulations, the operator is responsible for management of the storage site until released by the Department. Finally, the regulations require the development of a mitigation plan that identifies trigger thresholds and corrective action if the containment system fails.[131]

4. Other Selected States— Kansas, Oklahoma, New Mexico, and California

In 2007, Kansas passed House Bill 2419.[132] The bill directed the Kansas Corporation Commission to promulgate rules for standards and procedures for carbon sequestration and created incentives for the development of carbon sequestration projects.[133] For incentives, the

124. *Id*. § 173-218-115-6.
125. *Id*. § 173-218-115.
126. *Id*. § 173-407-110.
127. *Id*. § 173-218-115.
128. *Id*.
129. *Id*.
130. *Id*.
131. *Id*. § 173-218-115-8.
132. H.R. 2419, 2007 Leg. (Kan. 2008), *available at* http://www.kslegislature.org/bills/2008/2419.pdf.
133. *Id*. § 2(b), 6.

legislation exempts any carbon capture and sequestration utilization property (as well as any electric generation unit which captures and sequesters all carbon dioxide) from all property taxes for five taxable years following the construction or installation of such property.[134] Additionally, the legislation provides for certain amortization deductions for carbon sequestration machinery and equipment.[135] (The law specifies that the tax incentives apply only to property and equipment used for CO_2 capture and sequestration from anthropogenic sources.)[136] The legislation also created a "carbon dioxide injection well and underground storage fund."[137] The purpose of the fund is to administer the provisions of the law, and the Commission is authorized to use the fund for a variety of activities, including permitting activities, long-term monitoring and enforcement, mitigation of adverse environmental impacts, and emergency remedial activities.[138] The Kansas Corporation Commission was directed to promulgate rules by July 2008, but, as of the date of this article, the rules had not been published.[139]

In May 2008, the Oklahoma legislature passed Senate Bill 1765, though the bill was greatly pared down from its original form.[140] Originally the bill was modeled after the IOGCC model statute and regulations. In the enrolled version, the bill simply states that Oklahoma's current statutes for governing CO_2 for enhanced oil recovery are sufficient to protect human health and the environment, and the bill establishes the Oklahoma Geologic Storage of Carbon Dioxide Task Force, with the mandate "to provide [for] the safe storage and regulation of carbon dioxide."[141]

Other states are commissioning studies to understand the issues surrounding carbon sequestration regulation. For example, in New Mexico, by executive order, the New Mexico Energy, Minerals, and Natural Resources Department was required to identify statutory and regulatory requirements necessary to govern carbon sequestration.[142]

134. *Id*. § 6(a)-(b).
135. *Id*. § 7(a).
136. *Id*. § 6(d).
137. *Id*. § 2(c).
138. *Id*. § 2(b)-(c).
139. As of October 1, 2008, the proposed rules had been sent to the Attorney General for review.
140. S. 1765, 51st Leg., 2008 Reg. Sess. (Okla. 2008) (enrolled version), *available at* http://webserver1.lsb.state.ok.us/2007-08bills/SB/SB1765_ENR.RTF. Compare with S. 1765, 51st Leg., 2008 Reg. Sess. (Okla. 2008) (introduced version), *available at* http://webserver1.lsb.state.ok.us/2007-08SB/SB1765_int.rtf.
141. S. 1765, 51st Leg., 2008 Reg. Sess. §§ 1(A)(4), 1(B) (Okla. 2008) (enrolled version).
142. MARK E. FESMIRE ET AL., N.M. ENERGY, MINERALS, NATURAL RES. DEPT., OIL CONSERVATION DIV., A BLUEPRINT FOR THE REGULATION OF GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE IN NEW MEXICO 4 (2007), *available at* http://www.emnrd.state.nm.us/ocd/documents/CarbonSequestrationFINALREPORT1212007.pdf.

