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Carbon Sequestration: Resource Management through the Storage of Carbon Dioxide in Geologic Structures - A Proposed Legislative Framework for Louisiana

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I. The Premise.

From the pre-industrial era (i.e., ending about 1750) to 2005, concentrations of greenhouse gases (e.g., carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O)) increased globally by 36, 148, and 18 percent, respectively.[1] A draft of the latest greenhouse gas inventory released by the United States Environmental Protection Agency ("EPA") on Wednesday, March 4, 2009, reported that emissions of heat-trapping gases grew 1.4 percent from 2006 to 2007.[2] In 2007, total U.S. greenhouse gas emissions were 7,125.2 Tg CO2 Eq.[3] The bulk of that increase was carbon dioxide from the burning of fossil fuels (e.g., coal, oil, gas) to meet a greater demand for electricity. Since 1990, U.S. emissions have risen 17.1 percent.[4]

In 2002 (the most recent year for which data was reported by Project Vulcan)[5], Louisiana manufacturing facilities and refineries produced 36.4 million metric tons of CO2, slightly more than Texas, where industrial sources generated 35.3 million metric tons of CO2, and more than double that generated in California.[6] Combining all sectors, including industrial, residential, transportation and electricity generation, Louisiana's overall carbon dioxide production ranked at No. 8 in the nation. This reportedly is due to the high level of influence of the oil industry. As commented by Project Vulcan, "[t]here's a lot of refineries and associated industry that

1 EPA *Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007* (March 4, 2009).

2 EPA Draft Inventory at ES 1-3.

3 *Id.* at ES3 One teragram is equal to 10^{12} grams or one million metric tons.

4 *Id. at ES4*(The total U.S. greenhouse gas emissions were about 7,125 million metric tons of CO_2 equivalent. Overall, emissions have grown by 17.1 percent from 1990 to 2007).

5 Project Vulcan, funded primarily by NASA and the U.S. Department of Energy, is a team of researchers based at Purdue University who over the past three years have compiled an inventory of CO2 emissions and sources across the country. *See* Emilie Bahr, *Louisiana tops in CO2 emissions* (New Orleans City Business March 9, 2009).

6 *Id.*

go along with it. That is where the majority of [Louisiana's] emissions are coming from."[7]

The promise of successful carbon sequestration and carbon trading is on the horizon.[8] While scientific research has revealed avenues for mitigating greenhouse gas problems, recent government policy has focused on sequestration as a means of lowering the atmospheric concentration of greenhouse gases, including carbon dioxide.[9] The future of sequestration in the United States is closely tied to political policies. There is thus a growing interest both within industry and government in the possible opportunities for mitigating the release of carbon into our atmosphere, particularly through carbon capture and geologic storage (CCGS).

Louisiana also leads the nation in CO2 storage potential.[10] Identified as one of the leading ways for reducing concentrations of anthropogenic[11] greenhouse gases, carbon capture and geological storage (CCGS) is a process whereby CO2 is captured and stored in geologic formations through underground injection (instead of being released into the atmosphere).[12] To give a sense of scale, the estimated geological storage capacity in the Lower 48 states is equivalent of over 450 years at recent U.S. green house gas emissions rates.[13] Louisiana, both onshore and offshore, lead the way with a combined storage capacity of over 674 billion tons of sequestration potential – i.e., roughly 20 % of the Lower 48 states' total potential geologic storage capacity.[14]

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7 *Id.*

8 *See, e.g., Energy Policy Act of 2005*, Pub. L. No. 109-58, § 503(a), 119 Stat. 594.

9 *Id.*

10 ICF International 2009, *Carbon Sequestration and Storage: Developing a Transportation Infrastructure* at 34 (February 2009).

11 Anthropogenic is defined in this context as "of, relating to, or influenced by the impact of man on nature." *Webster's New Collegiate Dictionary* 48 (1st ed., G. & C. Merriam Company 1975).

12 National Energy Tech. Inst., U.S. Dep't of Energy, *Carbon Sequestration Technology Roadmap and Program Plan 2005: Developing the Technology Base and Infrastructure to Enable Sequestration as a Greenhouse Gas Mitigation Option* 4 (2005) http://www.netl.doe.gov/coal/Carbonsequestration/pubs/2005_roadmap-for_web.pdf (The Department of Energy's Office of Fossil Energy, on behalf of the United States government, has begun an aggressive research program in this regard through its National Energy Technology Laboratory (NETL)).

13 *See ICF International* at 2.

14 *Id.* at 34.

Estimated Geologic Storage Capacity (million tons)[15]

	Lower 48 States	Canada
Enhanced Oil Recovery	17,000	1,000
Depleted Oil and Gas Fields	110,000	2,702
Coal and CBM	51,000	5,000
Shale Formations	107,000	0
Deep Saline-filled Basalt	100,000	0
Deep Saline Reservoirs	2,990,000	60,730
Total	3,375,000	69,432

Assessment of US Sequestration Potential by State and Reservoir Type[16]

State	MARKAL Region	EOR[17]	Abnd Oil	Abnd Gas	Sub Total	ECBM Areas[18]	Coal	Sub Total	Shale	Deep Saline Aquifers	Basalt	Total
Alabama	Eastern Gulf Coast	0.066	0.141	0.497	0.704	0.309	0.6	0.909	0	5.5	0	7.153
Arkansas	Midwest	0.081	0.533	0.402	1.016	0.000	0.1	0.1	5	22.9	0	28.986
Louisiana Offshore	Gulf of Mexico	1.463	4.878	6.603	12.943	0	1.2	1.2	0	500	0	512.943
Louisiana Onshore	Midwest	1.355	4.004	6.349	11.708	0.000	1.2	1.2	0	148.3	0	161.248
Mississippi	Midwest	0.135	0.72	0.386	1.241	0.000	0.6	0.6	0	86.9	0	88 721
Texas Onshore	Midwest	7.554	19.025	15.368	41.947	0.000	3.6	3.6	20	288.2	0	353.789
Texas Offshore	Midwest	0.00	0.603	1.781	2.384	0.00	0.00	0.00	0.00	300.	0.00	302.384
Lower 48 Total	Total	16.527	59.535	49.654	125.716	19.692	31.933	51.625	106.71	2,990.6	99.9	3,374.56
L48 Offshore	L48 Offshore	1.463	6.730	8.421	16.614	0 000	0.000	0.000	0.000	1,186.64 0	0.000	1,203.254
L48 Onshore	L48 Onshore	15.064	52.805	41.233	109.102	19.692	31.933	51.625	106.709	1,804.0	99.900	2,171.306

For the United States, the High Case scenario developed for the Department of Energy anticipates 1,000 million tons per year of CCGS by 2030 while the Low Case has 300 million tons per year by that date. These numbers can be compared against U.S. CO2 emission from coal power plants, which are approximately 2,000 million tons per year. Hence, the High Case and Low Cases are roughly equivalent to having

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15 *Carbon Sequestration Atlas of the United States and Canada – Second Edition,* U.S. Department of Energy, National Energy Technology Laboratory, Morgantown, WV, November, 2008.

16 *Id.*

50 percent and 15 percent respectively of the existing U.S. coal plant capacity operated with CCGS by 2030.[17] Louisiana thus has the potential, should it act prudently in the area of CCGS regulation, to lead the nation in reducing CO2 emissions while still providing its citizens with economic energy alternatives.

II. Introduction

A. Greenhouse Gases and Effect.

The major components of greenhouse gases are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), chlorofluorocarbons (CFCs), and ozone (O3).[18] Of these, carbon dioxide accounts for roughly eighty percent of the greenhouse gases emitted by developed countries.[19] At thirty percent, the United States has the highest cumulative release of carbon dioxide.[20] As noted above, Louisiana leads the nation in industrial generation of CO2.[21]

The greenhouse effect is primarily a function of the concentration of water vapor, CO2, and other trace gases in the atmosphere that absorb the terrestrial radiation leaving the surface of the Earth.[22] The "greenhouse" effect results in the capture of radiation from sunlight by preventing radiative heat from reflecting back into space. In other words, these gases influence the climate system by trapping in the atmosphere heat that would otherwise escape to space. Although this greenhouse effect is critical in making our planet warm and habitable, the fact that concentrations of CO2 are increasing yearly raises concern that it could be a primary factor in climate change.

