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Legal Requirements for Widespread Implementation of CO_2 Sequestration in Depleted Oil Reservoirs

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I. Introduction

As Americans, eighty-five percent of our energy comes from combustion of fossil fuels.[1] It is predicted that fossil fuels will remain the primary source of energy in the near to mid-term future.[2] Moreover, the United States is the largest emitter of greenhouse gases,[3] sixty percent of which is carbon dioxide (CO_2).[4] Under the current and projected use of fossil fuels for energy, the levels of anthropogenic carbon dioxide emitted into the atmosphere will increase, unless major advances are made to reduce emissions.[5]

Scientific evidence suggests that continued warming from increased greenhouse gases in the atmosphere can melt polar ice caps, thereby increasing sea levels.[6] The climate shift will cause droughts in regions that were accustomed to sufficient rainfall, while causing severe storms in other areas, leading to flooding.[7]

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1. P.R. Knox & S.D. Hovorka, *Geologic Sequestration of Greenhouse Gases: Opportunities for Industry-Academe Research Partnerships*, HOUSTON GEOLOGICAL SOC'Y NEWSLETTER (Houston Geological Soc'y, Houston, TX) 2001, *available at* http://www.hgs.org/en/articles/view.asp?articleid=42 (last visited Oct. 7, 2003) [hereinafter Knox & Hovorka].

2. OFFICE OF SCIENCE & OFFICE OF FOSSIL ENERGY, U.S. DEP'T OF ENERGY, CARBON SEQUESTRATION RESEARCH AND DEVELOPMENT 1-6 (1999), *at* http://www.fossil.energy.gov/programs/sequestration/publications/1999_rdreport/ (last visited Oct. 7, 2003) [hereinafter CARBON SEQUESTRATION].

3. Jasmine Abdel-khalik, *Prescriptive Treaties in Global Warming: Applying the Factors Leading to the Montreal Protocol*, 22 MICH. J. INT'L L. 489, 520 (2001).

4. *Id.* at 492.

5. CARBON SEQUESTRATION, *supra* note 2, at 1-1.

6. Abdel-khalik, *supra* note 3, at 495.

7. *See id.* at 494.

Within the United States, our national parks can be greatly damaged by melting glaciers in Glacier National Park and deteriorating air quality in the already polluted Great Smoky Mountains National Park.[8]

An available option to reduce greenhouse gases emitted into the atmosphere, specifically CO_2, is carbon sequestration.[9] A study estimated that global sequestration capacity in depleted oil and gas fields is substantial, with the capacity to store 125 years of current worldwide CO_2 emissions from fossil fuel-fired power plants.[10] Carbon sequestration, along with other emissions-reducing alternatives, can effectively reduce mass output of CO_2 to the atmosphere.[11]

The Bush administration does not believe global warming is truly a problem.[12] Consequently, the environmental agenda does not include greenhouse gas reduction but, in fact, provides for increases in the amount of allowable greenhouse gas emissions to the atmosphere by fourteen percent.[13] Furthermore, "[t]he Administration will not support any legislation that would cause a significant decline in our nation's ability to use coal as a major source of current and future electricity."[14] Due to Bush's lack of a comprehensive policy, governors of ten northeastern states have agreed to work on a regional greenhouse gas strategy that will achieve meaningful reductions of CO_2 while promoting economic

8. *Bush Administration's Clear Skies Plan Falls Short of National Park Needs*, U.S. NEWSWIRE, Feb. 14, 2002, *at* http://www.npca.org/media_center/PressReleaseDetail.asp?id=84 (last visited Oct. 7, 2003).

9. Geological carbon sequestration is defined as the "capture of CO_2 directly from anthropogenic sources and disposing of it into the ground for geologically significant periods of time, *i.e.*, 10,000 years." Stefan Bachu, *Sequestration of CO_2 in Geological Media in Response to Climate Change: Road Map for Site Selection using the Transform of the Geological Space into the CO_2 Phase Space*, 43 ENERGY CONVERSION & MGMT. 87, 90 (2002).

10. Scott H. Stevens & John Gale, *Geologic CO_2 Sequestration May Benefit Upstream Industry*, 5/15/00 OIL & GAS J. 40 (2000), *available at* 2000 WL 14257244 (online version is not paginated) [hereinafter Stevens & Gale].

11. Alternatives to coal-fired power plants include using natural gas, coal gasifiers, wind energy, automobile emission reductions, and other "clean-air technologies." Abdel-khalik, *supra* note 3, at 515-18.

12. *WRI Says Bush Plans Will Increase Greenhouse Emissions By 14 Percent*, U.S. NEWSWIRE, Feb. 14, 2002, *at* http://www.wri.org/press/wri_reaction_bush.html (last visited Oct. 7, 2003).

13. *Id.*

14. *Prepared Testimony of Robert S. Kripowicz Acting Assistant Secretary for Fossil Energy Before the S. Comm. on Env't and Pub. Works Subcomm. on Clean Air, Wetlands, and Climate Change*, FED. NEWS SERV., Jan. 29, 2002, *available at* LEXIS, Federal News Service File [hereinafter *Prepared Testimony*].

development.[15] Furthermore, some U.S. industrial companies and utilities are pushing for reduced carbon emissions[16] and are willing "to embark on aggressive and innovative greenhouse gas reduction strategies."[17]

Opponents of reducing emissions, specifically CO_2, claim that it would cost the government, industry, and society too much to alter its CO_2 emitting activities, *i.e.*, cleaning up coal-fired power plants, which are currently the primary contributor of CO_2 emissions.[18] Opponents further believe that increased temperatures can provide a net positive to rich countries who can adapt to the changing climate.[19] However, the longer we put off trying to find solutions to the problem, the more it will cost in the future to try to reduce the levels of greenhouse gases, particularly CO_2, in the atmosphere.

