NATURAL RESOURCES JOURNAL

Volume 49
Issue 3 *Summer-Fall*

Summer 2009

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Recommended Citation
Adam G. Rankin, *Geologic Sequestration of CO2: How EPA's Proposal Falls Short*, 49 Nat. Resources J. 883 (2009).
Available at: https://digitalrepository.unm.edu/nrj/vol49/iss3/9

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Geologic Sequestration of CO_2: How EPA's Proposal Falls Short

ABSTRACT

Carbon capture and geologic storage has been touted as the critical bridging technology to reduce anthropogenic emissions of carbon dioxide. The scale of a carbon capture and storage (CCS) program, in terms of land area and storage time, necessary to achieve significant emissions reductions demands a unique statutory and regulatory paradigm to ensure a safe and timely transition from fossil fuels. Deterrents to sequestration are primarily an uncertain legal framework and unconstrained operator liability, as well as environmental concerns. The U.S. Environmental Protection Agency is proposing to regulate CCS under a modified rule of the Safe Drinking Water Act's Underground Injection Control program. This approach falls short of the comprehensive scheme necessary. It fails to address long-term environmental and financial liabilities unique to CCS and fails to take into account how existing laws and regulations may impede CCS development. This article recommends that CCS be exempted from key federal environmental statutes and regulations and that a wholly unique statutory and regulatory framework be developed as part of a broader effort to curb climate change. Such a framework would limit the long-term liability of injectors to encourage development while offering greater protections for the public and environment against loss and impairment during the highest-risk phases of CCS.

I. INTRODUCTION

Mankind's continued reliance on fossil fuels as a primary energy source cannot continue unabated without significant, possibly irreversible impacts to climate function and ecological health.[1] Average global

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1. *See generally* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, FOURTH ASSESSMENT REPORT, CLIMATE CHANGE 2007, SUMMARY FOR POLICYMAKERS (2007) [hereinafter IPCC FOURTH SUMMARY]; *see also* NICHOLAS STERN, STERN REVIEW: THE ECONOMICS OF CLIMATE CHANGE, EXECUTIVE SUMMARY i–iii (2006) (noting that "climate change presents very serious global risks, and it demands an urgent global response" and that "[t]he scientific evidence

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surface temperatures have increased 0.74°C since 1901,[2] with most of the warming having occurred in the last half century.[3] Carbon dioxide (CO_2) is likely the primary driver of that warming and, consequently, is considered the most important anthropogenic greenhouse gas; its annual global emissions, for instance, have increased from 1970 to 2004 by about 80 percent or from 21 gigatons (Gt) to 38 Gt per year.[4] As a result, global concentrations of CO_2 have increased from a pre-industrial level of 270 parts per million (ppm) to 379 ppm in 2005—a 40 percent increase—and now far exceed the natural range of atmospheric concentrations that have been measured over the last 650,000 years.[5]

If CO_2 is the most important anthropogenic greenhouse gas, coal is its most important source. Coal represents the largest supply of conventional fossil fuels, exceeding combined reserves of oil and gas,[6] and is widely and evenly distributed around the world among developed and developing countries.[7] Approximately 50 percent of the electricity generated in the United States is derived from coal, accounting for roughly 1.5 billion tons of CO_2 emissions each year.[8] Coal and coal-based energy is also relatively cheap,[9] and widely used. Many scientists and policymakers believe that the only way to realize significant reductions in CO_2 emissions, therefore, is to phase out coal power altogether and/or to cap-

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points to increasing risks of serious, irreversible impacts from climate change associated with business-as-usual (BAU) paths for emissions").

2. IPCC Fourth Summary, *supra* note 1, at Topic 1.1, p.1.

3. Intergovernmental Panel on Climate Change, Fourth Assessment Report, Climate Change 2007 (2007) [hereinafter IPCC Fourth Full Report], at Topic 1.1, p.30 (noting that "[t]he linear warming trend over the 50 years from 1956 to 2005 (0.13 [0.10 to 0.16]°C per decade) is nearly twice that for the 100 years from 1906 to 2005").

4. IPCC Fourth Summary, *supra* note 1, at Topic 2.1, fig.SPM.3, p.5.

5. IPPC Fourth Summary, *supra* note 1, at Topic 2.2, p.5.

6. James Hansen et al., *Target Atmospheric CO_2: Where Should Humanity Aim?*, 2 The Open Atmospheric Science J. 217, 226 (2008); *see also* Granger Morgan et al., Pew Center on Global Climate Change, The U.S. Electric Power Sector and Climate Change Mitigation iii–iv (2005).

7. M.I.T., The Future of Coal: Options for a Carbon Constrained World 5 (2007) [hereinafter MIT]; *see also* Morgan et al., *supra* note 6, at 3 (noting that coal accounts for 51.2 percent of electric power generated in the United States).

8. MIT, *supra* note 7, Executive Summary, at ix (2007); *see* Morgan et al., *supra* note 6, at 3 (total CO_2 emissions from electric power in the United States is about 2.2 Gt per year).

9. MIT, *supra* note 7, at 5 ("[Coal] is the lowest-cost fossil source for base-load electricity generation.").

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ture and geologically sequester CO_2 emissions from coal-fired generators and other stationary sources for permanent subsurface storage.[10]

While a complete phaseout of coal-fired power plants may be ultimately necessary to fully arrest, if not reverse, increasing carbon emission trends, it will have to be accomplished over time as a new portfolio of energy sources can be brought online. Given current rates of anthropogenic greenhouse gas emissions, projected energy demand,[11] and anticipated climate warming, however, it would be imprudent to wait for an uncertain transition to alternative energy sources to achieve the emissions reductions necessary to avoid catastrophic or irreversible climate change. Estimates of CO_2 emissions from the electric power sector alone are projected to increase at least 85 percent from 2.2 Gt a year to about 4.2 Gt a year by 2050, but are more likely to increase 130 percent to 5.2 Gt a year.[12] If this projected trend is to be avoided, something must be done in the immediate interim to offset emissions resulting from the world's ravenous appetite for energy.[13]

Among the many proposals to reduce greenhouse gas emissions, carbon capture and storage (CCS) offers a realistic opportunity to go beyond merely offsetting projected increases in carbon emissions to actually *reducing* current concentrations of atmospheric CO_2 by a significant margin. Unlike most climate mitigation proposals, CCS could actually reduce current carbon emissions, not just replace carbon energy sources with non-carbon alternatives. Aside from nuclear power, CCS is also nearest to being ready for full-scale, commercial deployment. A recent MIT study announced that "no knowledge gaps today appear to cast doubt on the fundamental likelihood of the feasibility of CCS."[14] It is also the only proposed technology that would reduce carbon emissions from coal, which is projected to be the dominant energy source for the next half century and the fossil-fuel source that emits the highest concentration of CO_2. For these reasons, CCS has been called "the only credible

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10. Hansen et al., *supra* note 6; Morgan et al., *supra* note 6, at 63 (noting that "substantial reductions in CO_2 emissions from the electric power sector will be very difficult to achieve without significant use of technologies for carbon capture and sequestration").

11. Electricity demand in 2000 was roughly 2,500 kilowatt-hours (kWh); based on a linear projection of demand growth, which is what demand has hued to since 1950, electricity demand in 2050 will be about 6,400 kWh, an increase of roughly 160 percent. Morgan et al., *supra* note 6, at 57 fig.21.

12. Morgan et al., *supra* note 6, at 59.

13. *See* Stern, *supra* note 1, Executive Summary, at i ("[W]hat we do in the next 10 or 20 years can have a profound effect on the climate in the second half of this century and in the next.").

14. MIT, *supra* note 7, at 44.

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option that would allow the continued use of fossil energy without the threat of dangerously altering Earth's climate system."[15]

CCS technologies, however, remain unproven on a very large scale. "The primary obstacles to widespread use of carbon capture and sequestration are likely to be non-technical," including unanswered questions of cost and reliability,[16] as well as long-term liability.[17] CCS also poses some unique environmental concerns, including the risk of CO_2 leakage into non-target subsurface strata and the atmosphere.[18] Therefore, regulation of CCS requires a robust environmental statutory and regulatory framework capable of instilling confidence in the public that the technology is safe and effective, and certainty in the private sector by means of clear performance levels and liability limits. Without a robust regulatory paradigm that achieves these goals it is unlikely that a meaningful implementation of CCS will occur.