Climate change refers to any significant changes in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period.[23] Historically, natural factors such as volcanic eruptions and changes in the amount of energy released from the sun have affected the earth's climate. Beginning in the late 18th century, human activities

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17 *See ICF International* at 5.

18 See EPA Draft Inventory at 1-2 thru 1-5.

19 Linda M. Young, *Soil Carbon Sequestration in Agriculture: The U.S. Policy Context*, Ag/Extension Communications for Montana State University (2003), available at http://www.montana.edu/wwwpb/pubs/mt200312.html [hereinafter "*Soil Carbon Sequestration in Agriculture*"].

20 Kelly Connelly Garry, *Managing Carbon in a World Economy: The Role of Am. Agric.*, 9 Great Plains Nat. Resources J. 18, 19 (2005).

21 Emilie Bahr, *Louisiana tops in CO2 emissions* (New Orleans City Business March 9, 2009).

22 *EPA Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007* (March 4, 2009).

23 *Preamble, Proposed Mandatory GHG Report Rule*, Federal Register 25, Docket ID No. EPA-HQ-OAR-2008-0508 (March 10, 2009).

associated with the industrial revolution have also changed the composition of the earth's atmosphere and very likely are influencing the earth's climate.[24] The heating effect caused by the buildup of green house gases ("GHGs")[25] in our atmosphere enhances the Earth's natural greenhouse effect and adds to global warming. As global temperatures increase other elements of the climate system, such as precipitation, snow and ice cover, sea levels, and weather events, change.[26] The term "climate change," which encompasses these broader effects, is often used instead of "global warming."[27]

According to the Intergovernmental Panel on Climate Change ("IPCC"), warming of the climate system is "unequivocal," as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.[28] Global mean surface temperatures have risen by 0.74°C (1.3°F) over the last 100 years. Global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries. U.S. temperatures also warmed during the 20th and into the 21st century; temperatures are now approximately 0.56°C (1.0°F) warmer than at the start of the 20th century, with an increased rate of warming over the past 30 years. Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations.

Changes in the atmospheric concentrations of these greenhouse gases can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. Holding everything else constant, increases in greenhouse gas concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth).[29] Without human interaction with the environment the atmosphere maintains a balance of greenhouse gases.[30] However, human activities augment and increase the accumulation of greenhouse gases in the atmosphere.[31]

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24 *Id.* at 25-26.

25 See *EPA Draft Inventory* at ES2 to ES4.

26 *Preamble, Proposed Mandatory GHG Rule* at 25-27.

27 *Id.* at 26.

28 *EPA Draft Inventory* at 1-2 to 1-3.

29 USDA Forest Service, Gen. Tech. Rep. PSW-GTR-171, *Urban Forests and Climate Change* 1 (1999) [hereinafter *"Urban Forests and Climate Change"*].

30 *Urban Forests and Climate Change* at 1.

31 *Id.* at 1-2.

Historically, changes in emissions from fossil fuel combustion have been the dominant factor affecting U.S. emission trends.[32] Changes in CO2 emissions from fossil fuel combustion are influenced by many long-term and short-term factors, including population and economic growth, energy price fluctuations, technological changes, and seasonal temperatures. On an annual basis, the overall consumption of fossil fuels in the United States generally fluctuates in response to changes in general economic conditions, energy prices, weather, and the availability of non-fossil alternatives. For example, in a year with increased consumption of goods and services, low fuel prices, severe summer and winter weather conditions, nuclear plant closures, and lower precipitation feeding hydroelectric dams, there would likely be proportionally greater fossil fuel consumption than a year with poor economic performance, high fuel prices, mild temperatures, and increased output from nuclear and hydroelectric plants.

As the largest source of U.S. greenhouse gas emissions, CO2 from fossil fuel combustion has accounted for approximately 79 percent of GWP-weighted emissions since 1990, growing slowly from 78 percent of total GWP weighted emissions in 1990 to 81 percent in 2007. Emissions of CO2 from fossil fuel combustion increased at an average annual rate of 1.2 percent from 1990 to 2007. The fundamental factors influencing this trend include (1) a generally growing domestic economy over the last 17 years, and (2) significant overall growth in emissions from electricity generation and transportation activities. Between 1990 and 2007, CO2 emissions from fossil fuel combustion increased from 4,717.4 Tg CO2 Eq. to 5,747.6 Tg CO2 Eq. – a 21.8 percent total increase over the eighteen-year period. From 2006 to 2007, these emissions increased by 101.0 Tg CO2 Eq. (1.8 percent).[33]

B. Industry Contribution by Sector.

The five major fuel consuming sectors contributing to CO2 emissions from fossil fuel combustion are electricity generation, transportation, industrial, residential, and commercial. CO2 emissions are produced by the electricity generation sector as they consume fossil fuel to provide electricity to one of the other four sectors, or "end-use" sectors.

Electricity Generation. The United States relies on electricity to meet a significant portion of its energy demands, especially for lighting, electric motors, heating, and air conditioning. Electricity generators consumed 36 percent of U.S. energy from fossil fuels and emitted 42 percent of the CO2 from fossil fuel combustion in 2007. The type of fuel combusted by electricity generators has a significant effect on their emissions. For example, some electricity is generated with low CO2 emitting

[32] *Id.*

[33] *Id.*

energy technologies, particularly non-fossil options such as nuclear, hydroelectric, or geothermal energy. However, electricity generators rely on coal for over half of their total energy requirements and accounted for 94 percent of all coal consumed for energy in the United States in 2007. Consequently, changes in electricity demand have a significant impact on coal consumption and associated CO2 emissions.

Transportation End-Use Sector. Transportation activities (excluding international bunker fuels) accounted for 33 9 percent of CO2 emissions from fossil fuel combustion in 2007. Virtually all of the energy consumed in this end10 use sector came from petroleum products. Nearly 60 percent of the emissions resulted from gasoline consumption for personal vehicle use. The remaining emissions came from other transportation activities, including the combustion of diesel fuel in heavy-duty vehicles and jet fuel in aircraft.

Industrial End-Use Sector. Industrial CO2 emissions, resulting both directly from the combustion of fossil fuels and indirectly from the generation of electricity that is consumed by industry, accounted for 27 percent of CO2 from fossil fuel combustion in 2007. Just over half of these emissions resulted from direct fossil fuel combustion to produce steam and/or heat for industrial processes. The remaining emissions resulted from consuming electricity for motors, electric furnaces, ovens, lighting, and other applications.

Residential and Commercial End-Use Sectors. The residential and commercial end-use sectors accounted for 21 and 18 percent, respectively, of CO2 emissions from fossil fuel combustion in 2007. Both sectors relied heavily on electricity for meeting energy demands, with 72 and 79 percent, respectively, of their emissions attributable to electricity consumption for lighting, heating, cooling, and operating appliances. The remaining emissions were due to the consumption of natural gas and petroleum for heating and cooking.

C. Reducing Emissions.

Reducing concentrations of anthropogenic greenhouse gases can be accomplished in four basic ways: (1) through energy conservation and energy efficiency; (2) by using technologies involving renewable energy, nuclear power, hydrogen, or fossil fuels containing lower carbon content, e.g., natural gas; (3) by indirect capture of CO2 after its release into the atmosphere utilizing the oceans or terrestrial sequestration, e.g., reforestation, agricultural practices, etc.; or (4) by carbon capture and geological storage (CCGS), whereby CO2 is captured and stored in geologic formations through underground injection (instead of being released into the atmosphere).[34]

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[34] National Energy Tech. Inst., U.S. Dep't of Energy, *Carbon Sequestration Technology Roadmap and Program Plan 2005: Developing the Technology Base and Infrastruc-*

Geological storage of CO2 is one of several viable methodologies for reducing emissions of anthropogenic CO2 into the atmosphere. Carbon sequestration is the "capture and storage of CO_2 and other greenhouse gases that would otherwise be emitted to the atmosphere."[35] Sequestration provides the potential for "deep reductions in greenhouse gas emissions" in the United States.[36] The premise behind sequestration is three-fold. First, sequestration reduces the presence of greenhouse gases in the atmosphere. Second, sequestration can be a means for enhanced oil recovery. Third, there is potential for the carbon market to make sequestration economically feasible.