Although the report was completed in December 2007, the New Mexico legislature is not expected to contemplate legislation until its 2009 session.[143] The report, however, took a comprehensive look at various legal issues, including siting, monitoring, long-term liability, and potential conflict between surface and subsurface interests.[144] Among the issues that the report identified were: (1) while the New Mexico Oil Conservation Division is responsible for regulating CO_2 injection for enhanced hydrocarbon recovery, there is no clear authority for state regulation of CO_2 injection for sequestration alone; (2) pore space ownership likely belongs to the surface owner; (3) no authority exists under current law for the acquisition by eminent domain of subsurface pore space ownership for CO_2 sequestration; and (4) there is concern that, if long-term liability is transferred to the state, then operators may have reduced incentive to ensure that sequestration is successful beyond the scope of the operator's direct liability.[145]

California has also commissioned a report by the state's Department of Conservation to assess carbon sequestration. The report was published in February 2008 and was similar to that of New Mexico in comprehensively identifying gaps in the statutory and regulatory framework and identifying potentially contested legal issues in regulating sequestration.[146] In addition, the report provided an overview of other issues, including technical aspects related to CCS, sites within the state that are potentially viable for sequestration, and economic considerations.[147]

IV. OTHER LEGAL CONSIDERATIONS

A. Property Rights—Ownership of Pore Space

For a carbon sequestration project to be feasible, a clarification of property rights is essential. Many different stakeholders will potentially have interests in carbon sequestration projects, including injectors, owners of the injected material, surface owners, mineral owners, mineral lessees, and neighboring surface and mineral owners.[148] Because operators must have the legal right to utilize the subterranean space, debate has arisen over the legal ownership of subsurface pore space. Of course, if the fee simple interest in the property overlying the underground storage space has not been severed, then the fee simple

143. *Id*. at 11-12.
144. *See generally id. passim*.
145. *Id*. at 5-10.
146. *See generally* CAL. JOINT REPORT, *supra* note 17.
147. *Id*.
148. Elizabeth Wilson & Mark de Figueiredo, *Geologic Carbon Sequestration: An Analysis of Subsurface Property Law*, 36 ENVTL. L. REP. 10114, 10123 (2006).

owner owns the underground storage space. Under the common law, a fee simple owner owns land "up to the sky and down to the center of the earth."[149]

However, problems arise when the fee simple interest has been severed into a mineral estate and a surface estate.[150] Property rights are governed by state law, and as a result, legal authority governing pore space ownership will necessarily be jurisdiction-specific. Various commentators have undertaken surveys of different jurisdictions, and although ownership of pore space for carbon sequestration is largely unsettled, some patterns in the case law have emerged that suggest certain results.[151] Commentators who have surveyed the law tend to conclude that the surface owner owns the subterranean pore space; however, they also conclude that the prudent approach for an injection operator is to obtain permission from the owners of both the surface and mineral estates.[152] This approach is recommended because, although the surface owner is likely to be the owner of the pore space in most jurisdictions, the mineral estate is the dominant estate, which grants the mineral owner the right to use the surface or subsurface in a manner reasonably necessary to explore for minerals.[153] Further, the mineral estate survives as long as there remain minerals to be extracted.[154]

As an example, it is possible to imagine that a CO_2 injection operator may drill a well and inject CO_2 into a formation one mile below the earth's surface. Later, after the CO_2 has been sequestered in the formation, the mineral owner may decide to drill for oil two miles below the surface. The mineral owner may be inhibited from drilling below the CO_2 storage formation because of the disruption to the formation, and a dispute will arise regarding whose property rights were violated.

Certain jurisdictions, including Texas, permit the condemnation of subterranean storage space for natural gas storage,[155] and these laws have prompted commentators to question whether similar laws should exist for CO_2 storage. The power of eminent domain would eliminate the burden of securing permission from all necessary owners, and groups such as the IOGCC have suggested that a robust carbon sequestration legal regime must include the right of eminent domain.[156] Because of the large scale of carbon sequestration projects, eminent domain would have advantages.

149. *See* Owen Anderson, *Geologic Sequestration: Who Owns the Pore Space?*, 2008 CARBON AND CLIMATE CHANGE 2 (Univ. of Tex. Sch. of Law Continuing Legal Educ.).