Carbon capture and storage requires the physical separation of CO_2 from industrial and energy-related emissions sources, transport to a suitable subsurface storage location, and injection into geologic strata that have the capacity to safely store large volumes of pressurized carbon.[19] Injection involves technologies similar to those currently employed in the oil and gas industry and for the injection and disposal of oil-field wastes.[20] Suitable geologic formations for long-term CO_2 storage include depleted oil and gas fields, unminable coal beds, and deep saline water formations that have a naturally occurring cap rock or trapping mechanism sufficient to contain injected CO_2.[21] While injection of carbon dioxide has been practiced for years in the context of enhanced oil recov-

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15. Editorial, *Capturing Carbon*, 442 Nature 601, 602 (2006), *available at* http://www.nature.com/nature/journal/v442/n7103/full/442601b.html.

16. Morgan et al., *supra* note 6, at 70, 74 (noting that CCS is "likely affordable and technically feasible"); *see also* Intergovernmental Panel on Climate Change, Special Report: Carbon Capture and Storage, Summary for Policymakers 12 (2005) [hereinafter IPCC Special Report].

17. *See, e.g.*, Larry Nettles & Mary Conner, *Carbon Dioxide Sequestration—Transportation, Storage, and other Infrastructure Issues*, 4 Tex. J. Oil, Gas & Energy 27, 29–30 (2008–09); Elizabeth Wilson et al., World Resources Institute, Liability and Financial Responsibility Frameworks for Carbon Capture and Sequestration 1 (2007).

18. *See, e.g.*, Emily Rochon et al., Greenpeace, False Hope: Why Carbon Capture and Storage Won't Save the Climate 6–7 (2008); IPCC Special Report, *supra* note 16, at 12.

19. IPCC Special Report, *supra* note 16, at 3; Wilson et al., *supra* note 17.

20. Intergovernmental Panel on Climate Change, Special Report: Carbon Capture and Storage (2005) [hereinafter IPCC Special Report Full Report], ch.1, p.60 ("Injection of CO_2 underground would involve similar technology to that employed by the oil and gas industry[.]").

21. *Id.* "Generally, injected CO_2 will be less dense than the subsurface waters found in the site's geologic formation, and will have a tendency to migrate upwards and laterally

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ery, it has never been employed on the scale contemplated for a successful climate mitigation program. At full scale, unique—but manageable—environmental issues arise, such as possible leakage into drinking water sources or saline displacement into fresh groundwater sources, induced seismicity, and other surface and near-surface impacts that have never before been addressed by any regulatory paradigm.[22]

The primary adverse environmental impacts that might arise from CCS result from the unwanted migration of carbon out of the target geologic reservoir or area of containment.[23] While CO_2 is not categorized as a hazardous substance, a sudden, catastrophic release of a large volume of CO_2 into the air through a faulty injection well, an abandoned well, or some other rapid system failure, could pose a substantial danger to human life and health if ambient air concentrations exceed 710 percent CO_2 by volume.[24] Gradual leaks into the subsurface through undetected faults, fractures, or perforating wells could kill vegetation and sub-soil animals and contaminate groundwater.[25] "[C]onsiderable uncertainty" remains regarding the potential damages to local ecosystems from CO_2 seepage "but it is known that relatively large releases from natural CO_2 reservoirs can inflict measurable damage."[26] Nonetheless, with appropriate site selection, monitoring and a robust regulatory system, the local health, safety and environmental risks of geological storage of CO_2 "would be comparable to the risks of current activities such as natural gas storage, [enhanced oil recovery] and deep underground disposal of acid gas."[27] To achieve this level of control over environmental and safety risks, CCS regulations must be applicable to a broad range of potential environmental impacts and property interests.[28] But as the IPCC noted in its report on CCS, there is a "lack of regulations that are specifically relevant for CO_2 storage and [a] lack of clarity relating to post-injection responsibilities."[29]

within the formation, making an effective trapping mechanism a key component of minimizing leakage." WILSON ET AL., *supra* note 17.

22. *See generally* WILSON ET AL., *supra* note 17.

23. *See* WILSON ET AL., *supra* note 17, at 3 (recognizing "four distinct areas that may yield liability including: (1) CO_2 leakage to the surface; (2) groundwater contamination; (3) hydrocarbon damage [impacts to existing mineral rights]; and (4) geological hazards."

24. IPCC SPECIAL REPORT, *supra* note 16, at 12.

25. *Id.* at 13.

26. IPCC SPECIAL REPORT FULL REPORT, *supra* note 20, ch.1, at 63.

27. IPCC SPECIAL REPORT, *supra* note 16, at 12–13.

28. "Injected CO_2 is likely to spread over a large subsurface area . . . implicating pre-existing mineral rights, water rights, and surface owner claims." WILSON ET AL., *supra* note 17, at 2 (citations omitted).

29. IPCC SPECIAL REPORT FULL REPORT, *supra* note 20, ch.5, at 255.

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Critics of CCS argue that leakage to the atmosphere will limit the technology's effectiveness, but unless leakage rates are substantially greater than 1 percent, leakage will not pose a barrier to achieving significant emissions reductions in the near term.[30] As a recent IPCC report on CCS indicated, appropriately selected and managed geologic reservoirs will "very likely" retain more than 99 percent of stored CO_2 over 100 years, and will "likely" retain more than 99 percent of stored CO_2 for the first 1,000 years.[31]

Because of inherent uncertainties, such as leakage, CCS must be employed only as a bridging technology to allow timely transition away from fossil fuels and not as a permanent solution to enable the indefinite use of coal and fossil fuels. With all criticisms of CCS fairly considered, however, it is important to realize that "deep cuts in CO_2 emissions from the electricity sector will be very difficult to achieve over the next 50 years without significant use of technologies for carbon capture and sequestration."[32]

This article is not intended to champion the cause of CCS, so does not fully weigh its pros and cons. Rather, recognizing the technology's viability and the primary impediments to its implementation, this article sets out to propose a rough framework for developing a workable statu-

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30. The largest sequestration project in the world has been injecting about one million tons of CO_2 per year since 1996 with no leakage yet detected. INT'L ENERGY AGENCY, PROSPECTS FOR CO_2 CAPTURE AND STORAGE 90 (2004) [hereinafter IEA PROSPECTS] ("So far, results suggest that there is no leakage and CO_2 storage is technically feasible."). Further, at the current rate of global CO_2 emissions from all sources (about 38 Gt a year) it would take about 16 years to accumulate that much CO_2 in subsurface storage *if* sequestration were capturing *all* CO_2 from *all* emissions sources in the world starting now. That is to say, a 1 percent leakage rate might indeed be a problem 20 years from now if all CO_2 emission sources can be sequestered. A much more likely scenario, however, is that only a small fraction of CO_2 emissions will be captured; emissions will probably only be captured from large stationary sources, such as industrial plants and electric generation facilities. If all CO_2 emissions from electric generation—approximately nine Gt a year—could be sequestered every year, it would take between 67 and 100 years to inject 600 Gt into the subsurface. By all accounts, that is an overly optimistic estimate. The International Energy Agency (IEA) projects that if "ambitious CO_2 policies are introduced" between five and 19 gigatons of CO_2 can be sequestered by 2050. *Id*. at 145. Assuming a 1 percent leakage rate for IEA's projected pool of stored CO_2, the annual global loss of CO_2 from the subsurface would amount to a volume of between 50 megatons and 190 megatons of CO_2 per year, which is a tiny fraction—0.001–0.005—of the current annual global output of 38 Gt. A leakage volume of between 50–190 megatons would be a drop in the global bucket of carbon emissions, even if emissions are significantly reduced from the 38 Gt volume by that time.

31. IPCC SPECIAL REPORT FULL REPORT, *supra* note 20, at 246.

32. MORGAN ET AL., *supra* note 6, at 70; Howard J. Herzog, *What Future for Carbon Capture and Sequestration?*, 35(7) ENVT'L SCIENCE & TECH. 148, 153 (Apr. 1, 2001) ("Carbon capture and sequestration are not an alternative to better energy efficiency or increased use of noncarbon energy sources.").

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tory and regulatory scheme that is environmentally protective but that also constrains CCS liability. Given the importance of CCS technologies in achieving emissions reductions, its potential environmental impacts, and remaining uncertainties, CCS, if it is to be employed, must be accompanied by a robust legal framework that has the flexibility, capacity, and authority to address a broad range of impacts and concerns. While some have argued generally that existing federal and state legal regimes are adequate for CCS,[33] this article contends that the current regulatory regime is insufficient and critiques the U.S. Environmental Protection Agency's (EPA) approach to addressing CCS.