One of the major strategies identified for reducing future CO2 emissions released to the atmosphere is its capture and storage in underground geologic formations. Carbon capture and geologic storage (CCGS) has been shown by several studies undertaken by the Energy Information Administration as well as by others to be a viable, if not critical compliance option under any comprehensive greenhouse gas (GHG) reduction policy.[37] The technical challenges of CCS are significant both in the capture of CO2 and how and where to sequester it. Considerable research into these areas is ongoing. By contrast, the task of transporting CO2 has received less attention.[38] It is generally accepted that a pipeline network will be needed to transport CO2 from the point of capture to the point of storage. However, there has been little examination of the size, configuration, commercial structure and regulation of a national pipeline system to accomplish this.[39]

The natural gas pipeline industry is frequently mentioned as a model for what a CO2 pipeline network might look like since the North American natural gas pipeline network interconnects thousands of natural gas distribution companies, power plants, and industrial facilities with natural gas producing basins.[40] The technology, scope, operations, commercial structure, and regulatory framework that characterize natural gas pipelines appear to be useful analogues for a CO2 pipeline system. It can be expected that some additional gas pipeline companies beyond those that currently transport CO2 for enhanced oil recovery (EOR) projects

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ture to Enable Sequestration as a Greenhouse Gas Mitigation Option 4 (2005) http://www.netl.doe.gov/coal/Carbonsequestration/pubs/2005_roadmap_for_web.pdf (The Department of Energy's Office of Fossil Energy, on behalf of the United States government, has begun an aggressive research program in this regard through its National Energy Technology Laboratory (NETL)).

35 *Id.*

36 *Id.*

37 *See ICF International* at 13.

38 *Id.*

39 *Id.*

40 *Id.*

may expand into the CO2 transportation business. At the same time, it has to be recognized that the investment needed to support a national CO2 transportation network will require significant capital and may entail competition for the same material and manpower resources as that of the natural gas and oil pipeline industries.[41]

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.[42] 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%.[43] 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.[44] 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.[45] And, in July 2008, the DOE announced it would provide $36 million for fifteen projects with the goal of furthering the development of technologies for carbon capture from existing coal-fired power plants.[46]

D. Carbon Capture and Sequestration

Carbon capture and geologic storage (CCGS) consists of the separation of carbon dioxide (CO2) from industrial and power plant sources,

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41 *Id.*

42 *See* L. Nettles & M. Conner, *Carbon Dioxide Sequestration – Transportation, Storage, and Other Infrastructure Issues*, 4 Tex. J. Oil, Gas & Energy L. 27 (2009); *Abundance of Coal for Electricity Generation*, American Coalition for Clean Coal Electricity, 2008, http://www.cleancoalusa.org/docs/abundant; Matthew L. Wald, *Science Panel Finds Fault with Estimates of Coal Supply*, N.Y. Times, June 21, 2007, at C2.

43 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.

44 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].

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

46 *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.

transport to a storage location and long-term isolation from the atmosphere. The principal technical, economic and regulatory challenges of CCGS are significant for the capture and storage phase of the process and considerable research into these areas is ongoing.[47] The three steps in carbon capture and geologic storage are (1) CO2 capture and compression, (2) pipeline transportation, and (3) underground storage.[48] While many of the underlying technologies involved in CO2 capture are mature, their use in the circumstances and scale needed for CCGS carries considerable technological and commercial risks. Coal power plants will dominate the proposed CCGS projects in the future.[49]

The major components of costs are in the capture/compression and storage. The capture component of CCGS is the most technologically challenging and uncertain. Depending on the quality of the CO2 stream, capture costs range from nothing to over $50/ton.[50] A small volume of high-purity CO2 streams produced in the industrial sector can be captured at near zero costs and then dehydrated and compressed for approximately $15 per ton.[51] However, the big volume of emissions from coal power plants will be captured and compressed for incremental cost ranging from $31 per ton for a new integrated gas combined cycle (IGCC) power plant, $51 per ton for new pulverized coal plants and $56 on up per ton for existing coal power plants. Compression costs add $9 to $15/ton.[52]

Transportation of CO2 by pipeline is a mature technology and should not see significant change over the next 20 years. The transportation component will vary based on volume and distance. CO2 from industrial sites that moves over a pipeline network in which some aggregation of volumes from several sources is possible would have a generalized cost of $4.60 per 150 miles.[53]

Geologic storage costs vary depending on whether the site is an enhanced oil recovery site, where costs are negative, or is one of various types of underground rock formations for which geologic storage costs are a few dollars per ton.[54] Cost of geologic storage would depend on the type of formation into which the CO2 is to be injected, site-specific parameters (e.g. drilling depth, injection rates per well, storage capacity per

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47 ICF International 2009, *Carbon Sequestration and Storage: Developing a Transportation Infrastructure*, at 1 (February 2009).

48 *Id.*

49 *Id.*

50 *Id.* at 1-2.

51 *Id.* at 2.

52 *Id.*

53 *Id.* at 15-16.

54 *Id.* at 1-2.

well, etc.) and regulatory and legal regime under which the site will be permitted, constructed, operated, closed and monitored after closing. In cases where the CO2 can be used for enhanced oil recovery it might be sold to oil companies for a price of $30-40 per ton.[55] The sales price for EOR will depend on oil prices, the other (non-CO2) costs of EOR and the degree of competition among CO2 sellers. The economics of geologic sequestration into a saline reservoir will vary widely from site to site but are expected to cost $3 to $7 per ton at the favorable locations that are most likely to be developed first.[56]

E. Geologic Sequestration

Geological storage of CO2 is accomplished by injecting it in dense form into a rock formation below the earth's surface.[57] Porous rock formations that hold or have previously held fluids, such as natural gas, oil or saline reservoirs, are potential candidates for CO2 storage. [58] Suitable storage formations can occur in both onshore and offshore sedimentary basins. Coal beds and shales also may be used for storage of CO2 where it is unlikely that they will later be mined and provided that permeability is sufficient.[59] Regardless of the form of sequestration, "global sequestration capacity in depleted oil and gas fields . . . [has] the capacity to store 125 years of current worldwide CO_2 emissions from fossil fuel-fired power plants."[60]

The injection of CO2 in deep geological formations involves many of the same technologies that have been developed in the oil and gas exploration and production industry. Well-drilling technology, injection technology, computer simulation of storage reservoir dynamics and monitoring methods from existing applications are being developed further for design and operation of geological storage. Other underground injection practices also provide relevant operational experience. In particular, natural gas storage, the deep injections of liquid wastes, and acid gas dis-

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[55] *Id.*

[56] *Id.* at 16.

[57] *Id.* at 26 (At depths below 2,600 to 3,300 feet (800–1,000 meters), CO2 remains a supercritical fluid with liquid-like density of about 31 to 50 pounds per cubic foot (500–800 kg per cubic meter). This provides for efficient utilization of underground storage space. Under these conditions, the density of CO2 will range from 50 to 80 percent of the density of water. This is close to the density of some crude oils, resulting in buoyant forces that tend to drive CO2 upwards. Consequently, a well-sealed cap rock over the selected storage reservoir is important to ensure that CO2 remains trapped underground.).

[58] Stephanie M. Haggerty, *Legal Requirements for Widespread Implementation of CO2 Sequestration in Depleted Oil Reserves*, 21 Pace Envtl. L. Rev. 197, 200-01 (2003). Anthropogenic sources are those sources that are created by human activity, largely the combustion of fossil fuels. Id. at 197.

[59] *Id.* at 201.