This article discusses carbon sequestration as an option for reducing emissions into the atmosphere. Specifically, this article briefly describes carbon sequestration in geologic formations, such as oil and gas reservoirs. It further addresses the issue of whether a current statute, the Underground Injection Control (UIC) program of the Safe Drinking Water Act (SDWA), could account for large-scale CO_2 sequestration projects. Finally, this article focuses on what items should be added to the current statutory framework if it does not currently provide for large-scale injections of CO_2 underground.

II. Carbon Sequestration

"Carbon sequestration, if it can be developed to the point where it is practicable, affordable, and environmentally safe, offers the potential for dramatic CO_2 reductions over the long-term, perhaps even more than would be possible through efficiency im-

15. Darren Samuelsohn, *Northeast States Pledge CO_2 Cap-and-Trade Program*, GREENWIRE, July 25, 2003, *available at* LEXIS, News Library, GRNWRE File.

16. *Coalition of Businesses, Enviros Recommend GHG Reductions*, GREENWIRE, June 18, 2003, *at* http://eenews.net/Greenwire/Backissues/06180306.htm (last visited Oct. 7, 2003); Lauren Miura, *Utilities, Energy Investors Call for Mandatory CO_2 Caps*, GREENWIRE, June 6, 2003, *at* http://eenews.net/Greenwire/Backissues/061803/06060308.htm (last visited Oct. 7, 2003).

17. *Coalition of Businesses, Enviros Recommend GHG Reductions*, GREENWIRE, June 18, 2003, *at* http://eenews.net/Greenwire/Backissues/06180306.htm (last visited Oct. 7, 2003).

18. *See* Jeff Tollefson, *Los Alamos Lab Researching Cleaner Coal Burning*, ASSOCIATED PRESS NEWSWIRES, July 28, 2002.

19. Frank H. Murkowski, *The Kyoto Protocol is Not the Answer to Climate Change*, 37 HARV. J. ON LEGIS. 345, 349-50 (2000).

provements and low-carbon fuels together."[20] Currently, carbon sequestration is considered a third approach to carbon management.[21] The first approach is to "increase the efficiency of primary energy conversion and end use so that fewer units of primary fossil energy are required to produce the same energy service."[22] The second "is to substitute lower-carbon or carbon-free energy sources for our current sources."[23] As the United States relies on fossil fuels for more than eighty-five percent of its energy needs,[24] carbon sequestration would act as a counterpart to these traditional areas of research. However, by reducing the amount of CO_2 emitted to the atmosphere, carbon sequestration continues to permit the use of fossil energy, "while buying time to make the transition to other energy sources in an orderly fashion."[25]

Before CO_2 can be sequestered underground, it must be captured. Carbon dioxide can be separated from large point sources, such as coal steam power plants, oil refineries, and natural gas combustion plants. For carbon sequestration to be economically viable, separated CO_2 must be concentrated (greater than ninety percent) into a liquid or gas steam.[26] After capture, carbon sequestration would require identification of major CO_2 sources and of sizeable geologic formations.[27] Large formations in "remote areas, even if suitable for CO_2 sequestration from a geological point of view, will probably be eliminated at this stage because of transportation, environmental and economic reasons."[28]

There are a number of ways CO_2 can be stored, including advanced biological and chemical processes, and ocean, terrestrial (soils and vegetation), and geologic sequestration.[29] Geological sequestration is defined as the "capture of CO_2 directly from anthro-

20. *Prepared Testimony, supra* note 14.

21. CARBON SEQUESTRATION, *supra* note 2, at 1-1.

22. *Id.* at 1-2.

23. *Id.*

24. Howard J. Herzog, *What Future for Carbon Capture and Sequestration?*, 35 ENVTL. SCI. & TECH. 148, 148A (2001).

25. *Id.*

26. DEP'T OF ENERGY NAT'L CLIMATE CHANGE TECH. INITIATIVE WHITE PAPER, CO_2 CAPTURE AND STORAGE IN GEOLOGIC FORMATIONS (2002), *at* http://www.netl.doe.gov/coalpower/sequestration/pubs/CS-NCCTIwhitepaper.pdf.

27. *See* Perry D. Bergman et al., *Disposal of Power Plant CO_2 in Depleted Oil and Gas Reservoirs in Texas*, 38 ENERGY CONVERSION & MGMT. 211 (1997).

28. Bachu, *supra* note 9, at 90.

29. CARBON SEQUESTRATION, *supra* note 2, at 1-3.

pogenic sources and disposing of it into the ground for geologically significant periods of time, *i.e.*, 10,000 years."[30]

Geologic sequestration includes storage of CO_2 in un-minable coal beds, deep saline aquifers, depleted oil and gas reservoirs, and the ocean.[31] Geologic sequestration in oil and gas reservoirs, which this article discusses, will most likely be the first route explored because of collateral economic benefits, suitable geologic formations, geologic analogs, and extensive industrial experience in oil and gas storage.[32] Moreover, there are numerous formations that once held oil and gas but could now serve as sites for storing CO_2.[33] Research has indicated that "[t]he preferred underground storage concept is injection via wells into deep reservoir rocks capped by very low permeability seals."[34] The oil and gas industry has been injecting CO_2 into wells for use in Enhanced Oil Recovery (EOR) for years; their expertise in the field is invaluable.[35] The majority of CO_2-EOR wells in the U.S. are located in the Permian and Rocky Mountain basins in the southwestern region of the United States.[36]