This article lays out a rough legal framework that serves to encourage CCS development, while offering increased environmental protections relative to EPA's proposal. The history and background of CCS is discussed in Part II, which specifically reviews the development of CCS technologies and current roadblocks to its commercial deployment. Part III introduces EPA's proposed regulatory changes to the Underground Injection Control program (UIC) to address CCS; Part III.A provides background on the development and purpose of the UIC; Part III.B describes EPA's proposed regulations. Part IV evaluates the shortcomings of EPA's proposed rule; Part IV.A discusses the applicability of other environmental laws and regulations to CCS; Part IV.B discusses financial assurance provisions in EPA's proposal; Part IV.C reviews transferability of CCS liability under EPA's proposal. Part V investigates general liabilities facing CCS operators; Part V.A introduces methods for managing CCS liability through analogous liability models; Part V.B proposes legislative methods to limit liability. Part VI details statutory and regulatory recommendations for a comprehensive carbon management scheme and Part VII concludes that for climate change mitigation to be successful in the near term, liabilities facing CCS must be constrained to encourage its development.

II. CARBON CAPTURE & STORAGE

Significant storage capacity for anthropogenic CO_2 has been identified within the crustal voids, unminable coal seams, and saline waters buried deep within the earth's sedimentary basins, often more than a mile underground. Published estimates of the earth's total geologic capacity for CO_2 storage range as high as 200,000 Gt.[34] Total U.S. capacity

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33. *See, e.g.*, Larry Nettle & Mary Conner, *Carbon Dioxide Sequestration—Transportation, Storage, and Other Infrastructure Issues*, 4 TEX. J. OIL, GAS & ENERGY L. 27 (2008–2009).

34. MIT, *supra* note 7, at 46 fig.4.2.

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has been estimated to be as high as 3,700 Gt.[35] To put those figures into context, total U.S. emissions of CO_2 from coal-fired power plants is about 1.5 Gt a year;[36] total global emissions of CO_2 from coal is about 9 Gt per year.[37] All that capacity for carbon dioxide—enough to hold hundreds, even thousands or tens of thousands of years of emissions—is going to be needed if significant near-term cuts in greenhouse gas emissions are to be realized.

To maintain current atmospheric concentrations of CO_2, emissions must be reduced by 50–85 percent below 2000 levels by 2050.[38] Even if such cuts are achieved, average global air temperatures at the earth's surface are still expected to increase 2°C to 2.4°C[39] by 2150 as a result of delayed feedback from already-emitted greenhouse gases.[40]

As a consequence of this increasingly likely future, scientists, environmental groups, and others have applied increasing pressure to policymakers and leaders of industrialized nations—the largest emitters of greenhouse gases—to work together to amend their fossil-fuel ways. But to achieve meaningful, long-term reductions in emissions requires a radical shift away from fossil-fuel economies, a move that likely cannot be accomplished in the short term even though deep emission cuts—as much as 80 percent below 2000 levels—are required now to avoid possible irreversible ecosystem impacts and limit warming to less than 3°C.[41] A shift by developed countries away from fossil fuels is especially important when considering the growing climate impact from developing countries; they are expected to soon usurp industrialized nations as the largest emitters of greenhouse gases do not have the resources to implement more costly carbonless energy regimes. With successful implementation in industrialized nations, feasible non-carbon alternatives could be instituted more easily in developing nations with little disruption to regional or global economies,[42] but time and a commitment to transition are critical to making this happen.

The problem is how to buy the time necessary to implement a new energy regime without undue economic disruption and without al-

35. *Id.*; *see also* Philip M. Marston & Patricia A. Moore, *From EOR to CCS: The Evolving Legal and Regulatory Framework for Carbon Capture and Storage*, 29 Energy L.J. 421, 438 (2008) (quoting Dep't of Energy (DOE) estimates for U.S. storage capacity of between 1,158–3,644 Gt).

36. MIT, *supra* note 7, Executive Summary, at ix.

37. *Id.* at 43 (applying a conversion factor of 3.6 to convert tons of C to tons of CO_2).

38. IPCC Fourth Full Report, *supra* note 3, Topic 5, p.67, tbl.5.1.

39. *Id.*

40. *Id.*

41. *Id.*

42. *See generally* Morgan et al., *supra* note 6.

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lowing ballooning emissions from developing nations to sink the world in a carbon hole so deep that climate change and its ecological impacts become irreversible. One answer is CCS. To critics, the concept is anathema,[43] as if tucking carbon dioxide into mile-deep saline reservoirs is akin to sweeping our most odious environmental problems under a rug without bothering to properly dispose of the mess, because it allows the current carbon-based regime to motor on without a commitment to change and detracts from possible advances toward a carbonless energy regime.[44] More and more, however, scientists and policymakers view sequestration as a critical bridge in the transition between energy regimes.

The IPCC concluded in a 2005 report that CCS is likely to be a highly successful means of preventing anthropogenically produced CO_2 from contributing to climate change for long timescales.[45] More recently, a 2007 Massachusetts Institute of Technology (MIT) report concluded that "CO_2 capture and sequestration is the *critical* enabling technology that would reduce CO_2 emissions significantly. . . ."[46] Environmental groups like the Natural Resources Defense Council now advocate against approving additional coal-fired power plants without also requiring that they employ CCS technologies.[47] And yet CCS projects have been slow to develop; not one commercial-scale project is in operation

43. *See, e.g.*, ROCHON ET AL., *supra* note 18, at 7 ("Spending money on CCS is diverting urgent funding away from renewable energy solutions for the climate crisis."); Gabrielle Wong-Parodi et al., *Environmental Non-Government Organizations' Perceptions of Geologic Sequestration*, 3 ENVT'L RES. LETTERS 1, 3–4 (2008) (noting that "negatively inclined interviewees described [CCS] as 'terrible' or 'not a good thing,'" and classifying a group of NGOs as opponents "who view geologic sequestration negatively and that it was unnecessary," and further noting that opponents see CCS as a way to prolong fossil-fuel extraction, "continuing an unsustainable energy infrastructure."); *but see id.* at 2 ("Little research has been done, however, to understand what NGOs' views are of these [CCS] technologies, or if and how they plan to share them with the public.").

44. It should be noted that research to date suggests that CCS is generally seen among U.S. environmental groups as an acceptable mitigation strategy, preferred, for instance, over increased nuclear energy and even terrestrial sequestration. *See* Wong-Parodi et al., *supra* note 43, at 7 ("Overall it seems that the majority of US environmental NGOs will accept CCS with Geologic sequestration as a mitigation solution, while only a small fraction will not.").

45. IPCC SPECIAL REPORT, *supra* note 16, at 14 (finding that "[o]bservations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geologic reservoirs is very likely to exceed 99 percent over 100 years and is likely to exceed 99 percent over 1,000 years").

46. MIT, *supra* note 7, Executive Summary, at x (emphasis added).

47. DAVID HAWKINS & GEORGE PERIDAS, NO TIME LIKE THE PRESENT: NRDC'S RESPONSE TO MIT'S 'FUTURE OF COAL' REPORT 1 (2007); Herzog, *supra* note 32, at 148 (noting that in 1998 about 43 megatons of CO_2 were injected at 67 commercial enhanced oil recovery projects in the United States).

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worldwide and only one pilot project is injecting CO_2 in volumes of about one megaton a year.

The paucity of significant projects is not because CCS is technically difficult or outrageously expensive. Techniques employed in carbon sequestration are well understood—more than 50 million tons of CO_2 are successfully injected in the oil patch through 6,100 active injection wells every year in the United States alone through enhanced oil recovery (EOR) projects.[48] Cumulatively, EOR operations have injected more than 600 million metric tons of CO_2 into the subsurface since 1972.[49] Approximately 50 percent of that volume cannot be recovered for future EOR activities and so remains in the subsurface formations.[50] Impediments to a large-scale commercial sequestration project are not technical, rather legal barriers and unconstrained liability function together as the primary deterrents to commercial development of sequestration.[51]

Beginning in the early 1990s, scientists and engineers began taking an interest in CO_2 injection as a possible method of climate change mitigation.[52] U.S. government investment in CCS started slowly. Prior to 1998, the annual U.S. budget for CCS was between $1 and $2 million, but by 2001 the budget had increased to $38 million.[53] The Energy Independence and Security Act of 2007 authorized a significant increase in CCS spending.[54] In 2008, Congress authorized $36 million for 15 projects aimed at furthering development of CCS technologies.[55]

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48. Marston & Moore, *supra* note 35, at 423 (noting that 50 million metric tons is "roughly equivalent to the amount of CO_2 that might be captured from the first twenty newly constructed 500 MW coal-fired power plants that capture eighty percent of their CO_2 output"); *see also* HAWKINS & PERIDAS, *supra* note 47, at 4; MIT, *supra* note 7, at 43.

49. Marston & Moore, *supra* note 35, at 423.

50. *Id.*

51. Nettles & Conner, *supra* note 17, at 47 ("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.").

52. Herzog, *supra* note 32, at 148.

53. *Id.* at 150.