[60] *Id.* at 198.

posal (mixtures of CO2 and H2S) have been conducted in Canada and the U.S. since 1990 at the megaton per year scale.[61]

Depleted Natural Gas Fields and Oil Fields. Depleted natural gas and oil fields can be excellent candidates for CO2 storage.[62] These represent known structures that have trapped hydrocarbons over geologic time, thus proving the presence of an effective structure and seal above the reservoir. These fields have also been extensively studied, there is a large amount of well log and other data available, and the field infrastructure is already in place. This infrastructure could in some cases be utilized in storage. A potentially problematic aspect of using depleted fields for storage is the presence of a large number of existing wellbores, which can provide leakage pathways. Typically, oil fields are developed with a closer spacing than natural gas fields, resulting in a larger number of existing wells per unit area than in natural gas fields. It is possible that in old fields, the original oil and gas wells may have been completed and then -- at the end of their lives -- plugged and abandoned using substandard materials and practices. In such instances the plugged wells will have to be remediated before CO2 injection can begin at the site. The cost of this process may render an old oil or gas field economically unsuitable.[63]

The In Salah Field in Algeria was the world's first project in which CO2 is injected at commercial scale into a natural gas reservoir. However, in this case, the natural gas is injected in the lower part of an actively producing gas reservoir. This differs from an abandoned gas reservoir scenario in which the gas field is no longer producing.

Enhanced Oil Recovery Conversion. Industry has already examined geological sequestration, in part, because oil and gas reservoir sequestration provides the potential for enhanced oil recovery (EOR).[64] Carbon dioxide EOR involves the injection of carbon dioxide deep into well reservoir rocks that are sealed by rock having low permeability.[65] Carbon dioxide EOR enables the gathering of an additional 10-15% more oil from a well and, additionally, some of the carbon dioxide remains trapped in the reservoir rock (sequestered).[66] The increase in revenue re-

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61 *See ICF International* at 26.

62 *Id.* at 29.

63 *Id.* at 29-30.

64 *See* Haggerty, *Legal Requirements for Widespread Implementation of CO2 Sequestration.* at 201. The oil and gas industry uses enhanced oil recovery (EOR) in the field and, thus, already has a working sequestration model. *Id.*

65 *Id.* at 201.

66 *Id.*

sulting from this additional oil provides the economic means to enable anthropogenic CO_2 to be feasibly employed.[67]

Under certain reservoir and fluid conditions, CO2 can be injected into an oil reservoir in a process called miscible CO2 enhanced oil recovery.[68] The effect of the CO2 is to mobilize the oil so that it can move more readily to the production wells. As the oil is produced, part of the injected CO2 is produced with the oil. This CO2 is then separated and reinjected. The EOR portion of U.S. CO2 storage capacity represents the amount of CO2 that could be permanently sequestered in association with EOR operations that have been converted from enhanced production to permanent storage.

In the U.S. most CO2 EOR projects are located in the Permian Basin of West Texas, where projects have been in place for several decades. Most of the present carbon dioxide EOR utilizes carbon dioxide extracted from deeply buried, naturally occurring CO_2 rock reservoirs rather than anthropogenic sources.[69] A switch to anthropogenic sources makes carbon dioxide enhanced oil recovery a perfect candidate for sequestration.[70] Using anthropogenic carbon dioxide for EOR helps mitigate, rather than add to, greenhouse gases while adding value through increased oil production.[71]

In 2005, CO2 EOR operations produced approximately 237,000 barrels of oil per day in the U.S. About 180,000 barrels per day of that occurred in West Texas, with most of the rest produced in the Rockies, Mid-Continent, and Gulf Coast. At the Weyburn Field in Saskatchewan, CO2 from the Dakota Gasification Facility in North Dakota is injected into an oil reservoir for EOR and monitoring of CO2 storage. Over the 25-year life of this project, it is expected that about 18 million tons of CO2 will be sequestered.[72]

Enhanced Coalbed Methane Recovery. CO2 potentially can be sequestered in coalbed formations through the process of adsorption. CO2 injected as a gas into a coalbed will adsorb onto the molecular structure and be sequestered. Methane is naturally adsorbed onto coalbeds and coalbed methane now represents a significant percentage of U.S. natural gas production. Major coalbed methane production areas include the San Juan Basin of northwestern New Mexico and southwest-

67 *Id.* at 201-02.

68 *See ICF International* at 30.

69 Haggerty, supra note 58, at 202.

70 *Id.*

71 *Id.*

72 *See ICF International* at 30.

ern Colorado, the Powder River Basin of eastern Wyoming, and the Warrior Basin in Alabama.[73]

The concept of enhanced coalbed methane recovery is based upon the fact that coalbeds have a greater affinity for CO2 than methane. Thus, when CO2 is injected into the seam, methane is liberated and the CO2 is retained. This additional methane represents enhanced natural gas recovery. Depending upon depth and other factors, coalbeds may be mineable or unmineable. Because the process of mining the coal would release any stored CO2, only unmineable coalbeds are assessed as representing permanent CO2 storage.13 One of the potential drawbacks to CO2 injection into coal seams is that as the CO2 is absorbed into the coal, the coal can swell, thereby reducing permeability. This phenomenon can make certain coals technically unsuitable or increase the cost of injection.[74]

Gas Shales. The potential to sequester CO2 in organic shale formations is based upon the same concept as that of coalbeds. CO2 will adsorb onto the organic material, displacing methane. Gas shales have recently emerged as a major current and future source of natural gas production in the U.S. These include the Haynesville Shale in northwest Louisiana and east Texas, the Barnett Shale in the Fort Worth Basin, the Fayetteville and Woodford Shales in the Arkoma Basin, and the Appalachian Devonian Shale. These Devonian and Mississippian age organic shale formations represent tremendously large volumes of rock. To date little research has been done on enhanced gas recovery with organic shales. However, should it prove technically feasible, the U.S. could become one of the major areas worldwide for this type of storage.[75]

Existing Projects. Large-scale geologic sequestration storage projects in operation now include: the offshore Sleipner natural gas processing project in Norway, the Weyburn Enhanced Oil Recovery project in Canada, which stores CO2 captured in the United States, and the In Salah natural gas project in Algeria. Each captures and stores one to two million tons of CO2 per year.[76]

The Petroleum Technology Research Centre of Canada is currently pursuing EOR working with partnership organizations and corporations on the Weyburn oil field in southeast Saskatchewan.[77] By applying sequestration technology to global oilfields for the next one hundred years, between one-half and one-third of global emissions could be eliminated

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[73] *Id.* at 30-31.

[74] *Id.* at 31.

[75] *Id.*

[76] *Haggerty,* supra note 58, at 202.

[77] Petroleum Technology Research Centre, IEA GHG Weyburn *CO2 Monitoring and Storage Project* (2005), available at http:// www.ptrc.ca/access/DesktopDefault.aspx?tabindex=0&tabid=81.

from the atmosphere and billions of barrels of otherwise untapped oil could be produced.[78] For example, through application of EOR technologies in Western Canada alone, billions of barrels of oil could come into the market, and CO_2 emissions could drop to the equivalent of taking more than 200 million cars off of the road for a year's time.[79] According to the findings from the Weyburn project, EOR will allow the recovery of up to 60% more oil from oilfields.[80]

F. Contribution of the O&G Industry.

Given the regulatory complexities of CO2 storage including environmental prot^ction, ownership and management of the pore space, maximization of storage capacity and long-term liability, geologically stored CO2 should be treated under resource management frameworks as opposed to waste disposal frameworks.[81] A resource management framework allows for the integration of these issues into a unified regulatory framework and proposes a "public and private sector partnership" to address the long-term liability, given that the release of CO2 into the atmosphere is at least partially a societal problem and the mitigation of that release is likewise at least partially a societal responsibility.[82]

The interest of states in the geologic storage of CO2 arises because, in addition to conservation, it is among the most immediate and viable strategies available for mitigating the release of CO2 into the atmosphere. The thirty member states and four Canadian affiliate member provinces of the Interstate Oil and Gas Compact Commission (IOGCC) are well suited for regulation of CO2 storage because of their jurisdiction, experience, and expertise in the regulation of oil and natural gas production.[83] For half a century, most of these states have been the prin-

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[78] *Id.*

[79] U.S. Department of Energy, *Successful Sequestration Project Could Mean More Oil and Less Carbon Dioxide Emissions* (2005), available at http:www.fossil.energy.gov /news/techlines/2005tl_weyburn_mou.html [hereinafter *Successful Sequestration Project Could Mean More Oil and Less Carbon Dioxide Emissions*].

[80] *Id.* at note 40.

[81] *Id.; Carbon Dioxide Sequestration,* 4 Tex. J. Oil, Gas & Energy L. at 38.