150. *Id.*

151. *Id*. at 2-11.

152. *See id.* at 8; Wilson & de Figueiredo, *supra* note 148, at 10123; IOGCC REPORT, *supra* note 80, at 22; FESMIRE ET AL., *supra* note 142, at 15.

153. *See* Anderson, *supra* note 149, at 3.

154. *See* FESMIRE ET AL., *supra* note 142, at 19.

155. *See* TEX. NAT. RES. CODE ANN. § 91.181 (Vernon 2001).

156. IOGCC REPORT, *supra* note 80.

However, if it were allowed, disputes might arise regarding which interests ought to receive compensation. Commentators have suggested that both the surface and the mineral estate owner would need to be compensated.[157] Although condemnation would provide an efficient legal mechanism for ownership of all pore space necessary for a carbon sequestration project, condemnation often comes with high costs. Moreover, because condemnation can be a politically sensitive issue, it is not clear that all jurisdictions will be receptive to its use for CO_2 sequestration.

Unitization is used in the oil and gas industry to facilitate resource extraction and, like condemnation, may be an effective tool to manage pore space.[158] Unitization involves treating an oil and gas field like a unit so property owners may share in the proceeds from the mineral extraction based on negotiated agreements.[159] Unitization arrangements are approved by the applicable state administrative agency, and the state agency ensures that the rights of the owners of the interests in the field are protected.[160] Unlike condemnation, there is no court proceeding and, therefore, fewer complications and hurdles. Some have advocated that formations for carbon sequestration could be unitized in a manner similar to oil and gas reservoirs.[161]

B. Long-term Liability

Another issue for commercial-scale carbon sequestration raised by commentators is post-closure, long-term liability. While there are liabilities associated with the operational phase as well, they can largely be managed through proper site selection and good operational and well-plugging practices.[162] Among the potential liabilities associated with the operational phase are fluid migration, groundwater contamination, and damage to property rights.[163] There is precedent in the oil and gas industry for handling these types of risks, such as experience with EOR, natural gas storage, transportation of CO_2, and acid gas injection.[164] Also,

157. *See* Anderson, *supra* note 149, at 10; FESMIRE ET AL., *supra* note 142, at 37.
158. *See* Jeffrey Moore, *The Potential Law of On-Shore Geologic Sequestration of CO_2 Captured from Coal-Fired Power Plants*, 28 ENERGY L.J. 443, 481 (2007).
159. *Id*.
160. *See* TEX. NAT. RES. CODE ANN. § 101.013(a)(3) (Vernon 2001).
161. *See id.*
162. Thomas Weber, *Assessing the Liability Associated with Geologic Carbon Sequestration: Analyzing Texas Oil & Gas Law Related to EOR Operations, Waste Disposal and Natural Gas Storage*, 2008 CARBON AND CLIMATE CHANGE 3 (Univ. of Tex. Sch. of Law Continuing Legal Educ.), *available at* http://www.msmtx.com/PDF/Weber-Carbon_Sequestration_Liability.pdf.
163. *Id.*
164. M. A. de Figueiredo et al., *Framing the Long-Term In Situ Liability Issue for Geologic Carbon Storage in the United States*, 10 MITIGATION & ADOPTION STRATEGIES FOR GLOBAL CHANGE 647, 648 (2005), *available at* http://sequestration.mit.edu/pdf/Framing_the_Long-Term_Liability_Issue.pdf.

short-term liabilities can often be addressed through contractual arrangements, as between the CO_2 generator and injector.[165]