III. Enhanced Oil Recovery

Carbon capture, coupled with CO_2 use in Enhanced Oil Recovery (EOR), could reduce CO_2 levels emitted to the atmosphere and provide an economically viable use for the captured carbon.[37] EOR enables ten to fifteen percent more oil or gas to be recovered from a well.[38] EOR includes injection of CO_2 into a well, which reduces the viscosity of the oil and increases the hydraulic pressure in the well, thereby mobilizing material in the reservoir.[39] This mobilization causes a release of additional oil or gas, increasing production from the reservoir.[40] The additional product released from the reservoir and the corresponding increased

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30. Bachu, *supra* note 9, at 90.
31. CARBON SEQUESTRATION, *supra* note 2, at 5-3.
32. Sally M. Benson et al., *An Overview of Geologic Sequestration of CO_2*, ENERGEX'2000: PROCEEDINGS OF THE 8TH INT'L ENERGY FORUM 1219, 1219-25 (2000).
33. Bergman, *supra* note 27, at 211.
34. Sam Holloway, *An Overview of the Underground Disposal of Carbon Dioxide*, 38 ENERGY CONVERSION & MGMT. 193, 194 (1997).
35. *See* Herzog, *supra* note 24, at 148A (2001).
36. Stevens & Gale, *supra* note 10.
37. CARBON SEQUESTRATION, *supra* note 2, at 5-1.
38. Wendy Drake, *Sinking O_2 Carbon Dioxide Sinks*, 43 ENV'T 6 (2001).
39. *See* CARBON SEQUESTRATION, *supra* note 2, at 5-8.
40. *Id.*

revenue can provide the economic means by which anthropogenic CO_2 can feasibly be employed.[41]

Collateral economic benefits are possible from EOR, which would offset the cost of sequestration and could amplify interest.[42] "The economics of disposal in oil reservoirs is more favorable than disposal in gas reservoirs because of the by-product oil credit."[43] Currently, naturally occurring deposits of CO_2, like those found in McElmo Dome in Colorado and Jackson Dome in Mississippi, supply most of the CO_2 being injected for EOR.[44] Using natural stores of CO_2, which is the current regime, only increases the amount of CO_2 that can potentially escape to the atmosphere.[45] In effect, using natural stores creates yet another source of CO_2. Rather, CO_2 from anthropogenic sources, instead of natural sources, can generate the same EOR effect, yet reduces emissions to the atmosphere.[46] Moreover, the natural stores of CO_2 are perfect natural laboratories for research into understanding how CO_2 is naturally held underground and the long-term effects of that storage.[47]

While widespread implementation of carbon sequestration appears to be a win-win situation, there is much we do not know about the long-term health and environmental effects it could cause. Widespread implementation of CO_2 sequestration would necessitate: 1) power plant alterations, such as those upgrades called for by Senate Bill 556,[48] and 2) construction of an extensive pipeline system, which would be costly and problematic given the current and past terror threats directed at American pipeline systems.[49] Thus, extensive revision of the current statutory framework would be essential.

41. *See* OFFICE OF FOSSIL ENERGY, DEP'T OF ENERGY, GEOLOGIC SEQUESTRATION RESEARCH, *at* http://fossil.energy.gov:7778/programs/sequestration/geologic/ (last visited Oct. 7, 2003).

42. CARBON SEQUESTRATION, *supra* note 2, at 5-1.

43. Bergman, *supra* note 27, at 211-12.

44. Stevens & Gale, *supra* note 10.

45. *See id.*

46. *Id.*

47. *Id.*

48. Eric Pianin, *Senate Panel Backs Bill to Curb Power Plant Pollution*, WASH. POST, June 28, 2002, at A5, *available at* www.washingtonpost.com/ac2/wp.dyn?pagename=article&node&contentId=A58538-2002Jun27&notFound=true (last visited Oct. 7, 2003); Clean Power Act of 2002, S. 556, 107th Cong. (2002).

49. *See Pipelines, State Regulators Question Bill to Fund Pipeline Research*, 3/18/02 INSIDE F.E.R.C. 15 (Mar. 18, 2002), *available at* 2002 WL 10511165; *Hardball with Chris Matthews, Profile: Christopher Witcomb, Former FBI Agent, Talks About Poten-*

IV. Statutory Framework

A. United Nations Framework Convention on Climate Change

In response to international concerns over pollution and increased levels of greenhouse gases in the atmosphere, an international conference was held in Rio de Janeiro, Brazil, in 1992 to address these issues.[50] One hundred and fifty-five nations, including the United States, signed the United Nations Framework Convention on Climate Change (UNFCCC) at the 1992 United Nations Conference on Environment and Development.[51] The conference established the goal of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[52]

The United States subsequently ratified the UNFCCC in March 1994, thereby binding itself to the terms set by the Convention on Climate Change.[53] Under article 4, section 1(f), parties to the UNFCCC shall take into account climate change considerations, with a focus on minimizing adverse effects on global environmental quality.[54] Article 4, section 2(a), establishes that developed countries, like the United States, shall limit emissions of greenhouse gases such as CO_2 and shall protect and enhance its greenhouse sinks and reservoirs.[55] UNFCCC Article 1(9) defines a source as a process or activity that releases greenhouse gases into the atmosphere.[56] Article 1(7) further defines a reservoir as a component of the climate system where a greenhouse gas is stored.[57] The United States could enhance its sinks by using oil and gas reservoirs as storage units for CO_2, thereby fulfilling its commitment to the UNFCCC.

The Unites States' obligations under the UNFCCC require, at a minimum, that a comprehensive consideration of a full range of impacts and alternatives be considered before proceeding.[58] Arti-

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tial Risks of Terrorists Attacks on Various U.S. Energy Facilities (CNBC television broadcast, Jan. 9, 2002).