[82] Regulating the storage of CO2 under a waste management framework sidesteps the public's role in both the creation of CO2 and the mitigation of its release into the atmosphere and places the burden solely on industry to rid itself of "waste" from which the public must be "protected." Such an approach lacking citizen buy-in with respect to responsibility for the problem as well as the solution could well doom geological storage to failure and diminish significantly the potential of geologic carbon storage to meaningfully mitigate the impact of CO2 emissions on the global climate.

[83] In July of 2002, the Interstate Oil and Gas Compact Commission (IOGCC), with sponsorship from the U.S. Department of Energy (DOE), convened a meeting of state regulators and state geologists in Alta, Utah, concerning carbon sequestration. *See* IOGCC Storage of Carbon Dioxide in Geologic Structures; a Legal and Regulatory Guide for States and Provinces (September 25, 2007).

cipal regulators of enhanced oil recovery (EOR), as well as natural gas storage and acid gas disposal. They also are strategically well situated for the storage of CO2. Regulations already exist in these petroleum-producing states covering many of the same issues that need to be addressed in the regulation of CO2 storage, and consequently serve as adaptable frameworks for CO2 storage.[84] It should also be noted that there exists a significant number of CO2 EOR and acid gas injection projects in the U.S. and Canada, and, therefore, "storage" of CO2 is already taking place. This fact makes it possible that CO2 EOR projects could be an important vehicle in driving CCGS, at least in its early years. It also could prove the means to build both injection/storage experience, regulatory and otherwise, and provide the physical infrastructure (pipelines/facilities). Together the EOR, natural gas storage, and acid gas injection models provide a technical, economic, and regulatory pathway for long-term CO2 storage.[85]

However, owing to the scarcity of post-injection CO2 EOR projects and abandoned natural gas storage fields, inadequate guidance for a long-term CO2 storage regulatory framework exists. Consequently, a regulatory framework needs to be established to determine long-term liability and to address long-term monitoring and verification of the reservoir and mechanical integrity of wellbores penetrating formations in which CO2 has been emplaced.

Because most of the proposed CO2 geologic storage regulations are based on natural gas storage and oil and gas injection well rules, it can be reasoned that the most logical and best equipped lead agency for implementing and administering regulations effectively and efficiently would be the state oil and gas regulatory agency.[86] The treatment of geologically stored CO2 as waste using waste disposal frameworks rather than resource management frameworks will diminish significantly the potential to meaningfully mitigate the impact of CO2 emissions on the global climate through geologic storage.[87]

III. The Legal and Regulatory Regime for Geologic Storage (GS)

There is no definitive federal legal and regulatory framework set up for CCGS regulation. There is no economic regulation of CO2 pipelines since the Surface Transportation Board (STB) and the Federal Energy

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[84] *Id.* at 9. States that do not have oil and natural gas production may have experience regulating natural gas storage that will give them an important analogous regulatory experience for purposes of CO2 geologic storage.

[85] *Id.* at 14.

[86] *See CO2 Storage: A Legal and Regulatory Guide* at 24-25; *CARBON DIOXIDE SEQUESTRATION*, 4 Tex. J. Oil, Gas & Energy L. at 37-40.

[87] *See CO2 Storage: A Legal and Regulatory Guide* at 4-5; *CARBON DIOXIDE SEQUESTRATION*, 4 Tex. J. Oil, Gas & Energy L. at 37-40.

Regulatory Commission (FERC), assert they lack jurisdiction.[88] Potential analogues are the oil and natural gas regulatory systems.[89] Moreover, because the production of CO2 is a consequence of the public's demand for and use of fossil energy, it is only logical that oil and natural gas producing states, and in particular the oil and natural gas regulatory agencies in these states, might be able to play a meaningful role in the sequestration (otherwise known as "storage") of CO2. It is sound policy and in the public interest for state agencies to actively participate along with industry in efforts to reduce CO2 emissions through geologic storage.[90]

A. Federal

As noted above, the future of sequestration in the United States is closely tied to political policies. With the recent change in administrations, proposed statutory and regulatory frameworks are coming at an ever-faster pace. For example, on Tuesday, March 10, 2009, in an effort to determine what greenhouse gas emissions cap will be set in the US, the Environmental Protection Agency proposed the first comprehensive national system for the reporting of carbon dioxide and other GHG emissions, with the first reports expected in 2011.[91] EPA said about 13,000 facilities, accounting for about 85% to 90% of domestic GHG emissions, would be covered under the proposal. The reporting requirements would apply to suppliers of fossil fuel and industrial chemicals, manufacturers of motor vehicles and engines, as well as large direct emitters with emissions equal to or greater than 25,000 metric tons/year. EPA said the direct emission sources covered under the reporting requirement would include energy-intensive sectors such as cement production, iron and steel production, and electricity generation, among others.[92]

Although the impact of this proposed rule is still being assessed, several industries believe the rule would require "major effort." For example, pipeline operators claim that they will likely be the gas industry segment most affected by proposed new greenhouse gas reporting requirements.[93] Gas processors, pipelines, storage operators and liquefied natural gas terminals all would be required to report their CO2 and methane leaks and combustion annually if they exceed 25,000 metric tons, or about 467,000 MMBtu, per year.[94] The proposed rule is estimated to cost

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88 *See ICF International* at 9.

89 *See ICF International* at 8.

90 *See CO2 Storage: A Legal and Regulatory Guide for States* (IOGCC Geological CO2 Sequestration Task Force, 2008).

91 *Preamble, Proposed Mandatory GHG Rule* at 73.

92 *Id. passim.*

93 Platts Gas Daily, *EPA rule would require 'major effort' by pipelines* (March 12, 2009).

94 *Id.*

$160 million for US companies to comply with.[95] One industry representative was quoted in her belief that 85% of interstate pipeline facilities would be affected, driven in large part by the emissions of their gas-burning compressor stations. Based on "a back-of-the-envelope estimate," a 13,000-horsepower compressor will generate enough CO2 to qualify for reporting if it ran constantly throughout the year. "We are not running small units," said the representative, adding that the proposed rule "doesn't miss a whole lot."[96]

On July 25, 2008, the Environmental Protection Agency ("EPA") published a proposed rulemaking to regulate the injection and geologic sequestration of CO_2.[97] The rules are not expected to become final until 2010 or 2011. The proposed regulations were developed under the 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.[98] 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.[99]

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").[100] 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.[101] 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

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95 *Id.*

96 *Id.*

97 *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).

98 *Id.* at 43,535.

99 *Id.* at 43,502.

100 *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.

101 *Classification of Wells*, 40 C.F.R. § 144.6(b) (2007).

associated with the extraction of minerals or energy, including the mining of sulfur and solution mining of minerals.[102] 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.[103] 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.[104] Class V wells include experimental technology wells,[105] such as those being used for carbon sequestration pilot projects.

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.[106] The rule clarifies that geologic sequestration is the "long-term containment of a gaseous, liquid or supercritical carbon dioxide stream in subsurface geologic formations."[107] The rulemaking also limits the operation of Class VI injection wells to formations beneath the lowermost formation containing a USDW.[108] 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.[109] Operators also must prepare and implement a testing and monitoring plan to ensure the injection is not endangering USDWs.[110]

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).[111] The rules propose that the 50-year post-injection period may be shortened or lengthened depending upon performance of the site.[112] 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

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102 *Id.* § 144.6(c).

103 *Id.* § 144.6(d); *Prohibition of Class IV Wells*, 40 C.F.R. § 144.13 (2007).

104 40 C.F.R. § 144.6(e).

105 *Does This Subpart Apply to Me*, 40 C.F.R. § 144.81(14) (2007).

106 *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, 2008)* (to be codified at 40 C.F.R. §§ 144 and 146).

107 *Id. at 43,535.*

108 *Id. at 43,534.*

109 *Id. at 43,540.*

110 *Id. at 43,536-37.*

111 *Id. at 43,540-41.*

112 *See id.*

related to closing and remediating sequestration sites, including emergency and remedial response.[113] 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.[114]

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.[115] 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.[116] By granting discretion to the permitting authorities to tailor regulatory requirements, the EPA is allowing local permitting 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 must be drilled below the lowermost formation containing a USDW, but this requirement may preclude the viable use of coal bed seams.[117] Also, the EPA solicited comment on whether CO_2 injection for EOR purposes should still be regulated as a Class II well and whether hazardous waste can be injected into Class VI wells.[118] Financial responsibility requirements were also identified as an area in which EPA would like to receive comments.[119] 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.[120] 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

[113] *Id.* at 43,537.