Commentators tend to agree that the long-term liability following the injection and closure phases of a sequestration project presents unique legal issues, in part because of the large scale of the project (carbon sequestration sites will be larger than natural gas storage or EOR), and in part because of the long period of time.[166] Long-term liability risks are similar to those during the operational phase, but there are additional risks due to future uncertainty, such as the formation of leaks to the surface or damage to wells from seismic events.[167] Many have expressed concern that if owners or operators retain long-term liability, as opposed to transferring liability to the state, the development of sequestration projects will be hindered because the costs or risks inherent in future uncertainty will be too high.[168] Some have also argued that, in light of the widespread benefits that global sequestration projects would provide in mitigating the rise of atmospheric temperatures, the private sector should not be forced to bear the entire liability of a sequestration project that could last a thousand years or more.[169] However, the competing concern is, if the state assumes long-term liability for the sequestration projects, there may be an undue burden on the public.[170]

Certain groups, such as the IOGCC, have advocated that long-term liability be transferred to the public sector.[171] Under this paradigm, typically a public trust is established that would fund the long-term monitoring and any remediation at the sequestration sites.[172] The advantage of the public sector assuming long-term liability is that business entities have finite lives and, while the business entities will likely assume some of the costs of post-closure monitoring, the state will be in a better position for long-term stewardship.[173] Perhaps notably, the Lieberman-Warner bill (discussed below) directs the EPA to establish a task force to study the feasibility of "potential Federal assumption of liability with respect to closed geological storage sites."[174]

Understanding liability allocation will be essential before carbon sequestration can attain large-scale commercial viability. Notably, in recognition of the need for such certainty, both Texas and Illinois passed legislation providing for state assumption of liability for the proposed

165. FESMIRE ET AL., *supra* note 142, at 39.
166. *See id.* at 16.
167. CAL. JOINT REPORT, *supra* note 17, at 133.
168. *Id*.
169. *See* Weber, *supra* note 162, at 7.
170. FESMIRE ET AL., *supra* note 142, at 16.
171. *Id*.
172. IOGCC REPORT, *supra* note 80, at 34.
173. Weber, *supra* note 162, at 7.
174. Lieberman-Warner Climate Security Act of 2008, S. 3036, 110th Cong., § 8004(a).

FutureGen project, a pilot sequestration project that was to be funded by the federal government but that has since been terminated.[175] Yet neither Wyoming nor Washington, in developing their regulatory regimes, directly addressed long-term liability (although Washington keeps operators on the hook indefinitely). It is worth noting that, even though commentators raise long-term liability resolution as a key issue for successful carbon sequestration, injection wells have been used for decades to inject hazardous waste or oilfield waste. According to the EPA, U.S. facilities discharge a variety of hazardous and nonhazardous fluids into more than 800,000 injection wells.[176] The EPA also states that its UIC program eliminates more than nine billion gallons of hazardous waste and one trillion gallons of oil field waste from the environment each year.[177] Although there have been a few notable failures (such as the Daisetta sink hole in Texas, which was caused by an operator injecting twice as much produced water and oilfield waste into a nearby waste injection well as was allowed), the history of underground injection has largely been a successful one. As one commentator has said, how long-term liability for CO_2 injection will be treated will depend in part on the results of research assessing the risk, on public reaction to those risks, on early projects that attempt to sequester CO_2 on a large scale, and on financial analyses of liability.[178]

C. Federal Legislation

1. Energy Independence and Security Act of 2007

The Energy Independence and Security Act of 2007 became law in December 2007.[179] Earlier versions of the bill included carbon capture tax credits and accelerated depreciation for dedicated CO_2 pipelines, but these provisions were not included in the version of the bill that was ultimately adopted.[180] However, Title VII of the law directs the DOE, the Department of the Interior, and the EPA to establish a number of projects and programs. Subtitle A is designated the "Department of

175. *Perry Submits Two Final Offers for FutureGen Project*, FUTUREGEN TEXAS, Aug. 1, 2007, http://www.beg.utexas.edu/futuregentexas/pdf/GovernorsAnnouncementBAFO.pdf; *Governor Signs Legislation as Part of Push to Bring FutureGen to Illinois*, ILL. GOV'T NEWS NETWORK, July 30, 2007, http://www.illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=1&RecNum=6108.

176. *US EPA's Program to Regulate the Placement of Waste Water and Other Fluids Underground*, U.S. ENVTL. PROT. AGENCY, June 2004, http://www.epa.gov/safewater/sdwa/30th/factsheets/uic.html.