54. Energy Independence and Security Act of 2007, H.R. 6, 110th Cong. §§ 703, 711 (providing $200 million per year for fiscal years 2009 through 2013 for CCS demonstration projects and $30 million a year for years 2008 through 2012 for geologic capacity research); *see generally* PETER FOLGER, CONGRESSIONAL RESEARCH SERVICE REPORT FOR CONGRESS, CARBON CAPTURE AND SEQUESTRATION (CCS) (updated Feb. 7, 2008), *available at* http://opencrs.com/document/RL33801/2008-02-07/.

55. U.S. DOE, Press Release, 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.

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Spending on CCS has ramped up as it has become more apparent that a solution to atmospheric warming may lie underground. Estimates from the U.S. Department of Energy and the International Energy Agency (IEA) suggest that the United States may have storage capacity for "a thousand years of CO_2 emissions from nearly 1,000 coal-fired power plants."[56]

EPA's analysis of recent legislative proposals relating to climate change "indicate[s] that CCS has the potential to play a significant role in climate change mitigation scenarios."[57] For example, EPA estimates that CCS could account for 30 percent of CO_2 emissions reductions in 2050 under the Lieberman-Warner bill, S. 2191.[58]

For CCS to be an effective mitigation option, however, it must be deployed on a grand scale. Under a rough assumption of CO_2 density at depth, the IEA has estimated that a 500-megawatt power plant storing three megatons of CO_2 per year would require six square kilometers of aquifer storage per year.[59] Over the plant's lifespan of about 40 years, required storage would occupy about 240-square kilometers or roughly 93-square miles.[60] Storage of 16 Gt of CO_2 per year—about 1.8 times the current volume of global CO_2 emissions from coal—could require an area of about 40,000-square kilometers or about 1,550-square miles, a massive area.[61] Beyond the enormous storage areas required to achieve CCS climate mitigation goals, other projections of what full commercial deployment of CCS would look like suggest the immense scale of such an undertaking. If all the CO_2 emitted from U.S. coal-burning plants were captured, the quantity of that gas would be "equivalent to three times the weight and . . . one-third of the annual volume of natural gas transported by the U.S. gas pipeline system."[62] If only 60 percent of this CO_2 were "compressed to a liquid for geologic sequestration, its volume would about equal the total U.S. oil consumption of 20 million barrels per day."[63] These figures are of particular significance because while the earth's subsurface has a significant storage capacity, storage sites "are

56. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,492, 43,496 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

57. *Id.*

58. *Id.* (citing U.S. EPA, Climate Change—Climate Economics, http://www.epa.gov/climatechange/economics/economicanalyses.html.)

59. IEA PROSPECTS, *supra* note 30, at 92 (assuming a CO_2 storage depth of about three meters at a density of 0.5 tons of CO_2 per cubic meter). R

60. *Id.*

61. *Id.*

62. MIT, *supra* note 7, Executive Summary, at ix. R

63. *Id.*

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not spread evenly across and within all regions," meaning that either a significant transportation infrastructure must be developed to move CO_2 to injection zones, or power plants and industrial facilities that emit CO_2 will have to be relocated over time to regions where CCS is viable.[64]

Despite these challenges, interest in CCS has accelerated in recent years in response to the technology's increasing feasibility.[65] Nonetheless, no commercial projects have been initiated to date and only a few research-scale pilot projects have been undertaken worldwide. A significant reason for this slow development is the lack of a clear legal and regulatory framework.[66] Many current projects are regulated on a case-by-case basis, creating uncertainty and confusion about property rights and long-term environmental and financial liability. This uncertainty is especially problematic during the post-injection phase of projects,[67] which can endure for hundreds, even thousands of years until the injected CO_2 has stabilized. Commentators have argued that it is necessary to create a legal framework that resolves these legal uncertainties for CCS to be advanced on a scale that would be required to effectively reduce carbon emissions.[68] To date, however, no federal statutes or regulations address the unique nature of CCS, though several states have flirted with creating a comprehensive regulatory framework.[69] Further,

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64. IEA PROSPECTS, *supra* note 30, at 92. R

65. *See* NATIONAL ENERGY TECHNOLOGY LABORATORY, INTERNATIONAL CARBON CAPTURE AND STORAGE PROJECTS: OVERCOMING LEGAL BARRIERS 5 (2006) [hereinafter NETL LEGAL BARRIERS].

66. *See* INTERSTATE OIL AND GAS COMPACT COMMISSION, CARBON CAPTURE AND STORAGE: A REGULATORY FRAMEWORK FOR STATES, SUMMARY OF RECOMMENDATIONS 5 (2005); NEW MEXICO ENERGY, MINERALS, AND NATURAL RESOURCES DEP'T, OIL CONSERVATION DIV., CARBON DIOXIDE SEQUESTRATION: REPORT ON IDENTIFIED STATUTORY AND REGULATORY ISSUES: A BLUEPRINT FOR THE REGULATION OF GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE IN NEW MEXICO (2007) [hereinafter NEW MEXICO CCS]; DEP'T OF ENERGY, NAT'L ENERGY TECH. LAB., INTERNATIONAL CARBON CAPTURE AND STORAGE PROJECTS OVERCOMING LEGAL BARRIERS 1 (2006); ROCHON ET AL., *supra* note 18, at 7. R

67. *See* NETL LEGAL BARRIERS, *supra* note 65, at 5–6. R

68. *See, e.g.*, *id.*

69. In 2008, 31 states were considering legislation addressing CCS. COURTNEY WELCH, NATIONAL CONFERENCE OF STATE LEGISLATURES, MEMORANDUM ON CARBON CAPTURE AND SEQUESTRATION LEGISLATION 1 (2008). For example, Wyoming passed a law to clarify ownership of subsurface pore space in anticipation of CCS. *See* WYO. STAT.1977 § 34-1-152 (2008) (declaring ownership of subsurface pore space belongs to the surface owner). Other states have proposed legislation that has not passed, or have conducted extensive studies of what is required to implement CCS. *See* NEW MEXICO CCS, *supra* note 66; ELIZABETH A. BURTON ET AL., CALIFORNIA ENERGY COMMISSION, NO. CEC-500-2007-100-CMF, GEOLOGIC CARBON SEQUESTRATION STRATEGIES FOR CALIFORNIA: REPORT TO THE LEGISLATURE (2008), www.energy.ca.gov/2007publications/CEC-500-2007-100/CEC-500-2007-100-CMF.PDF. No state has addressed long-term liability and no state action can ameliorate the questions regarding federal environment liabilities. R

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industry representatives argue that under current law, CCS projects "may face excessive liability" and regulatory control, creating "[l]egal uncertainty, undue restrictions and liability [that] could discourage the development and deployment" of CCS.[70]

In partial response to these legal shortcomings and to address gaps in regulations as the number of pilot projects increase, EPA has issued a proposed UIC rule specific to CCS.[71] But while EPA acknowledges that the unique factors inherent to CCS require specific and unique regulations, the proposal focuses on only the injection phase, site closure, and protection of drinking water sources. In doing so, the proposal falls far short of a comprehensive statutory and regulatory paradigm that is necessary to provide the adequate guidance carbon injectors need. EPA acknowledges that "regulatory certainty" is needed to foster industry adoption of CCS,[72] but the proposed rule provides only a sliver of the certainty required. As commentators have emphasized, "a clumsy regulatory approach could seriously impede or even eliminate further development of this promising mitigation option."[73] To avoid such an outcome, the federal government should develop a comprehensive and integrated approach to addressing climate change. Regulation of CCS would be but a part of such a scheme.

III. EPA'S PROPOSED REGULATORY CHANGES TO UIC

Recognizing "the unique nature of CO_2 injection for [geological sequestration]," EPA proposed in July 2008 to create a new category of injection wells under the existing Underground Injection Control (UIC) Program of the Safe Drinking Water Act "to allow for permitting of the injection of CO_2 for the purpose of [geologic sequestration]."[74] The proposed rule applies to "owners and operators of wells that will be used to inject CO_2 into the subsurface for the purpose of long-term storage."[75] It essentially proposes the creation of a new class of injection well—Class VI—under the UIC program with minimum technical criteria for the characterization of the injection-site geology, fluid movement, area of re-

70. Jeffrey W. Moore, *The Potential Law of On-Shore Geologic Sequestration of CO_2 Captured From Coal-Fired Power Plants*, 28 Energy L.J. 443, 443, 447 (2007).

71. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,495 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

72. *Id.* at 43,496.

73. Morgan et al., *supra* note 6, at 70.

74. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,492, 43,495 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

75. *Id.* at 43,492.