[114] *Id.*

[115] *Id.* at 43,523.

[116] *Id.* at 43,535.

[117] *Id.* at 43,534.

[118] *Id.* at 43,502.

[119] *Id.* at 43,522.

[120] *Id.* at 43,540.

that the regulated community will modify or improve upon the rules during the public comment period.[121]

B. States

1. Interstate Oil and Gas Compact Commission

In 2002, the IOGCC created the "Geological CO_2 Sequestration Task Force" to examine technical, policy, and regulatory issues related to carbon sequestration.[122] 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.[123] 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.[124] Importantly, the Task Force also advocated that CO_2 be treated not as a waste, but as a commodity.[125] 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.[126] The Task Force recognized that additional study was necessary and, under the sponsorship of the DOE, began further research.[127]

In 2007 the Task Force published a Legal and Regulatory Guide for States and Provinces.[128] 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. The Task Force emphasized that the states are in the best posi-

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121 *Id. passim.*

122 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) 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.

123 *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).

124 *Id.*

125 *Id.* at 4.

126 *Id.* at 5.

127 *Id.* at 3.

128 *Id.*

tion to manage a storage site from "cradle to grave."[129] 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 concerning geologic storage of carbon dioxide"'"[130] 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.[131] 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.[132] 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.[133] The Task Force noted that, for some states, unitization would serve the same purpose.[134] The Model Rules include provisions for permit amendments, storage site operational standards, and reporting and closure requirements.[135]

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.[136] 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.[137] 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.[138] 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.[139] 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 ac-

129 *Id.* at 12.

130 *Id.* at 32.

131 *Id.* at 33.

132 *Id.* at 33-34.

133 *Id.* at 33.

134 *Id.* at 28.

135 *Id.* at 28-29.

136 *Id.* at 29, 34.

137 *Id.* at 34.

138 *Id.* at 29.

139 *Id.* at 11, 29.

tivities.[140] The Trust Fund would assume all management of the storage site during the Post-Closure Period.[141]

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.[142] 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."[143] By contrast, in the proposed EPA rule-making, geologic sequestration is defined to limit sequestration to "long-term containment."[144] 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.[145]

B. Applicability

The Task Force discussed the applicability of these rules and regulations relative to CO2 injection in enhanced oil recovery (EOR) projects, as well as to CO2 injection for storage in non-EOR applications, such as storage in depleted oil and gas reservoirs, deep saline formations, and coal seams. The Task Force does not intend for these rules and regulations to apply to EOR projects during their normal working life except to the extent an EOR project operator may propose to also permit the EOR project as a CO2 storage project simultaneously. The Task Force assumed that this conversion generally would occur at the end of the normal operating life of an EOR project. An operator desiring that an EOR project be simultaneously used or converted for CO2 storage only could submit that project for approval under this program.[146]

Although the potential of developing different sets of rules and regulations to deal with ongoing or former EOR and non-EOR geologic projects was discussed, the Task Force concluded that the similarities were greater than the differences. Consequently, one set of rules and regula-

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140 *Id.*

141 *Id.*

142 *Id.* at 35.

143 *Id.* at 32.

144 *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).

145 *Id. at 43,512-16.*

146 *See CO2 Storage: A Legal and Regulatory Guide* at 23.

tions was written to accommodate both scenarios and, thus, these rules and regulations are designed to have general applicability.

The Task Force did not address the regulatory issues involving CO2 emissions trading and accreditation for purposes of securing carbon credits. Viewed as beyond the scope of the effort, the proposed Model Rules and Regulations primarily address the regulatory issues related to public health and safety and environmental protections associated with the geologic storage of CO2. The Task Force stated that the issue of CO2 emission trading and accreditation would best be addressed either in the marketplace or at the federal government level. However, the Task Force stated that development of future CO2 emissions trading and accreditation regulatory frameworks should utilize the experiences of the states.[147]

C. Definitions

The Task Force provided definitions for many of the terms used throughout the model rules and regulations. These terms, such as Geological Storage Unit (GSU), CO2 Storage Project (CSP), and CO2 Facility (CF), are used extensively throughout the model rules and regulations.[148]

"CO2" is defined in the Model Rules and Regulations. Although the Task Force originally defined CO2 as a direct emissions stream with purity in excess of 95 percent or a processed emission stream with commercial value, this definition was modified to accommodate the evolving capture technologies and new research regarding reservoir storage capabilities.[149] In addition, the Task Force clarified in its definition of "CO2" that the Model Rules and Regulations only addressed anthropogenically sourced CO2, which is produced as a byproduct of combustion in the industrial process (including CO2 generated from oil and gas production and processing operations) and not non-hydrocarbon associated geologically occurring CO2.[150] In addition to quality requirements for transportation of CO2, ultimately it will be up to the State Regulatory Agency to decide what is and what is not suitable to long-term geologic storage.

The Task Force discussed the most appropriate state regulatory entity to implement the rules and regulations, but ultimately each state will have to make its own decision in this regard.[151] Because the analogs for the majority of the proposed regulations are based on natural gas storage and oil and gas injection well rules, states might well conclude that the most logical and best equipped lead agency for implementing and admin-

147 *Id.* at 23-24.

148 *Id.* at 24-25.

149 *Id.*

150 *Id.*

151 *Id.* at 25.

istering regulations in an effective and efficient fashion would be the state oil and gas regulatory agency. However, other states, especially those without an existing oil and gas regulatory framework, might choose to designate another regulatory agency, such as an environmental agency or public utility commission, as the lead agency for the state.

D. Long-Term Monitoring and Closure

A major issue was how to deal with long-term monitoring and liability issues. A two-stage Closure Period and Post-Closure Period has been proposed.[152] The Closure Period is defined as that period of time when the plugging of the injection well has been completed and continuing for a defined period of time (10 years unless otherwise designated by the State Regulatory Agency) after injection activities cease and the injection well is plugged. During this Closure Period, the operator of the storage site would be responsible to maintain an operational bond and individual well bonds.[153] The individual well bonds would be released as the wells are plugged. At the conclusion of the Closure Period, the operational bond would be released and the liability for ensuring that the site remains a secure storage site during the Post-Closure Period would transfer to the state.

During the Post-Closure Period, the financial resources necessary for the state or a state-contracted entity to engage in future monitoring, verification, and remediation activities would be provided by a state-administered trust fund.[154] Although other methodologies were reviewed, the most efficient methodology to accomplish these tasks is to utilize existing frameworks developed by the states for addressing abandoned and orphaned oil and gas wells.[155] Consequently, the legislation proposes the creation of an industry-funded and state-administered trust fund as the most effective and responsive "care-taker" program to provide the necessary oversight during the Post-Closure Period. The trust fund would be funded by an injection fee assessed to the site operator and calculated on a per-ton basis, at the point of custody transfer of the CO2 from the generator to the site operator.[156]

Given that the state is the proposed "care taker" and responsible party during the Post-Closure Period, the Task Force did not address monitoring and related issues in the Model General Rules and Regulations because the state regulatory entity would have the authority to implement any monitoring, verification, and remediation methods necessary to ensure the security of the storage site. However, given the availability of

152 *Id.* at 29-30.

153 *Id.*

154 *Id.*

155 *Id.*

156 *Id.*

the state-administered trust fund model and assuming the reservoir has been adjudged by the State Regulatory Agency (SRA) to be appropriate for long-term storage, adequate resources should be available for the state entity, as care taker, to field these monitoring, verification, and remediation methods.[157]

Finally, there has been considerable discussion at the national level regarding the proper venue for CO2 geological storage regulation, in particular whether the U.S. EPA might be the best regulatory authority for oversight of storage. Although the UIC Program may be applicable at the discretion of a state program, the current limitations of the UIC program make it applicable only to the operational phase of the storage project. It would therefore appear that given the ownership issue and the proposed long-term "care-taker" role of the states, the states are likely to be best positioned to provide the necessary "cradle to grave" regulatory oversight of geologic storage of CO2.