50. Murkowski, *supra* note 19, at 352.

51. *Id.*; *see* United Nations Framework Convention on Climate Change, *available at* http://unfccc.int/resource/conv/conv.html (last modified Oct. 12, 1999) [hereinafter UNFCCC].

52. Murkowski, *supra* note 19, at 352.

53. *Id.*; *see* UNFCCC, *supra* note 51.

54. UNFCCC, *supra* note 51.

55. *Id.*

56. *Id.*

57. *Id.*

58. *See id.*

cle 4, section 2(e)(ii), of the UNFCCC indicates that parties to the treaty should periodically review their policies that could encourage activities leading to greater emissions of greenhouse gases.[59] A reasonable way to deal with our obligations under the UNFCCC is to enhance CO_2 sinks, such as oil and gas reservoirs. "Geologic sequestration is an immediately available and technologically feasible option."[60] However, the United States' commitment to reduce greenhouse gases to 1990 levels has yet to be met.[61] In fact, the current emission standards set by the Bush administration are only voluntary, will not meet the "1990 levels" goal, and will actually permit emissions levels to increase.[62] To date, the United States is nowhere near fulfilling its commitment to the UNFCCC.

B. National Environmental Policy Act

The National Environmental Policy Act (NEPA), specifically 42 U.S.C. § 4332(1)(C)(i), requires all agencies of the federal government to prepare a detailed report of the environmental impacts of, and the potential alternatives to, significant proposed actions.[63] Compliance with NEPA includes preparation of an Environmental Assessment (EA) on the proposed action and an Environmental Impact Statement (EIS) if the action would have significant environmental impacts.[64] These reports are to cover all environmental impacts, mitigation possibilities, and a reasonable range of alternatives.[65] NEPA analysis requires that a full range of alternatives, which includes a CO_2 supply from power plants, be considered before a project is approved.[66] NEPA analysis would also reveal the hazards of employing natural, rather than anthropogenic, sources of CO_2 for EOR purposes.[67] NEPA could potentially play an important role in decreasing the apparent pull towards using natural CO_2, thereby creating a market demand for anthropogenic CO_2. NEPA could also help uncover

59. *Id.*
60. Bachu, *supra* note 9, at 88.
61. David Gardiner & Lisa Jacobson, *Will Voluntary Programs be Sufficient to Reduce U.S. Greenhouse Gas Emissions?*, 44 ENV'T 24 (2002), *available at* 2002 WL 10543773.
62. *Id.*
63. National Environmental Policy Act, 42 U.S.C. § 4332(1)(C)(i) (2000).
64. *Id.* § 4332(1)(C)(i).
65. *Id.*
66. *Id.*
67. *See id.*

potential environmental impacts caused by injection of large quantities of CO_2 underground by requiring an EA and/or EIS for every major project.

C. Safe Drinking Water Act and the Underground Injection Control Program

While the practice of using injection wells for waste disposal in oil fields began in the 1930s,[68] laws protecting underground sources of drinking water were not implemented until the mid-1970s. The Safe Drinking Water Act (SDWA), which was enacted in 1974, directed the EPA to set health-based standards for contaminants in drinking water.[69] The SDWA established the Underground Injection Control (UIC) Program in the early 1980s.[70] The SDWA also provided a framework for the UIC program to safeguard against the injection of wastes into aquifers, which would contaminate public drinking water supplies.[71] The UIC program is implemented by individual states, upon program approval by the EPA, or by the EPA itself.[72] "Gases and CO_2 injection are directly managed under the UIC program."[73] The UIC regulations establish five classes of wells:

Class I: Injection of municipal or industrial waste (including hazardous waste) below the deepest underground source of drinking water (USDW).[74] These deep injections are separated from the lowermost USDW by layers of impermeable clay and rock.
Class II: Injection related to oil and gas production.
Class III: Injection for mineral recovery.

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68. Chin-Fu Tsang et al., *Scientific Considerations Related to Regulations Development for CO_2 Sequestration in Brine Aquifers* 2 (2001), *available at* http://esd.lbl.gov/GEOSEQ/pdf/tsang_netl.pdf.

69. Safe Drinking Water Act, 42 U.S.C. §§ 300f-300j-26 (2000).

70. ENVTL. PROT. AGENCY, SUMMARY OF THE HISTORY OF THE UIC PROGRAM, *available at* http://www.epa.gov/safewater/uic/history.html (last modified June 11, 2001).

71. ENVTL. PROT. AGENCY, UNDERSTANDING THE SAFE DRINKING WATER ACT, Report 810-F-99-008 2 (1999), *at* http://www.epa.gov/safewater/sdwa/understand.pdf [hereinafter UNDERSTANDING THE SDWA].

72. ENVTL. PROT. AGENCY, GUIDANCE FOR STATE SUBMISSIONS UNDER SECTION 1425 OF THE SAFE DRINKING WATER ACT 2 (1981), *at* http://www.epa.gov/safewater/uic/guidance/guid19.pdf.

73. Elizabeth J. Wilson et al., *Regulating the Ultimate Sink: Managing the Risks of Geologic CO_2 Sequestration* (2002) (unpublished manuscript, on file with ENVTL. SCI. & TECH.).

74. EPA defines USDW as an aquifer that currently does or could supply a public water system and is not exempted from protection by the EPA. Underground Injection Control Program, 40 C.F.R. § 146.3 (2002).