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view and corrective action, well construction, operations, integrity testing, monitoring, well plugging, post-injection site care, and site closure, all with the "purpose[ ] of protecting underground sources of drinking water [ ]."[76] As EPA makes clear, the proposed regulations rely heavily on the preexisting regulatory framework of the UIC, but is tailored "so that they are appropriate for the unique nature of injecting large volumes of CO_2 into a variety of geological formations," and again, with the principal goal being the protection of underground sources of drinking water.[77] The proposed rule's chief benefit is that it will promote consistency in permitting CCS projects across the United States and consistency in reviewing criteria for each proposed injection project.[78] Given the limitations inherent in the authority granted by the Safe Drinking Water Act, however, EPA's proposed rule under the UIC does not address the most critical gaps responsible for the bulk of the uncertainty currently impeding CCS development: Subsurface property rights and a long-term liability scheme.[79]

A. UIC Background

The Safe Drinking Water Act (SDWA)[80] was enacted in 1974 and directed EPA to set and maintain health-based standards for contaminants in drinking water sources.[81] The UIC regulatory program[82] was implemented under the authority of Part C of the SDWA in 1980.[83] The program now manages more than 800,000 injection wells nationwide.[84] Primacy for state implementation of the program has been delegated to 34 states.[85] The UIC regulations were "designed to prevent fluid movement into [underground sources of drinking water] by addressing the

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76. *Id.*

77. *Id.* at 43,495.

78. *Id.*

79. EPA expressly acknowledges this shortcoming of the proposed rule. *See* Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,495 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

80. 42 U.S.C. § 300(f)–(j) (2000).

81. *See* 42 U.S.C. § 300(g-1) (2000).

82. 40 C.F.R. §§ 144–49 (2008).

83. U.S. EPA, History of the UIC Program—Injection Well Time Line, http://www.epa.gov/safewater/uic/history.html (last visited Mar. 29, 2009).

84. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,498 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

85. *See* U.S. EPA, UIC Program Primacy, http://www.epa.gov/safewater/uic/primacy.html (last visited Mar. 29, 2009).

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potential pathways through which injected fluids can migrate into [underground sources of drinking water]."[86]

To accomplish its goals, the UIC classifies injection wells into five classes or well types each with similar functions, construction and operating features so the minimum technical requirements can be applied consistently across each well category.[87] Class I wells inject hazardous and non-hazardous fluids, both industrial and municipal wastes, into isolated formations beneath the lowermost underground source of drinking water. Because Class I wells include injection of hazardous wastes, they are the most strictly regulated under the UIC program and are further regulated under the Resource Conservation and Recovery Act (RCRA).[88] For example, operators of Class I wells must demonstrate that hazardous fluids injected into the substrata will not migrate from the identified injection zone for as long as the fluids remain hazardous.[89] Furthermore, Class I well operators must continuously monitor the injection well, the fluid within the well, and any possible migration out of the target injection zone.

Each of the broad regulatory components of the UIC—siting, area of review and corrective action, well construction, operation, mechanical integrity testing of the well during operation, injection monitoring, well-plugging and post-injection site care, and closure—is principally aimed at protecting groundwater sources. Siting requirements, for example, ensure that wells inject fluids into geologic strata or zones that are capable of storing the particular fluid and that the target zone is below a confining strata that is free of known faults or fractures that could allow upward migration of the injected fluid, potentially endangering underground sources of drinking water.[90] The UIC also requires an in-depth examination of the vertical and horizontal extent of the area that will be influenced by the injection and the identification of all artificial penetrations, such as wells, that may act as conduits for fluid movement into underground sources of drinking water. For perforations that need

86. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,498 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

87. *See* 40 C.F.R. § 144.6 (2008); U.S. EPA, Classes of Wells, http://www.epa.gov/safewater/uic/wells.html (last visited Mar. 29, 2009).

88. *See* 40 C.F.R. § 144.14 (2008) (requirements for wells injecting hazardous waste); U.S. EPA, Industrial & Municipal Waste Disposal Wells (Class I), http://www.epa.gov/safewater/uic/wells_class1.html (last visited Mar. 29, 2009).

89. 40 C.F.R. § 144.12 (2008).

90. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,498–99 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

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repairing, the UIC requires the injector to perform corrective action to ensure they are properly sealed.[91] In addition to having to periodically demonstrate the mechanical integrity of injection wells, injectors must also monitor the injected fluid to verify its location and to demonstrate that injected fluids are confined to intended geologic storage zones.[92] Upon completion of injection, the UIC requires that injection wells be adequately plugged to prevent their serving as conduits for future migration of injected fluids and that the fluids in the injection zone do not endanger underground sources of drinking water.[93]

B. EPA's Preferred Alternative[94]

Under EPA's proposal, the basic components of the UIC regulatory scheme remain intact, but are tailored through a new class of injection wells—Class VI—that addresses unique factors inherent in CCS, such as the large volumes of CO_2, long-term storage, the buoyant and viscous nature of CO_2 as a supercritical fluid, and its corrosiveness in water.[95] In general, the proposed rules are similar to existing UIC requirements, but are more restrictive.[96] In considering these factors, EPA proposes to modify UIC requirements for site characterization, area of review, well construction, mechanical integrity testing, monitoring, well plugging, site closure, and post-injection site care.[97]

The geologic siting requirements for the proposed Class VI wells are more substantial than current UIC requirements and target factors that are specifically relevant to CO_2 injection. They include "[a] detailed geologic assessment" identifying the contours and extent of nearby underground sources of drinking water and a demonstration "that the injection zone is sufficiently porous to receive CO_2 without fracturing and extensive enough to receive the anticipated total volumes of injected

91. *Id.* at 43,499.

92. *Id.*

93. *Id.*

94. The purpose of this section is to provide the reader with a brief, contextual overview of EPA's proposed rule. The intent is not to provide a comprehensive evaluation or analysis of the proposal, but merely to demonstrate that none of its provisions address the most significant hurdles to implementing CCS. To review specific requirements under the proposed rule see *id.* at 43,534–41.

95. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,504 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

96. Marston & Moore, *supra* note 35, at 468.

97. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,504 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

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CO_2."[98] The siting requirements also specify that there must be a confining strata to limit upward migration of the entire plume of injected CO_2, as well as a full characterization of other geologic features, including the presence of any fractures and faults, geo-mechanical studies of fault stability and rock stress, ductility, and strength, as well as the target zone's porosity.[99]

The area-of-review requirements under current UIC regulations are based on either a fixed radius (one-quarter mile surrounding a well or wells, for a permit area covering multiple wells for Class I, II, or III wells, or two miles around a well or permit area for Class I hazardous waste injection wells) or a simple mathematical computation.[100] To account for CO_2's "complex multi-phase buoyant flow" (i.e., CO_2 flows and behaves differently depending on whether it is a supercritical fluid, a gas, or some combination of the two) and "compounds that may be mobilized due to injection," EPA proposes that injectors use computational fluid-flow models designed for each specific injection site.[101] Similar to existing requirements in the UIC, EPA proposes that injectors must identify all artificial penetrations in the area of influence and determine if any require corrective action to address deficiencies, regardless of ownership, if they could serve as potential conduits to other strata, particularly those holding underground sources of drinking water.[102] Corrective action contemplated in the proposal includes using corrosion-resistant cements in deficient wells within the area of influence.[103] Because of the long timeframe contemplated for CCS projects, the proposed rule requires periodic reevaluation, "at a minimum fixed frequency, not to exceed 10 years," of the area of influence during the injection phase of the project.[104] The proposed rule also contemplates a phased approach to the corrective action requirements, if appropriate, to allow injectors to address issues over time as the CO_2 plume grows in size, rather than preemptively and all at once.[105]

Well construction requirements under EPA's proposed rule also include unique features designed to address CCS. The most significant proposed requirement for well construction is that the well's surface cas-

98. *Id.* at 43,505, 43,536.
99. *Id.* at 43,505, 43,436–38.
100. *Id.* at 43,506.
101. *Id.*
102. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,507 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).
103. *Id.*
104. *Id.*
105. *Id.* at 43,507–08.

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ing "be set through the base of the lowermost [underground source of drinking water] and cemented to the surface," and that the long-string casing be cemented along its entire length[106] to protect drinking water sources and to prevent migration of injectate out of the target zone.