177. *Id*.

178. De Figueiredo et al., *supra* note 164, at 9.

179. Energy Independence and Security Act of 2007, P.L. No. 110-140, 121 Stat. 1492.

180. Energy Independence and Security Act of 2007, H.R. 6, 110th Cong. §§ 1508-08 (engrossed amendment as agreed to by the House of Representatives).

Energy Carbon Capture and Sequestration Research, Development, and Demonstration Act of 2007." Among other provisions, the Secretary of Energy is directed to: (1) carry out science and engineering research to develop new approaches to capture and sequester or use CO_2 to lead to an overall reduction of CO_2 emissions; (2) promote regional carbon sequestration partnerships to conduct geologic sequestration tests; (3) conduct at least seven initial large-scale sequestration tests for geologic containment of CO_2 to collect and validate information on the cost and feasibility of commercial-scale technologies for carbon sequestration; (4) for those tests, give preference to proposals from partnerships among industrial, academic, and government entities in making competitive awards; (5) demonstrate technologies for the large-scale capture of CO_2 from industrial sources; and (6) establish a program of competitive grants to colleges and universities for newly designated faculty positions in integrated geologic carbon sequestration science programs.[181] The law also authorizes appropriations for these various projects and programs.[182] For example, for each large-scale testing of CO_2 sequestration and large-scale testing of CO_2 capture technologies, the law appropriates approximately $200 million per year for the next five years to the DOE.[183]

The Act specifically states that injection and geologic storage of CO_2 pursuant to Subtitle A must be subject to the requirements of the Safe Drinking Water Act.[184] The Act does not further specify how injection or storage operations should be regulated. The legislation does direct the EPA to "conduct a research program to address public health, safety, and environmental impacts that may be associated with capture, injection, and sequestration of greenhouse gases in geologic reservoirs."[185]

Subtitle B enacts various provisions requiring the Department of the Interior, through the U.S. Geological Survey, to undertake various studies relating to CCS.[186] Among other provisions, the Secretary of the Interior is directed to: (1) conduct a national assessment of capacity for CO_2 sequestration; (2) conduct a national assessment of the quantity of carbon stored in and released from terrestrial ecosystems, including from man-caused and natural fires, and of the annual flux of covered greenhouse gases in and out of terrestrial ecosystems; and (3) report to certain congressional committees on a recommended framework for managing geological carbon sequestration activities on public land.[187]

181. *See* Energy Independence and Security Act of 2007, 42 U.S.C.A. § 16293 (West 2008).
182. *Id*. § 17253.
183. *Id.* § 17251.
184. *Id*. § 17254.
185. *Id*. § 17255.
186. *See id.* § 17271.
187. *Id*.

2. Lieberman-Warner Climate Change Legislation

The leading proposed climate-change legislation in the U.S. Congress is the Lieberman-Warner Climate Security Act of 2008.[188] The bill would mandate a nationwide cap on greenhouse gas ("GHG") emissions, establishing a cap-and-trade system.[189] The bill proposes to regulate the emission of GHGs from "covered entities" (an exhaustively defined term under the bill). To do so, at the start of each compliance year the EPA is directed to issue a specific number of GHG emission allowances equivalent to the nationwide cap for that year.[190] Each allowance represents the emission of one ton of GHG emissions from a covered entity.[191] Some allowances would be freely distributed among designated industrial sectors, with the remainder to be auctioned by the federal government.[192] In later years of the program, the number of allowances freely distributed to industry would decline, and the number designated for auction would increase, although the combined total of allowances would decrease every year.[193] Once distributed or auctioned, the allowances could then be bought or sold by covered entities on the secondary market, so that by the end of the compliance year, each covered entity would possess enough allowances to surrender to the EPA to satisfy its compliance obligation.[194] The issuance and trading of allowances would begin in 2012, and the total number of emission allowances would decline beginning in 2012 until 2050. The funding from the auctions of allowances would be used for a variety of programs.[195]