Class IV: Injection of hazardous or radioactive waste into or above a USDW.
Class V: All other wells used for injection of fluids.[75]

Class I wells are managed by state departments of environmental or natural resources, while Class II hydrocarbon production wells are managed by state conservation commissions or divisions of oil and gas.[76] Operators of Class I wells must demonstrate that their hazardous injectate will not migrate from the injection zone as long as it remains hazardous.[77] This requirement is known as the "no-migration petition."[78] Furthermore, Class I well operators must continuously monitor the characteristics of the well, the fluid contained in the well, and migration out of the injection zone.[79] If large-scale carbon sequestration is implemented, there will be a move to reclassify the injection wells from Class II to Class I, which deal with hazardous materials injected beneath the lowermost USDW.[80] This reclassification would make it more difficult to obtain permits, as CO_2 would then be considered a hazardous waste.[81] Industry may push to have CO_2 injection wells classified as Class II wells, but for the sake of environmental safety and effective overview programs, CO_2 injection wells seem better suited for Class I classification, as Class I wells are more closely regulated.

Class II wells, which currently cover CO_2-EOR injection into deep underground formations, are divided into three subcategories: salt water disposal wells, EOR wells, and hydrocarbon storage wells.[82] Class II wells also have a "no-migration petition" attached to their permit.[83] In addition to assuring that the injectate will not migrate, an operator needs to identify other wells

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75. Chin Fu-Tsang, *supra* note 68, at 3. *See also* 40 C.F.R. § 146.5 (2002).

76. Wilson, *supra* note 73.

77. ENVTL. PROT. AGENCY, CLASS I UNDERGROUND INJECTION CONTROL PROGRAM: STUDY OF THE RISKS ASSOCIATED WITH CLASS I UNDERGROUND INJECTION WELLS, Report 816-R-01-007 (2001), *at* http://www.epa.gov/safewater/uic/classonestudy.pdf [hereinafter CLASS I INJECTION CONTROL PROGRAM].

78. *Id.*

79. *Id.*

80. Personal communication with EPA Region 3 Employee (July 2002) (notes on file with author).

81. *Id.*

82. GROUNDWATER PROTECTION COUNCIL, CLASS II INJECTION WELLS: INJECTION WELLS RELATED TO OIL AND GAS ACTIVITY, *at* http://www.gwpc.org/Brochures/InjectionWells/UICBropg4.htm (last visited Oct. 7, 2003).

83. ENVTL. PROT. AGENCY, OIL AND GAS INJECTION WELLS (CLASS II), *at* http://www.epa.gov/safewater/uic/classii.html (last updated June 13, 2002).

in the vicinity to determine whether they could serve as pathways for migration.[84] Identification of those pathways may become increasingly problematic with increased use of geologic formations for CO_2 sequestration.[85]

D. Primacy Under the Safe Drinking Water Act

A state may apply for primacy over their UIC wells. EPA has granted primacy for all well classes to thirty-four states, shares responsibility in six states, and implements a program for all well classes in ten states.[86] States that have acquired primacy manage their own UIC programs through state agencies, resulting in a wide range of requirements that vary from state to state.

Under section 1425 of the SDWA, a state is required to demonstrate that the Class II portion of its UIC program meets the requirements of sections 1421(b)(1)(A)-(D) and represents an "effective" program to prevent underground injection, which endangers drinking water sources. "Effective" has been defined by those in the field to mean necessary to ensure protection of underground sources of drinking water.[87]

UIC permits are written by the EPA and reviewed for criteria including geography and geology of well placement, well construction, compatibility of fluid with geology, area of review, well integrity, and plugging and abandonment financial responsibility.[88] Wells that are being used for oil or gas *production* and are injecting CO_2 for EOR purposes are covered under state production well guidelines, not under the UIC program.[89] These wells will have to be absorbed into a regime that provides for uniform enforcement rather than control under varying state programs.

V. Statutory Recommendations for Wide-Spread Implementation

In addition to offsetting CO_2 emissions to the atmosphere, properly designed and implemented carbon sequestration projects

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84. CLASS I INJECTION CONTROL WELLS, *supra* note 77, at 13.

85. *Id.* at 13-14.

86. ENVTL. PROT. AGENCY, STATE UIC PROGRAMS, *at* http://www.epa.gov/safewater/uic/primacy.html (last updated Nov. 26, 2002).

87. *Id.*

88. Personal communication with EPA Region 3 Employee (July 2002) (notes on file with the author).

89. Personal communication with EPA Region 10 Employees, Region Engineers and Geologists (July 2002) (notes on file with the author).

can also offer other collateral benefits.[90] It is thought that several decades of emissions can be sequestered in geologic formations around the country.[91] By the time geologic formations are full, a cleaner and more efficient energy source may be in use. In the meantime, however, if storage of carbon underground is to become a reality, protocols need to be in place to ensure the safety of public health and drinking water supplies. Even with current technology, carbon sequestration should not move forward until there is a clear demonstration that large CO_2 injections will not interfere with current supplies of drinking water or otherwise damage the environment.[92]

A number of bills were introduced in the 107th Congress that included components relating to climate change and, specifically, to carbon sequestration.[93] While some of these bills contained provisions that enhanced carbon sinks, overall, the U.S. Senate would consider only voluntary programs.[94] In general, the bills that were introduced contained the following provisions:

- Providing investment tax credits for carbon sequestration projects;
- Establishing or updating measurement, reporting, verification, and registration mechanisms for voluntary carbon storage in the United States;
- Establishing offices and/or programs to collect, monitor, and analyze carbon sequestration data, including baseline data; and
- Providing research and development money in support of carbon storage research, technologies, and implementation strategies.[95]

While there were a number of bills introduced that addressed the role of carbon sequestration, none of the bills directly addressed or provided for carbon injection into oil and gas reservoirs.

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90. David J. Hayes & Nicholas Gertler, *The Role of Carbon Sequestration in the U.S. Response to Climate Change Challenges and Opportunities*, 32 ENVTL. L. REP. 11,350 (Nov. 2002), *available at* WESTLAW, 32 ELR 11350 (online version not paginated) [hereinafter Hayes & Gertler].