Proposed well operation rules are similar to those in place for existing Class I deep-well requirements so that injectors must limit CO_2 injection pressures to avoid new fractures in the injection zone or the propagation of existing fractures, except for some limited circumstances.[107] EPA proposes that injection pressures not exceed 90 percent of the fracture pressure measured for the injection zone.[108] The injector must also submit a testing and monitoring plan for the period of operation at the time of the permit application. Such monitoring must include analysis of the injected carbon dioxide stream (physical and chemical characteristics); continuing recording devices to monitor injection pressures, rates, and volumes; corrosion monitoring of the well materials; periodic monitoring of groundwater quality and geochemical changes above the confining zones; placement of monitoring wells; monitoring of the extent of the carbon dioxide plume and its pressure front; and surface air and/or soil monitoring for carbon dioxide that could endanger an underground source of drinking water, at EPA director's discretion.[109]

Critical to understanding the subsurface impact of CCS is the ability to track and monitor the CO_2 plume. To that end, EPA's tracking and monitoring requirements for CCS exceed the scope of any of the UIC's current rules. Monitoring, using direct geochemical and indirect geophysical techniques, provides updated inputs for continuing modeling and helps identify needed corrective actions.[110] It also provides an adequacy check on the area of review[111] and allows it to be scaled back or expanded over time depending on the monitoring results.

Also similar to current requirements for Class I hazardous waste injection wells, EPA's proposal "specifies a requirement that . . . injection should be allowed only beneath the lowermost formation containing a[n] [underground source of drinking water],"[112] although EPA is

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106. *Id.* at 43,509.

107. *See* Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,510 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

108. *Id.* at 43,510.

109. *Id.* at 43,539–40.

110. *Id.* at 43,514–15.

111. *See id.* at 43,516.

112. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,511 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

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seeking comment on allowing injection above or between strata containing underground sources of drinking water.[113]

EPA explains that "[p]lacing distance between the point of injection and [underground sources of drinking water] allows for the necessary confining and buffer formations, and further provides for opportunity for additional monitoring to detect any excursions from the intended injection zone."[114]

Also exceeding the current UIC regulatory requirements is EPA's proposal for post-injection site care and site closure, which are "more substantial than that required for other classes of injection wells."[115] First, EPA is proposing that permit applicants "submit a demonstration of financial responsibility to plug the well, to provide for post-injection care, and site closure."[116] The proposal would further require that injectors provide EPA at least 60 days notice "of their intent to plug an injection well and of any updates to the post-injection site care and site closure plan."[117] After plugging, the owners or injectors must submit a report certifying that the well was plugged in accordance with the approved plans, at which point the site would enter a post-injection monitoring period of 50 years following the cessation of injection and may continue at EPA's discretion "until the geologic sequestration project no longer poses an endangerment to [underground sources of drinking water]."[118] Upon demonstrating to EPA's satisfaction that the CCS project no longer poses a threat to drinking water sources, EPA may reduce the monitoring frequency or may authorize site closure before the end of the 50-year period.[119] The proposed rule does not specify what data is required, or what techniques should be employed to make this demonstration, but instead assumes that operators will use one or more of a variety of tests

113. *Id.* at 43,512.

114. *Id.* at 43,511.

115. *Id.* at 43,517 (discussing some of the additional requirements related to Class VI wells); *id.* at 43,502 (noting that the proposed Class VI wells have the same basic requirements as Class I hazardous waste wells, which "are managed with technically sophisticated construction and operation requirements," but with additional and on-going permitting requirements relating to area of review and site characterization, operating, monitoring, well plugging, and post-injection site care and site closure requirements).

116. *Id.* at 43,517.

117. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,517 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

118. *Id.* at 43,540–41 (to be codified at 40 C.F.R. pt. 146.93). UIC's current regulations don't limit the duration of post-injection site care and monitoring, but "many environmental programs use a 30-year period as a frame of reference," which has generally "been sufficient." *Id.* at 43,519.

119. *Id.* at 43,541 (to be codified at 40 C.F.R. pt. 146.93(b)(2)).

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available.[120] EPA's approach to post-injection monitoring and site closure represents what is essentially a hybrid regulatory approach by "proposing . . . a combination of a fixed timeframe and performance standard be used to determine the duration of the post-injection site care period."[121] EPA selected this approach because research indicates the stabilization time will vary depending on the particular geochemical and geological conditions of the site, but that stabilization should occur within 10–100 years after cessation of injection.[122] The 50-year default is being proposed as a "mid-point" to ensure that the timeframe "is long enough to determine that there is no threat of endangerment to [underground sources of drinking water]," but the proposal also gives EPA discretion to shorten or lengthen the monitoring period "for 100 years (or longer)," if necessary.[123]

The EPA director can end the post-site closure monitoring period after all information has been received regarding the post-injection site care and closure plan if the director is satisfied that there is no threat to underground sources of drinking water.[124] After closure approval, the owner/operator of the site has 90 days to submit a site closure report documenting injection monitoring and well plugging; copies of notifications to state and local authorities with authority over drilling in the region and records reflecting the nature, composition, and volume of the injected CO_2.[125] The owner/operator is also responsible for recording a "notation on the deed to the facility property or any other document that is normally examined during title search that will, in perpetuity, provide

120. *Id.* at 43,518, 43,539 (to be codified at 40 C.F.R. pt. 146.90(g) (describing types of carbon dioxide monitoring techniques that would suffice, e.g., seismic, electrical, gravity, or electromagnetic surveys and/or down-hole carbon dioxide detection tools).

121. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,518 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

122. *Id.* at 43,519, 43,520 (expressing EPA's confidence that most CO_2 sequestration sites will stabilize within 100 years).

123. *Id.* at 43,519–20. Interstate Oil and Gas Compact Commission (IOGCC) proposes a 10-year closure period during which the operator maintains responsibility prior to transfer to the public sector. INTERSTATE OIL AND GAS COMPACT COMMISSION, CO_2 STORAGE: A LEGAL AND REGULATORY GUIDE FOR STATES 4 (2007) [hereinafter IOGCC 2007]. The European Union proposes a minimum 20-year, post-closure period during which the operator maintains responsibility prior to transfer to the public sector. *Directive of the European Parliament and Council*, No. 2009/31/EC, 2009 O.J. (L. 140), art. 18 (Apr. 23, 2009), *available at* http://www.europarl.europa.eu/oeil/file.jsp?id=5588432.

124. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,520 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

125. *Id.*

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notification to any potential purchaser of the property information that the land has been used to sequester CO_2."[126]

Finally, EPA also proposes imposing a financial responsibility requirement adequate to cover "activities related to closing and remediating" sequestration sites.[127] The proposal does not define what level of financial security is adequate. Instead, "EPA is proposing that the rule only specify a general duty to obtain financial responsibility acceptable to the [EPA] Director, and will provide guidance to be developed at a later date that describes recommended types of financial mechanisms that owners or operators can use to meet this requirement."[128] Responsibility, however, cannot "extend to . . . activities unrelated to protection of [underground sources of drinking water] (e.g., coverage of risks to air, ecosystems, or public health unrelated to [underground sources of drinking water] endangerment)."[129] The proposed rule, because of a lack of statutory authority under the SDWA, also "does not cover transfer of owner or operator financial liability to other entities, or creation of a third party financial mechanism where EPA is the trustee."[130]

The proposal, however, does clearly prescribe which liabilities are included within this financial responsibility scheme. Because of the SDWA's limited authority, these liabilities are quite narrow. Financial liability expressly extends to "corrective action," "injection well plugging," "post-injection site care and site closure," and "emergency and remedial response." Each of these regulatory components has requirements for sufficiency that are prescribed by the proposed rule.[131] The EPA director would have discretion to determine if the financial mechanism proposed by the operator is sufficient.[132] As the project progresses, the owner-operator must submit periodic updates on the cost estimate for its financial responsibility.[133]

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126. *Id.*

127. *Id.*

128. *Id.* EPA may be requiring only a "general duty" because the Safe Drinking Water Act (SDWA) provides no explicit authority to impose financial responsibility on injectors. *See* Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,520 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

129. *Id.*

130. *Id.* at 43,520, 43,522.

131. *Id.* at 43,537; *see also id.* at 43,540–41 (to be codified at 40 C.F.R. pt. 146.84, pt. 146.92, pt. 146.93, pt. 146.94, respectively).

132. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,520, 43,537 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

133. *Id.* at 43,520–21, 43,537 (to be codified at 40 C.F.R. pt. 146.85(b)).