A number of the bill's provisions address carbon sequestration. Under the current version of the bill, it creates a Bonus Allowance Account and provides for a set-aside of 4% of allowances, for the calendar years 2012 to 2030, as bonus allowances for carbon sequestration.[196] To be eligible for the bonus allowances, the carbon capture and sequestration project must: (1) have begun operation during the period beginning on January 1, 2008, and ending on December 31, 2035; (2) comply with the standards the EPA will establish, including compliance with the annual emissions performance standard for CO_2 emissions for the applicable electric generation unit or other non-electric generation unit that produces CO_2 emissions; and (3) sequester CO_2, captured from any unit for which allowances are allocated, in a geological formation permitted by the EPA

188. *See generally* Lieberman-Warner Climate Security Act of 2008, S. 3036, 110th Cong.
189. *Id*.
190. *Id*. § 1201.
191. *Id*. § 4.
192. *Id*. §§ 3101-3202.
193. *Id*.
194. *Id*. § 2101.
195. *See id.* §§ 4101-02.
196. *Id*. § 3601.

in accordance with regulations promulgated under the Safe Drinking Water Act.[197] The bill sets a ten-year limit on the bonus allowances: it allows their distribution to projects only for the first ten years of the project's operation, or, if the unit covered by the qualifying project began operating before January 1, 2012, then the period of calendar years 2012 through 2021.[198] The bill also contains an incentive for EOR. It indicates that reduced credit bonus allowances may be issued for CO_2 used for EOR, with the percentage of reduction to be determined by the EPA on economic factors.[199]

The bill also creates a Climate Change Credit Corporation that is allocated allowances for early auctions in order to generate funds to support energy technology deployment.[200] The bill provides that 25% of the auction proceeds shall be used to support advanced coal and sequestration technologies.[201] Among other projects, the Corporation is directed to support demonstration projects using advanced coal generation technology, including retrofit technology that could be deployed on existing coal generation facilities, and large-scale geological carbon storage demonstration projects that store CO_2 captured from electric generation units using coal gasification or other advanced coal combustion processes.[202]

Finally, the bill addresses a regulatory framework for carbon sequestration. Under these provisions, the bill directs the EPA to promulgate regulations for permitting commercial-scale underground injection of CO_2 for sequestration and, subsequent to the rules being finalized, to report to Congress every five years on the effectiveness of the regulations.[203] The bill then directs the Secretary of the Interior to complete a national assessment of the capacity for CO_2 storage and directs the Secretary of Energy to assess the feasibility of the construction of CO_2 pipelines for CO_2 sequestration and the feasibility of the construction of sequestration facilities.[204] Finally, the bill establishes a task force with the purpose of studying the legal framework and cost implications of potential federal assumption of long-term post-closure liability of geologic sequestration sites.[205]

A few of these provisions related to the regulatory framework appear obsolete. In its July 2008 proposed rulemaking, the EPA has already

197. *Id*. § 3602.
198. *Id*. § 3604.
199. *Id*. § 3605.
200. *Id*. §§ 4201, 4401.
201. *Id*. § 4403.
202. *Id*. *passim*.
203. *Id*. § 8001(a).
204. *Id*. §§ 8002(f), 8003.
205. *Id*. § 8004.

begun the process of promulgating regulations for commercial-scale sequestration. And, under the Energy Independence and Security Act, the Secretary of the Interior has been directed to study the nation's CO_2 storage capacity.[206] However, the inclusion of the carbon sequestration provisions in the Lieberman-Warner bill highlights the seriousness with which lawmakers are considering carbon sequestration as a vehicle to reduce CO_2 emissions.