91. *See* Nick Riley, *The Carbon Trap—Going Underground*, PLANET EARTH, Summer 2002, *at* http://www.nerc.ac.uk/publications/planteearth/pe-summ02.shtml (last visited Oct. 7, 2003).

92. Stevens & Gale, *supra* note 10.

93. Hayes & Gertler, *supra* note 90.

94. *Id.*

95. *Id.* (internal citations omitted).

The Safe Drinking Water Act's Underground Injection Control Program currently addresses carbon dioxide injection. It is this program that will have to be altered significantly if widespread sequestration is to occur and if another program is not introduced to take the UIC's place.

The current UIC program provides minimum rules for siting, testing, installing, operating, monitoring, reporting, and abandonment of underground injection wells.[96] Regional and/or state arms of the EPA, which also administer UIC permits, enforce UIC regulations.[97] While the current UIC program offers baseline provisions, numerous provisions that would provide for widespread application of carbon sequestration are absent from the current statutes. Furthermore, "[t]here is a risk that regulators will act precipitously, crafting a regulatory structure to fit the demands of a few early [geologic sequestration] projects, without adequate understanding of their long-term implications."[98]

A. Monitoring Programs

In order to achieve effective reduction of CO_2 levels in the atmosphere, which are both environmentally sound and protective of public health, more stringent and extensive monitoring and leakage control programs must be incorporated into the UIC. For example, the monitoring program could conduct tests on water quality in aquifers within the "wellhead protection area" of the injection wells, as well as emissions around the well cap to determine leakage rates and amounts.[99] Other monitoring tests would include mechanical integrity, containment within the injection zone, and characteristics of the injected material.[100] Underground sources of drinking water must also be monitored for migration of injected materials into those zones.

There are issues regarding when monitoring needs to be commenced, who would monitor the injections, and what exactly needs to be monitored. Current programs that inject solutions into aquifers typically conduct tests that record the injection volume, rate, and pressure over time.[101] Such tests include: continu-

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96. UNDERSTANDING THE SDWA, *supra* note 71.
97. *Id.*
98. Wilson, *supra* note 73.
99. CLASS I INJECTION CONTROL WELLS, *supra* note 77.
100. Personal communication with the manager of the International Weyburn CO_2 Monitoring Project (July 2002) (notes on file with author).
101. Chin-Fu Tsang, *supra* note 68, at 5-6.

ous monitoring of annulus pressure, reservoir pressure/ambient monitoring, seismic monitoring stations, and groundwater monitoring to detect upward migration of injection fluids through fractures.[102] Monitoring after injections are suspended should also be conducted. At this time, high-resolution geophysical imaging programs are available to monitor CO_2 migration in underground formations.[103]

As of yet, no post-closure monitoring protocols are in place for UIC wells.[104] Operators of Class I wells should report data on various injection pressure analyses and the results of well and USDW monitoring. Extensive reporting is necessary if we are to fully understand injection issues, as well as post-closure leakage issues. Determination of leakage rates and amounts would provide data for future injection projects and would instigate procedures to control the leak. Leakage control procedures would largely be on a case-by-case basis, but some information might be applicable on a widespread basis. Measuring reservoirs to determine how much CO_2 can be stored, for example, is critical to understanding how effective these reservoirs are in storing the CO_2 that is injected underground.[105] Subsequent testing to establish differences in the volume injected and the volume currently in the reservoir will lead to understanding leakage issues in a reservoir.[106] Any differences found will set off an alarm that the CO_2 may be leaking, potentially into the groundwater.[107]

B. Economic Feasibility and Incentive Programs

Due to the current high cost of technology, "[t]he market itself and perhaps government incentives will have to encourage the industry to seek implementation of these sequestration methods, since it currently appears as if no regulations will require them to do so."[108] Costs can potentially deter large-scale carbon sequestration from happening. "As it stands today, all of the technologies currently available are very expensive, and therefore unattractive as true industry options for reducing carbon dioxide

102. *Id.*
103. *See id.*
104. Personal communication with the manager of the International Weyburn CO_2 Monitoring Project (July 2002) (notes on file with author).
105. Chin-Fu Tsang, *supra* note 68, at 8.
106. *Id.*
107. *See id.*
108. Gregory D. Timmons & Mark A. Lindsay, *The Bush Administration and the National Energy Policy*, 22 ENERGY & MINERAL LAW FOUND. S. 1.03 (2001).

emissions."[109] Furthermore, while there is a growing interest in carbon sequestration, the accounting and measurement methods for creating a creditable and marketable commodity have not yet been developed.[110]

Costs of carbon sequestration include "capture, compression, transport and injection [of CO_2]. These costs depend on many factors, including the source [of] CO_2, transportation distance and the type and characteristics of the sequestration reservoir."[111] The first area of concern is the cost of reconfiguring power plants to concentrate CO_2 into a flue gas,[112] along with other costly separation and capture techniques. This is estimated to be seventy-five percent of the total cost of the sequestration process.[113] The costs to power plants will decrease over time with more research. The second area of concern is the cost of building a pipeline system. If carbon sequestration becomes a widespread practice, the limited existing pipeline system will be insufficient.[114] A new, expansive pipeline system will need to be constructed to deliver the captured CO_2 from large point sources to subsurface formations. Well distance from point sources, such as coal-fired power plants, is a larger constraint.[115] Studies indicate that the dirtiest power plants are primarily located in the southeast and midwest, whereas the majority of wells are located in the south-central portion of the United States.[116] It is the high cost of long-distance piping of CO_2 that makes large-scale disposal from power plants unattractive.[117] However, in areas with nearby point sources, anthropogenic CO_2-EOR projects can be completed at a substantial net profit.[118]