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Formal financial responsibility under the UIC terminates after the post-injection monitoring period has ended,[134] at which point the operator would be free to discontinue paying for whatever financial-assurance mechanism was in place. But, as EPA's comments in the Federal Register make clear, "owners or operators may still be held responsible after the post-injection site care period has ended . . . [because] [t]rust responsibility for potential impacts to [underground sources of drinking water] remain with the owner or operator *indefinitely* under current [Safe Drinking Water Act] provisions."[135] The perpetual liability under the SDWA and the UIC is a significant problem with the current EPA proposal, and will likely serve as an impediment to full commercial-scale implementation of CCS, as EPA itself recognizes. Indefinite liability imposes significant financial risks to owner/operators for ongoing costs that may arise, so "stakeholders have expressed interest in alternative instruments for addressing financial responsibility after the post injection care period has ended."[136] Despite this expressed interest and concern, the extent of EPA's discussion on "Considerations for Long-term Care" comprises less than one column in the federal register.[137]

Given the number of unknowns in the developing field of CCS, EPA has taken an "adaptive approach" to implementing CCS regulations,[138] culminating with a final rule that is expected to be issued in 2011.[139] Under this approach, EPA hopes to allow development of early CCS projects, including experimental projects that can be permitted as Class V wells through guidance documents,[140] while still providing a mechanism in the rulemaking process to collect and incorporate new data as it becomes available.[141] EPA will then "continue to evaluate ongoing research and demonstration projects, review input received . . . and gather other relevant information . . . to make refinements to the

134. *Id.*
135. *Id.* at 43,522 (emphasis added).
136. *Id.* at 43,522.
137. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,522 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).
138. *Id.*
139. U.S. EPA, Proposed UIC Regulations for Geologic Sequestration of Carbon Dioxide 7 (Feb. 26–27, 2008) (workshop minutes).
140. *See* U.S. EPA, Using the Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects—UIC Program Guidance (UICPG #83) (Mar. 1, 2007).
141. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,522 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

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rulemaking process," but will "issue a final rule in advance of full-scale deployment."[142]

IV. SHORTCOMINGS OF EPA'S PROPOSED RULE

EPA's proposed regulations are, in many ways, necessary for the proper and orderly implementation of CCS. The suggested regulatory vehicle, however, is ultimately inappropriate and affords insufficient statutory authority to adequately regulate CO_2 sequestration and its full complement of associated environmental risks. CCS appears on its surface to be similar to other injection programs already regulated under the UIC, so its regulation would seem to fit within the same framework. However, it is inappropriate to attempt to cram carbon mitigation into a box that was built solely to protect underground sources of drinking water when many more environmental impacts are in fact implicated by CCS.

Carbon is unlike any other regulated emissions source and should be regulated unlike any other emissions source—its behavior, importance, and impacts in the natural system do not fit easily within the definition of a pollutant because animals respire it, plants depend on it for energy production, and large volumes naturally circulate within the geosphere and biosphere. Carbon is unique in its chemical and environmental impacts and benefits, the role it plays in man's industry and economy, and also within the natural ecosystem. Therefore, carbon mitigation (e.g., CCS) ought to be contemplated within a much broader statutory and regulatory framework designed specifically for carbon. Because neither the SDWA nor the UIC contemplated CCS, EPA's proposed framework is ill-suited to address the unique liability issues associated with the anticipated scale—both in terms of time and areal extent—of this climate-change mitigation strategy. As a consequence, the proposed rule does little to encourage this critical carbon mitigation strategy and much to discourage it. The combined effect of a maladapted regulatory framework and industry disincentives could lower public confidence in CCS because environmental protections are lacking and the proposed liability framework does not generate certainty.

EPA's proposed regulations are, however, well-suited to certain aspects of the siting, drilling, injection, closure, and even post-closure phases of CCS. So much about these phases of CCS relate to the technical aspects of injection, which the UIC is particularly good at addressing: understanding the characteristics of the injection-site geology and the target formation, the surrounding formations and the nature and extent

142. *Id*.

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of nearby underground sources of drinking water, as well as ensuring that the most protective well drilling technologies are employed. Further, impairment of underground sources of drinking water is certainly one of the primary risks posed by CCS, particularly in the western United States, where domestic and municipal users rely heavily on groundwater as a drinking water source. From the sole purpose of the UIC, the proposed rule does manage to achieve a modicum of protection beyond the scope of the SDWA, albeit indirectly and without firm authority for enforcement. For example, in the preamble to the proposed rule, EPA emphasizes that "[w]hile preventing releases of CO_2 to the atmosphere is not within the scope of this proposal, today's proposed rulemaking also addresses the risks posed by releases to the atmosphere by ensuring that injected CO_2 remains in the confining formations."[143] But while this may be so and EPA's proposed rule "may also prevent migration of CO_2 to the surface,"[144] the rule does not provide enforcement authority for impacts to air, ecosystems or public health.[145] As a consequence, any protections afforded against other risks posed by CCS come merely as a side effect to protection of underground sources of drinking water. Without the power of enforcement, such secondary protections offer hollow comfort.

The SDWA, as the authorizing statute for the UIC and its regulations, does not provide adequate authority to address all, or even most, of the potential environmental issues that should be contemplated and managed in a comprehensive CCS regulatory framework. The SDWA limits regulatory authority over injection wells to the protection of underground sources of drinking water; the Act does not authorize regulation of injection wells for any other purpose. As a consequence, the proposed regulations are focused on the protection of underground sources of drinking water to the exclusion of all other environmental considerations, such as impacts to human health and other natural resources. The proposed regulations create uncertain and open-ended liability for numerous potential environmental impacts by implicating other environmental statutes—in particular the Comprehensive Environmental Response, Compensation, and Liability Act—and by barring the transfer of liability to the public sector or even another private entity that

143. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,498 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

144. *Id.*

145. *Id.* at 43,522. The SDWA also fails to provide authority to regulate carbon capture and transport, determination of property rights, transfer of liability, accounting and certification for greenhouse gas reductions. *Id.* at 43,495.

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might be better positioned to adopt and manage a site's long-term liability.

A. Implications of CERCLA and RCRA Applicability

EPA gives little guidance regarding the applicability to CCS of one of the nation's most important environmental statutes—the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)[146]—when, more than anything, certainty is required for public confidence and operator incentive. Conversely, EPA's approach regarding another major federal environmental statute—the Resource Conservation and Recovery Act (RCRA)[147]—provides a clearer path for operators and injectors to limit their liability under this statute.

If the CO_2 stream captured from coal combustion were pure, no question of RCRA or CERCLA applicability would arise because CO_2 itself is not considered a hazardous pollutant under either statute. Yet an injected carbon stream for CCS will likely never be pure CO_2, and will contain low concentrations of impurities from the source coal[148] that will vary "depending on the fuel source, the capture process" and other factors.[149] In general, impurities could create more acidic subsurface conditions (e.g., sulfur dioxide) that are themselves toxic by "accelerating the formation of fluid-conducting pathways . . . and the dissolution of geologic materials in the subsurface."[150]

The question, then, is whether any of the impurities, either by themselves or as a consequence of their mobilization of native subsurface contaminants cause the injected CO_2 to be subject to either RCRA or CERCLA. EPA's strategy regarding RCRA applicability is to essentially exempt CO_2 from RCRA by defining "carbon dioxide stream" to exclude hazardous wastes.[151] The proposed rule "assures that it would apply only to CO_2 streams that are not hazardous wastes" as defined by RCRA regulations.[152] Therefore, "operators will need to characterize their CO_2

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146. 42 U.S.C. § 9601–28 (2000).

147. 42 U.S.C. § 6901–54 (2000).

148. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,503 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146); U.S. EPA, Technical Support Doc., Vulnerability Evaluation Framework for Geologic Sequestration of Carbon Dioxide 22 (2008).

149. EPA, Technical Support Doc, *supra* note 148, at 22.

150. *Id.* at 23.

151. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,535 (proposed July 25, 2008) (to be codified at 40 C.F.R. pt.146.81(d)).

152. *Id.* at 43,503.

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stream as part of their permit application to determine if the injectate is considered hazardous."[153] If the CO_2 stream meets the RCRA definition of a hazardous substance, then it must be injected under "the more stringent UIC Class I requirements for injection of hazardous waste"[154] and the proposed Class VI category for CCS would not apply. Alternatively, operators could conduct additional scrubbing to further refine the CO_2 stream until it no longer meets the hazardous waste definition.

In contrast, EPA's analysis of whether CERCLA would apply "depends entirely on the make-up of the specific CO_2 stream and of the environmental media (e.g., soil, groundwater) in which it is stored."[155] EPA's parting thought on the applicability of CERCLA provides an even greater disincentive for CCS operators: "As applicable, a determination of liability would be made on a case-by-case basis by Federal courts in response to claims for natural resource damages (NRD) or response costs."[156] Granted, EPA takes great pains to highlight the possible statutory defenses that might be raised by an operator to a CERCLA claim, most prominently the defense that "the release constituted a 'federally permitted release' as defined in CERCLA, 42 U.S.C. 9601(10)."[157] Federally permitted releases include "releases in compliance with a UIC permit under SDWA."[158] But these are defenses to claims for natural resource damages, not exemptions. The difference is a substantial degree of certainty in the liability exposure—remember CERCLA imposes strict, joint and several liability, an extreme burden on an operator given the size and scale of anticipated CCS projects. Perhaps, for example, the operator, unbeknownst to itself and despite clean bills of health from periodic EPA reviews and inspections, was not meeting its permit conditions, and so the CO_2 release might not always be a "federally permitted release." In such cases the statutory defense might not be available.