IV The Regulatory Model: Cradle to Grave

A. Licensing including amalgamation of Storage Rights

As part of the initial licensing of a storage project the operator must control the reservoir and associated pore space to be used for CO2 Storage in order to allow for orderly development and maximum utilization of the storage reservoir.[158] In the United States, the right to use reservoirs and associated pore space is considered a private property right and must be acquired from the owner. With the exception of federal lands, the acquisition of these storage rights, which are considered property rights, generally are functions of state law. Additionally, as part of the initial licensing of a project an operator must submit for state approval detailed engineering and geological data along with a CO2 injection plan that includes a description of mechanisms of geologic confinement that would prevent horizontal or vertical migration of CO2 beyond the proposed storage reservoir. The operator is also required to submit for state approval a public health and safety and emergency response plan, worker safety plan, corrosion monitoring and prevention plan and a facility and storage reservoir leak detection and monitoring plan.

The rules also include requirements for an operational bond that would be sufficient to cover all operational aspects of the storage facility excluding wells that will be separately bonded.

B. The Storage Phase

During the storage phase the proposed legislation specifies the procedures for permitting and operating CO2 storage project wells to safe-

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[157] *Id.* at 30.

[158] *Id.* at 27-28.

guard life, health, property and the environment.[159] The operator must also post individual well bonds sufficient to cover well plugging and abandonment, CO2 injection and/or subsurface observation well remediation and bond release.

The rules also specify design standards to ensure that injection wells are constructed to prevent the migration of CO2 into other areas than the intended injection zone. Provisions in the rules also ensure that all project operational standards and plans submitted during the licensing phase are adhered to and the projects and wells are operated in accordance with all approved operating parameters and procedures. Quarterly and annual reports are required.

V. Other Legal Considerations

A. Analysis of Property Rights Issues Related to Underground Space Used for Geologic Storage of Carbon Dioxide.

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.[160] 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 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."[161]

However, problems arise when the fee simple interest has been severed into a mineral estate and a surface estate.[162] State law governs property rights, 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.[163] Commentators who have surveyed the law tend to conclude that the surface owner owns the subterranean pore space; however, they also conclude that the pru-

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[159] *Id.* at 25.

[160] L. Nettles & M. Conner, *Carbon Dioxide Sequestration--Transportation, Storage, and Other Infrastructure Issues*, 4 Tex. J. Oil, Gas & Energy L. 27 (2009); Elizabeth Wilson & Mark de Figueiredo, *Geologic Carbon Sequestration: An Analysis of Subsurface Property Law*, 36 Envtl. L. Rep. 10114, 10123 (2006).

[161] *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.).

[162] *Id.*

[163] *Id.* at 2-11.

dent approach for an injection operator is to obtain permission from the owners of both the surface and mineral estates.[164] 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.[165] Further, the mineral estate survives as long as there remain minerals to be extracted.[166]

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,[167] 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.[168] Because of the large scale of carbon sequestration projects, eminent domain would have advantages. However, if it was 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.[169] 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

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164 *See id.* at 8; Wilson & de Figueiredo, *supra* note 160, at 10123; *IOGCC Report, supra* note 83, at 22; 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.pd., at 15.

165 *See* Anderson, *supra* note 161, at 3.

166 *See* Fesmire et al., *supra* note 164, at 19.

167 *See* Tex. Nat. Res. Code Ann. § 91.181 (Vernon 2001).

168 *IOGCC Report, supra* note 83.

169 *See* Anderson, *supra* note 161, at 10; Fesmire et al., *supra* note 164, at 37.

pore space.[170] 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.[171] 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.[172] 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.[173]

Case law from various states relating to natural gas storage provides an effective comparison for geological storage. Even though natural gas is stored for relatively short periods of time and carbon dioxide likely will be stored for very long periods of time, the storage time should not impact determining who has legal interests in the structure used for storage and how a regulatory program should treat them.

Williams & Meyers suggest four different conclusions regarding subsurface storage of gas.[174]

> First, the mineral owner should be granted the exclusive right to the storage space "for all purposes relating to minerals, whether 'native' or 'injected', absent contrary language in the instrument severing such minerals."[175] Under this view, the surface owner should not have any rights or be owed any compensation concerning the pore space unless some use of the surface is needed for the storage,[176] which might be a reasonable approach when the subject is a mineral such as natural gas, but not so reasonable for geologic storage.
>
> Second, the owners of non-operating interests in the production of minerals should not be compensated and their consent should not be needed if the pore space no longer contains minerals; i.e., if the pore space is empty and using the space for storage as the next logical step, then those owners have no interest in the space.[177]

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170 *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).*

171 *Id.*

172 *See* Tex. Nat. Res. Code Ann. § 101.013(a) (3) (Vernon 2001).

173 *See id.*

174 Williams and Meyers, *Oil and Gas Law* Vol. 1, §222 (Matthew Bender, 2006).

175 *Id.* at 335.

176 *Id.* at 334.

177 *Id.* at 336-337.

> Third, the operating rights owner should not be compensated and consent should not be needed for the right to store natural gas unless the operating rights owner will be negatively impacted by the injection of natural gas.[178]
>
> Fourth, the consent of the mineral owner should be required regardless of whether the pore space still contains oil and gas.[179]

Through their conclusions, it appears that Williams & Meyers strongly believe that the dominant interest in the storage space belongs to the mineral owner, not the surface owner. Extrapolating their view, the mineral owner's rights must be secured in every situation where a potential purchaser seeks to acquire the storage space, whereas the surface owner's rights need not be secured unless the use of the surface is required.

Louisiana

In *U.S. v. 43.42 Acres of Land*, applying Louisiana law, the court held that after the extraction of minerals, the storage space that remained belonged to the surface owner and the mineral owner had no claim for compensation.[180] Compensation for the value of the storage space taken by eminent domain is not necessarily determined by the right to produce and mine the minerals.[181] The court further added that regardless of a state's ownership or non-ownership policy pertaining to mineral rights, in no instance should the mineral owner be found to have ownership of the pore space for storage purposes.[182] This decision is important because it involved who was owed compensation for the taking of the storage space, which tells us who under the law had the right to authorize the storage of natural gas. The court seemed clear that in Louisiana the surface owner had the prevailing interest in the storage space in all facets.

Texas

In Texas, there is no clear general rule on which estate, surface or mineral, possesses ownership of the pore space for storage purposes unless the severance contract expressly specifies. The natural gas storage case law in Texas gives conflicting results because in one case, *Mapco v. Carter*, the mineral owner prevailed[183] while another case, *Emeny v. U.S.*, held in favor of the surface owner.[184] The Texas Supreme Court in *Hum-*

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178 *Id.* at 337.

179 *Id.* at 338.

180 *United States v. 43.42 Acres of Land*, 520 F.Supp. 1042, 1045 (W.D. La. 1981).

181 *Id.* at 1044.

182 *Id.* at 1046.

183 *Mapco, Inc. v. Carter*, 808 S.W.2d 262 (Tex. App.—Beaumont 1991), *rev'd in part*, 817 S.W.2d 686 (Tex. 1991).

184 *Emeny v. United States*, 412 F.2d 1319 (Ct. Cl. 1969).

ble Oil v. West cited *Emeny*, but the court's holding did not rely on *Emeny*.[185]

In *Mapco*, the court held that the mineral owner, who was entitled to compensation for the use of the storage area, owned the subsurface storage area.[186] The mineral owner had created the cavern within a salt dome for the purpose of storing natural gas.[187] The cavern walls were constructed of salt, a mineral in Texas (and specifically reserved to the mineral owner in lease documents); therefore, the mineral owner in this case had the exclusive right to the storage.[188] This decision was overruled in part by the Texas Supreme Court, but not on the matter of ownership of the storage space.[189]

In *Emeny*, the Federal Court of Claims, applying Texas law, held that the surface owners retained all property rights, except the mineral rights for oil and gas operations, and the geological subsurface pore space belonged to the surface owners for storage purposes.[190] The natural gas produced elsewhere was transported through the mineral owner's pipeline into the pore space and stored there until the gas was needed.[191] The contracted rights of the mineral owners contained in the oil and gas lease were "for the sole and only purpose of mining and operating for oil and gas and of laying pipe lines . . . to produce, save, and take care of said products."[192] The court reasoned that this language allowed the mineral owner to store gas produced only from the leased premises, not extraneous gas produced elsewhere.[193] *West* cited *Emeny*, stating the surface owner retained the pore space for storage purposes of natural gas.[194] However, ownership of the pore space was conceded to the surface estate, and *West* turned on the issue of whether the pore space could be used for storage purposes prior to all gas being produced from the pore space.[195]

In the current analysis, it is fair to conclude that in Texas, *Mapco* applies only when the storage space is created and comprised of a mineral. Arguably, *Mapco* is inapplicable for GS because the space will be a geological non-mineral pore space. Surface owners in Texas have a solid

185 *Humble Oil & Refining Co. v. West*, 508 S.W.2d 812 (Tex. 1974).