The effectiveness of geologic sequestration of CO_2 will depend in large part on the market for CO_2 capture and storage. Currently no incentive programs exist to reward power plant or EOR operators for supplying or using anthropogenic sources of CO_2.[119]

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109. *Id.*
110. Hayes & Gertler, *supra* note 90.
111. Herzog, *supra* note 24, at 148A.
112. Stevens & Gale, *supra* note 10.
113. Media Release, National Energy Technology Laboratory, The Carbon Capture Project: Technology Solutions for Environmental Needs (Sept. 10, 2002), *available at* http://www.netl.doe.gov/coalpower/sequestration/pubs/mediarelease/mr-091002.pdf.
114. *See* Bergman, *supra* note 27, at 211.
115. *Id.* at 211-12.
116. *Id.* at 211.
117. *Id.*
118. Stevens & Gale, *supra* note 10.
119. *Id.*

It is this type of reward program that has helped other countries, such as Norway, effectively encourage companies to utilize anthropogenic CO_2.[120] Moreover, the future supply of CO_2 will depend on demand and regulations reducing emissions, thereby driving the market for anthropogenic, as compared to naturally occurring, CO_2. Researchers are still far from reaching their target price for each ton of CO_2 sequestered: "[W]ithout a tax on carbon or continued government subsidies, industry will not likely pay for [carbon] sequestration."[121]

C. International Studies as Examples

In 2000, the Weyburn oil field in Regina, Saskatchewan, became the newest site for storing large amounts of CO_2 underground.[122] The benefit of this project is that it will provide information of a large-scale demonstration of geologic sequestration of CO_2 during EOR operations.[123] The Weyburn Monitoring Project is unique in that background information was collected before the oil field was flooded with CO_2, which will provide a before-and-after comparison.[124] This will enable a better understanding of the interaction between oil recovery and CO_2 storage.[125]

Scientists will monitor the reactions of the CO_2 with the minerals and fluids in the reservoir.[126] The Weyburn project is monitoring its wells through microseismicity and soil gas analysis.[127] Microseismicity detects small fractures and seismic events with the use of geophones placed in on-working wells and soil gas analyses to identify upward seepage of CO_2 through caprock and overburden.[128]

While data will not be released from the Weyburn study until late 2003 into 2004, it could provide valuable insight into CO_2-

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120. *Id.*

121. Brian Stempeck, *Reliability, Cost of Carbon Sinks Pose Hurdles*, GREENWIRE, June 25, 2003, *at* www.eenews.net/sample/sample_gw/06250309.htm (last visited Oct. 7, 2003).

122. IEA GREENHOUSE GAS RESEARCH AND DEVELOPMENT PROGRAMME, CO_2 FOR ENHANCED OIL RECOVERY IN WEYBURN, *at* http://www.ieagreen.org.uk/weyburn5.htm (last visited Oct. 7, 2003).

123. *Id.*

124. *See id.*

125. *Id.*

126. Personal communication with the manager of the International Weyburn CO_2 Monitoring Project (July 2002) (notes on file with the author).

127. *Id.*

128. *Id.*

EOR interactions, storage characteristics of underground geologic formations, leakage potential, and leakage control. The Weyburn Monitoring Project will also provide an analysis of the costs associated with CO_2 sequestration and the benefits of reduced levels of CO_2.[129]

The Statoil Injection Project is a good example of underground injection of CO_2. Statoil is a Norwegian oil company injecting CO_2 into a deep-sea oil reservoir, 800 meters below the bed of the North Sea, off the coast of Norway.[130] About 2,800 metric tonnes of carbon dioxide are separated daily from Statoil's Sleipner West gas production and injected into the Utsira sandstone formation rather than released to the air.[131] It is estimated that the entire carbon dioxide emissions from all the power stations in Europe could be deposited in this structure for 600 years.[132] While this project does not inject into on-land underground reservoirs, it acts as an appropriate analogy for other geologic sequestration projects.

D. Improvement of Domestic Programs

A few governmental agencies, specifically the Department of Energy (DOE), acknowledge that CO_2 emission levels are a current problem and are developing programs in order to conduct research and development of new technologies to limit carbon emissions. The DOE's National Energy Technology Laboratory (NETL) has spent millions of dollars on projects that would bring concepts to commercial "deployment" in 2010.[133] The DOE has indicated three requirements for finding carbon sequestration techniques successful. First, the techniques must be effective and cost-competitive, *i.e.*, costing ten dollars or less per net ton of carbon.[134] Second, the techniques must provide stable, long-term storage. Finally, they must be environmentally benign.[135]

In order to further develop these techniques, the DOE has funded a number of programs that research carbon sequestration. One of the more prominent programs is the GEO-SEQ project op-

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129. *Id.*
130. Herzog, *supra* note 24, at 148A.
131. STATOIL, *Carbon Dioxide Storage Prized* (Dec. 18, 2000), *at* http://www.statoil.com/statoilcom/SVG00990.NSF/UNID/01a5a730136900a3412569b90069e947Open (last visited Oct. 7, 2003).
132. *Id.*
133. Hayes & Gertler, *supra* note 90.
134. CARBON SEQUESTRATION, *supra* note 2, at 2-10.
135. *Id.*

erated by the Lawrence Berkeley National Laboratory's Earth Sciences Division.[136] The GEO-SEQ project is a partnership of government agencies, academic institutions, and private energy companies from the United States and Canada investigating carbon sequestration, specifically in geologic formations.[137] Quality programs, such as the GEO-SEQ project, need to increase in order to develop carbon sequestration techniques that will ensure safe and environmentally friendly injection of CO_2.