V. CONCLUSION— FUTURE OPPORTUNITIES CAN BUILD ON PAST EXPERIENCE

A recent study has suggested that our economy needs to undergo a "carbon revolution," similar in impact to the Industrial Revolution, for the economy to maintain current growth projections, while at the same time keeping CO_2 emissions below levels that would cause significant risks to the climate.[207] This study suggested certain avenues to achieve CO_2 emissions goals, among them de-carbonizing energy sources. Noting that the world is dependent upon fossil fuels for 81% of total energy needs, the study advocated that, to meet emissions reduction targets, the power sector will need to undergo significant restructuring.[208] According to the study, carbon capture and storage must play a major role.[209]

A carbon revolution will present many opportunities. Opportunities are particularly prevalent in Texas, where there are both large power plants emitting CO_2 and also large potential repositories for CO_2 storage. According to the National Energy Technology Laboratory, the limestone shelf beneath Texas, which in some locations is several miles thick, could store 60 billion tons of carbon dioxide or more.[210] Perhaps the most readily available opportunities in Texas are for EOR, as EOR is viewed as one of the most commercially viable uses for CO_2 following capture. Carbon dioxide from natural sources has been transported by pipeline to mature oil fields in Texas for three decades. Yet, according to researchers at the University of Texas Bureau of Economic Geology, an additional 3.8 billion barrels of oil could be recovered through CO_2-EOR.[211]

206. Energy Independence and Security Act of 2007, 42 U.S.C.A. § 17271 (West 2008).

207. MCKINSEY & CO., THE CARBON PRODUCTIVITY CHALLENGE: CURBING CLIMATE CHANGE AND SUSTAINING ECONOMIC GROWTH 9 (2008).

208. *Id*. at 24.

209. *Id.*

210. Asher Price, *Texas Sees Goldmine in Storing CO_2 Underground*, AUSTIN AMERICAN-STATESMAN, Aug. 3, 2008, at A01.

211. *Spinning Straw into Black Gold: Enhanced Oil Recovery Using Carbon Dioxide: Hearing Before the Subcomm. on Energy and Mineral Resources of the H. Comm. on Natural Resources*, 110th Cong. (2008) (statement of Ian Duncan, Associate Director, Bureau of Economic Geology, The University of Texas at Austin), *available at* http://republicans.resourcescommittee.house.gov/pdf/Ian%20Duncan%20testimony.pdf.

Many see the use of anthropogenic CO_2 for enhanced oil recovery as a bridge to large scale sequestration, and companies are today investing billions of dollars in projects to capture CO_2 for use in EOR. Already early movers are making headlines. For example, SandRidge Energy and Occidental Petroleum Corporation have agreed to build and operate a CO_2 extraction plant that will allow SandRidge to utilize methane gas produced at the plant and allow Occidental to retain the CO_2 for EOR in West Texas.[212] As another example, Tenaska is building a coal-fueled electric generating facility in Sweetwater, Texas that will utilize post-combustion technology to capture CO_2 and then deliver it to West Texas for EOR.[213] A carbon revolution will present great opportunity, as companies such as these will require engineers, lawyers, developers, and contractors to design, oversee, permit, and construct the infrastructure and operations, including the plants and pipelines.

While long-term geologic carbon sequestration is a novel enterprise for a variety of reasons, it also represents a variation on practices that have taken place for a long time. Carbon dioxide has been compressed for transportation by pipeline for over thirty years in the oil and gas industry for enhanced recovery. Injection wells have been used for waste disposal for as long, if not longer. Clearly, momentum is building, as evidenced by the new legislation in Wyoming, Washington, Kansas, and Oklahoma and by the studies commissioned in New Mexico and California. The EPA's long-awaited proposed rulemaking for a carbon sequestration injection well was recently published. Many expect that the federal government will institute a carbon cap in the next few years, and carbon sequestration is likely to prove to be one of the more viable mechanisms to curb CO_2 emissions.

212. *SandRidge Energy, Inc. Announces Century Plant Agreement*, SANDRIDGE ENERGY, http://media.corporate-ir.net/media_files/irol/19/196066/6.30.2008CenturyPlant.pdf (last visited Nov. 12, 2008).

213. *Tenaska Proposes Nation's First New Conventional Coal-fueled Power Plant to Capture Carbon Dioxide*, TENASKA (2008), http://www.tenaska.com/newsItem.aspx?id=30.