186 *Mapco*, 808 S.W.2d at 274.

187 *Id.* at 264.

188 *Id.* at 274.

189 *Mapco, Inc. v. Carter*, 817 S.W.2d 686, 688 (Tex. 1991).

190 *Emeny*, 412 F.2d at 1323.

191 *Id.* at 1322.

192 *Id.* at 1323.

193 *Id.*

194 *Humble Oil*, 508 S.W.2d at 815.

195 *Id.*

interest because the *Mapco* court did emphasize that the storage space was comprised of salt and not a geological pore space.[196]

Texas case law on storage ownership seems to indicate that surface owners have a stronger argument for the right to authorize the pore space for storage. However, the case law is uncertain, and the mineral owners have valid arguments that a potential purchaser of the pore space should be required to obtain their consent as well, particularly if the geologic storage project could adversely affect mineral exploration or production. Perhaps the most important aspect of Texas law is that the question of pore space ownership is not clearly settled, highlighting the need for statutory and regulatory clarity.

Oklahoma

In *Ellis v. Arkansas Louisiana Gas*, an Oklahoma case, the Tenth Circuit held that in general the pore space belonged to the surface owner for gas storage purposes; however, in this particular case the mineral owner prevailed because the court found a prescriptive easement.[197] The mineral owner appealed the trial court's ruling concerning the prescriptive easement, but did not challenge the court's determination that the surface owner held the rights to the pore space.[198] Once again, an issue aside from the right to the storage space prevents a general rule being derived. One could assume that had there not been a prescriptive easement, the surface owner would have prevailed.

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.[199] Among the potential liabilities associated with the operational phase are fluid migration, groundwater contamination, and damage to property rights.[200] 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.[201] Also,

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196 *Mapco*, 808 S.W.2d at 274.

197 *Ellis v. Ark. La. Gas Co.*, 609 F.2d 436, 439 (10th Cir. 1979).

198 *Id.* at 439.

199 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.

200 *Id.*

201 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:// sequestra-

short-term liabilities can often be addressed through contractual arrangements, as between the CO_2 generator and injector.[202]

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.[203] 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.[204] 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.[205] 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.[206] 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.[207]

Certain groups, such as the IOGCC, have advocated that long-term liability be transferred to the public sector.[208] Under this paradigm, typically a public trust is established that would fund the long-term monitoring and any remediation at the sequestration sites.[209] 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.[210] Perhaps notably, the Lieberman- Warner bill (discussed below) directs the EPA to establish a task force to

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tion.mit.edu/pdf/Framing_the_Long-Term_Liability_Issue.pdf.

202 Fesmire et al., *supra* note 164 at 39.

203 *See id.* at 16.

204 Cal. Energy Comm'n & Cal. Dep't of Conservation, *Geologic Carbon Sequestration Strategies for California: Report to the Legislature* 133 (2008), available at http://www.energy.ca.gov/2007publications/CEC-500-2007-100/CEC-500-2007-100-CMF.PDF [hereinafter Cal. Joint Report].

205 *Id.*

206 *See* Weber, *supra* note 199, at 7.

207 Fesmire et al., *supra* note 164 at 16.

208 *Id.*

209 *IOGCC Report, supra* note 83, at 34.

210 Weber, *supra* note 199, at 7.

study the feasibility of "potential Federal assumption of liability with respect to closed geological storage sites."[211]

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 FutureGen project, a pilot sequestration project that was to be funded by the federal government but that has since been terminated.[212] 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.[213] 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.[214] 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.[215]

C. Federal Legislation

Energy Independence and Security Act of 2007

The Energy Independence and Security Act of 2007 became law in December 2007.[216] Earlier versions of the bill included carbon capture tax credits and accelerated depreciation for dedicated CO_2 pipelines, but

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211 *Lieberman-Warner Climate Security Act of 2008*, S. 3036, 110th Cong., § 8004(a).

212 Perry Submits Two Final Offers for FutureGen Project, FutureGen Texas, Aug.1, 2007, http:// www.beg.utexas.edu/futuregentexas/pdf/GovernorsAnnouncement BAFO .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.

213 *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.

214 *Id.*

215 de Figueiredo et al., *supra* note 160, at 9.

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

these provisions were not included in the version of the bill that was ultimately adopted.[217] 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 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.[218] The law also authorizes appropriations for these various projects and programs.[219] 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.[220]

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.[221] 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."[222]

Subtitle B enacts various provisions requiring the Department of the Interior, through the U.S. Geological Survey, to undertake various studies relating to CCS.[223] Among other provisions, the Secretary of the Interior is directed to: (1) conduct a national assessment of capacity for CO_2

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

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

219 *Id.* § 17253.

220 *Id.* § 17251.

221 *Id.* § 17254.

222 *Id.* § 17255.

223 *See id.* § 17271.

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.[224]

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.[225] The bill would mandate a nationwide cap on greenhouse gas ("GHG") emissions, establishing a cap-and-trade system.[226] 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.[227] Each allowance represents the emission of one ton of GHG emissions from a covered entity.[228] Some allowances would be freely distributed among designated industrial sectors, with the remainder to be auctioned by the federal government.[229] 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.[230] 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.[231] 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.[232]

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

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224 *Id.*

225 *See generally Lieberman-Warner Climate Security Act of 2008*, S. 3036, 110th Cong.

226 *Id.*

227 *Id.* § 120.

228 *Id.* § 4.

229 *Id.* §§ 3101-3202.

230 *Id.*

231 *Id.* § 2101.

232 *See id.* §§ 4101-02.

2012 to 2030, as bonus allowances for carbon sequestration.[233] 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 in accordance with regulations promulgated under the Safe Drinking Water Act.[234] 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.[235] 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.[236]

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.[237] The bill provides that 25% of the auction proceeds shall be used to support advanced coal and sequestration technologies.[238] 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.[239]

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.[240] The bill then directs the Secretary of the Interior to complete a national assessment of the capacity for CO_2 storage and directs the Secre-

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233 *Id.* § 3601.

234 *Id.* § 3602.

235 *Id.* § 3604.

236 *Id.* § 3605.

237 *Id.* §§ 4201, 440.

238 *Id.* § 4403.

239 *Id. passim.*

240 *Id.* § 8001(a).

tary 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.[241] 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.[242]

A few of these provisions related to the regulatory framework appear obsolete. In its July 2008 proposed rulemaking, the EPA has already 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.[243] 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.

VI. Conclusion

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.[244] A carbon revolution will present many opportunities.

Opportunities are particularly prevalent in Louisiana, 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, depleted reservoirs beneath Louisiana and its coastal waters in the Gulf of Mexico could store 670 billion tons of carbon dioxide or more. Perhaps the most readily available opportunities in Louisiana 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 for 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.[245]

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241 *Id.* §§ 8002(f), 8003.

242 *Id.* § 8004.

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

244 McKinsey & Co., *The Carbon Productivity Challenge: Curbing Climate Change and Sustaining Economic Growth* 9 (2008).

245 *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.[246] 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.[247] 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.

The revolution is upon us, but neither the federal government nor states have thus far filled the legal and regulatory void concerning carbon capture and sequestration. What laws will dictate how companies move forward with CCGS projects. The oil and gas industry has a rich history that is uniquely fitted to this emerging industry. The experiences we've all had should be garnered and applied so that the revolution can move forward with some sense of order, and not recklessly without concern for the health, safety and economic issues that prevail. The proposed legislation is a necessary step, which will keep Louisiana on the forefront of this important energy related revolution.

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

[247] *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.