E. Multifarious Regulatory Involvement

The government, industry, academia, and environmental groups are researching carbon sequestration to determine whether it is a safe and effective way to reduce levels of CO_2. If carbon sequestration were to become a means by which the U.S. reduces CO_2 emissions to the atmosphere, numerous agencies would weigh in on this issue, from the Environmental Protection Agency and the Department of Energy to the U.S. Geological Survey and various transportation agencies. Coordinating a multitude of agencies with different agendas may be very difficult. The current regulatory scheme is inconsistent. There are many federal and state regulations involved, bringing local political views into play.[138] Piping CO_2 long distances from power plants will also mean that many states and many federal agencies will be involved, each with their own regulations.[139] Even if an agreement were to be reached on how to permit and regulate CO_2 sequestration in depleted oil reservoirs, it would be a difficult process to get the agreed upon regulations in place.[140]

A new agency overseeing the entire process—from capture at the power plant to injection into a reservoir to post-injection monitoring—would be necessary. This agency would be in charge of overseeing every step of the process and facilitating research on the environmental effects of large-scale injections of CO_2. A centralized system would generate accountability and facilitate implementation of a large-scale project. This means removing power from state departments that are currently in charge of under-

136. *See Storing Carbon Dioxide Underground is One Option for Mitigating Greenhouse Gases*, AScribe Newswire, Feb. 5, 2001, *at* http://www.ascribe.org (accessible by subscription only) [hereinafter *Storing Carbon Dioxide Underground*].

137. *Id.*

138. *See* Wilson, *supra* note 73.

139. *See id.*

140. *See id.*

ground injection into oil and gas reservoirs in their individual state.

VI. Environmental Effects

The principal effect of carbon sequestration on the environment is reduced levels of CO_2 in the atmosphere, which reduces greenhouse gas levels and slows global warming. However, there are negative consequences that could offset the positive effect of reduced emissions to the atmosphere. The worst-case scenario is that failed systems could increase CO_2 emissions to the atmosphere, instead of reducing them. Carbon dioxide might leak back to the atmosphere in either slow, continuous leaks or rapid, intense leaks. These leaks could result from the failure of an injection well or could occur via an unidentified migration pathway from the reservoir, such as a geological fault.[141] The likelihood of leaks could be modeled from historical natural gas storage in aquifers.[142]

Slow leakage may not be a substantial health concern unless it persists over a long period of time, during which it could release significant volumes of CO_2 back into the atmosphere.[143] Additionally, slow leakage into overlying formations may be a desirable strategy for controlling reservoir pressure and limiting long-term impacts of CO_2 sequestration.[144] Conversely, sudden large-scale releases of CO_2 could cause asphyxiation problems in humans, depending on the location of the formation.[145] However, leakage is not considered a major problem by researchers, as CO_2 is handled safely in large quantities by industry every day.[146]

Leakage into drinking water sources is another major concern. Slow leaks can remain undetected and escape into an underground drinking water source.[147] To prevent such leakage, suitable geologic formations should not contain extensive faults, human-induced fractures, or be in close proximity to underground sources of drinking water. This will become more difficult as more geologic formations are used for storage of CO_2.

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141. Holloway, *supra* note 34, at 195.
142. *Id.*
143. Knox & Hovorka, *supra* note 1.
144. Chin-Fu Tsang, *supra* note 68.
145. Herzog, *supra* note 24, at 148A.
146. *Id.*
147. *Id.*

VII. Conclusion

"Dealing with the threat of global climate change may be the most complicated scientific, technological, environmental, economic, and political challenge in history."[148] Making informed decisions will take effort from all areas of development. There is much well founded skepticism to widespread implementation of carbon sequestration. Skeptics believe carbon sequestration and other methods of reducing emissions to the atmosphere are "diversionary from the 'real' project of reducing GHG [Greenhouse Gas] emissions"[149] and "are all just gleams in somebody's eye to avoid cutting down on fossil-fuel consumption."[150] These skeptics are correct. Carbon sequestration is an "extreme option"[151] and not the cure to over-consumption or dirty power plants. Carbon sequestration is a means by which we can reduce harmful emissions to the atmosphere while the United States finds cleaner sources of energy. Furthermore, it prevents "a rapid increase in greenhouse gas emissions . . . thus reducing the need for steep, economically harmful reductions in the future."[152]

It would be most desirable to learn everything about geologic carbon sequestration before it is implemented. However, the time frame involved does not provide that luxury. As of yet, there are no guarantees that CO_2 sequestered underground will remain there or that long-term storage will be environmentally sound. It is the promise of safe underground storage of CO_2 that will determine whether the concept of carbon sequestration will gain wide political and public acceptance.[153]

The United States needs to be convinced that its excess emissions from dirty, coal-fired power plants is adding to the change in the climate worldwide. The United States has to do its part in reducing not only CO_2, but also NO_x, SO_x, and Mercury emissions. Until such time, policy makers cannot move in the direction of making carbon sequestration a reliable and safe method of reducing carbon dioxide in the atmosphere. Moreover, carbon sequestration is only a partial solution, which needs to be complemented by cleaner energy sources and reduction in overall usage. Until

148. Murkowski, *supra* note 19, at 367.
149. Hayes & Gertler, *supra* note 90.
150. Tollefson, *supra* note 18.
151. *Storing Carbon Dioxide Underground*, *supra* note 136.
152. *Prepared Testimony*, *supra* note 14.
153. *See Storing Carbon Dioxide Underground*, *supra* note 136; *See also* Stempeck, *supra* note 121.

CO_2 emissions are reduced, the world's climate will continue to shift, leaving poorer countries without the climate they expect and rely on to survive.