A counterpoint to this concern is that if an operator fails to abide by the conditions of its permit and injects concentrations of fluids into the subsurface that qualify the fluids as a hazardous substance, knowingly or not, then perhaps it should be held accountable for a permit violation under CERCLA. But this approach severely undervalues, if not disregards, the powerful disincentive of the strict, joint and several liabil-

153. *Id.*
154. *Id.*
155. *Id.* at 43,504.
156. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,504 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).
157. *Id.*
158. *Id.*

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ity standard imposed through CERCLA. Allowing this level of uncertainty and potential liability to loom over nascent CCS projects is unacceptable. Nonetheless, the importance of holding operators accountable for damages to natural resources cannot be overstated.

The better approach to achieve this policy goal is to ensure that CERCLA has no authority over injected CO_2, but to have equally protective environmental standards in place that specifically address CCS and its associated concerns without strict, joint and several liability. Because CERCLA is drafted more broadly than RCRA, however, EPA likely cannot exempt CCS from CERCLA regulation without express statutory exemption from Congress.

B. Financial Responsibility

The SDWA does not "have explicit provisions for financial responsibility, as included in RCRA," so in its proposed rule EPA relies on "the general authorities provided under the SDWA authority to prevent endangerment of USDWs [or underground sources of drinking water] . . . to set standards for financial responsibility to prevent endangerment of USDWs from improper plugging, remediation, and management of wells after site closure."[159] EPA is to be commended for making a broad interpretation of its statutory mandate to propose at least some requirement to demonstrate financial responsibility should corrective action be required prior to the termination of the closure period and for the period of time during which financial responsibility endures until released by EPA. The problem, as EPA itself points out, is that "[t]he SDWA authority does not extend to financial responsibility for activities unrelated to protection of USDWs (e.g., coverage of risks to air, ecosystems, or public health unrelated to USDW endangerment)."[160] Therefore, any financial assurance imposed will necessarily fall short of what is required to be fully, even adequately, protective.

Because authority to implement strong financial assurances is merely implied under the SDWA, it is susceptible to court challenge. Susceptibility to court challenge contributes to a cumulative uncertainty in the robustness of the regulatory framework and reduces the public's belief that the system is fully protective. Requirements for financial assurance are a critical component of resource management schemes in which an operator's regulated activities stand to impair the environment or natural resources. When a resource management scheme is proposed on the scale of CCS, where numerous critical resources stand to be im-

159. *Id.* at 43,520.
160. *Id.*

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pacted, strong provisions requiring adequate financial assurance are essential for good public policy and for garnering public confidence.

The proposed rule's financial assurance provisions are deficient for the additional reason that the SDWA authority extends only to activities related to the protection of USDWs. That is to say, EPA would be unjustified in seeking to secure financial assurances from an operator for impacts to human health unrelated to USDWs, such as vegetation destruction, seismic activity, and other potentially significant and negative events associated with CCS. This inherent limitation in the rule's statutory authority means that any financial assurance requirement imposed by EPA will be necessarily inadequate to cover the full range of potential environmental and natural resource impacts.

Without broader statutory authority, the public and regulators cannot be assured that operators will have the resources to cover mitigation or remediation activities. This is a significant shortcoming that should disqualify the SDWA as the statutory source for authority to regulate CCS. At a minimum, this shortcoming should spur congressional action to amend SDWA authority to expressly authorize financial assurance requirements specific to CCS activities that cover the full range of potential impacts from its operations and management. Ideally, however, the issue of financial assurance would be addressed through a separate comprehensive statute specifically regulating anthropogenic carbon emissions and CCS. This shortcoming demonstrates the inaptness of SDWA for CCS regulation.

C. Transfer of Liability

While EPA recognizes the importance of transferability,[161] the SDWA does not authorize transfer of financial responsibility[162] or long-term liability to third parties or other entities.[163] Therefore, EPA's proposed CCS rule does not include such a provision. This is a significant problem and impediment to full-scale development of CCS.

While such a prohibition might very well be appropriate for the protection of drinking water sources, it is a policy out of place when

161. Even though EPA does not propose to regulate transferability in the new proposal, EPA researched and published alternative means for handling long-term liability, including transferability, in response to stakeholder requests. *See* U.S. EPA, APPROACHES TO GEOLOGIC SEQUESTRATION SITE STEWARDSHIP AFTER SITE CLOSURE (2008) [hereinafter APPROACHES TO GEOLOGIC SEQUESTRATION], *available at* http://www.epa.gov/OGWDW/uic/pdfs/support_uic_co2_stewardshipforsiteclosure.pdf.

162. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,520 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

163. *Id.* at 43,522.

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applied to CCS, again, because of the contemplated scale and size of its full deployment. If, in the broader market, one party is particularly adept at sequestration and injection, but has neither the long-term nor financial wherewithal to contemplate indefinite liability, which another party is more suited to handling, then CCS regulations should encourage business transactions transferring liability from one party to another to create a more efficient system. Such a transfer does not lessen the overall liability or create more exposure for the public sector; it merely allows transfers of what was once the injector's risk exposure to another through a willing, contractual transaction. At the very least, a comprehensive CCS framework should provide for, if not encourage, the transfer of liability and financial responsibility between parties, if not to the public sector.

The Interstate Oil and Gas Conservation Commission (IOGCC) has developed a model[164] that proposes to transfer liability to individual states, which would manage the long-term care, monitoring, and any necessary corrective measures by means of a trust fund established during the operational phase of the project by a tax or fee assessed during injection. Similarly, the European Union (EU) has proposed a CCS directive[165] providing that individual nations eventually take on the long-term care and responsibility for CCS sites. The EU directive even specifies, as an incentive for private CCS development, that after transfer of responsibility member nations cannot recoup any resulting management or remediation costs short of demonstrating operator negligence, willful deceit, or failure to exercise due diligence.[166]

Given the weight of these recommendations, it appears likely that in the early stages of CCS development some degree of liability transfer to the public sector may be necessary to accomplish its deployment—at least until the full contours of the risks and exposures created over the long-term by these projects are better quantified. In fact, "[n]early all of the sequestration literature assumes that long-term liability must be transferred to the public sector to maintain economic viability and to encourage industry participation."[167]

New Mexico looked at limited transfers of liability to the state, such as transferring liability for a limited number of initial CCS projects "(e.g. the first enhanced oil recovery CCS project, the first deep saline CCS project, the first deep coal seam CCS project)" or transferring liability "for a limited time frame (e.g. the first five years of [CCS])."[168] Wyo-

164. IOGCC 2007, *supra* note 123.
165. *Directive of the European Parliament and Council*, *supra* note 123.
166. *Id.* art. 18, ¶ 7.
167. New Mexico CCS, *supra* note 66, at 39.
168. *Id.*

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ming Governor Dave Freudenthal, however, recently argued that carbon management and climate change is "ultimately a national problem" and that federal lawmakers must act on several key issues or the success of CCS will be "hampered."[169] In particular, he noted that the federal government will have to "[a]ddress the long-term liability/indemnification issues surrounding sequestration, as no state will be able to assume the risk of a catastrophic release of carbon dioxide by itself."[170]

If states can't manage the risks, it seems improbable that corporate entities would have the means to cover this potential exposure. Corporations are designed to raise capital. It is possible, if not likely, that CCS is or will very soon be the type of technology that attracts huge sums of private investment, however, this won't occur until CCS has been demonstrated to be a commercially, economically, and politically viable option for climate mitigation. Nor is it likely until CO_2 emissions are subject to federal regulation, either through a carbon tax, or as is more probable, through a comprehensive cap-and-trade approach. Until then, corporate entities will tentatively approach CCS development, given the investment size, risk, and relative uncertainty.

Because long-term containment of CO_2 is one of the most significant unknowns of a CCS project, it is precisely this liability that must be subsidized in some way by the public sector to incentivize private investment. Because the environmental stakes are so great, and because the problem of climate change mitigation is so clearly national in scope—in terms of the emissions contributions and the environmental impacts—this subsidy should properly fall on the federal government in the form of a liability transfer from the private sector (i.e., the injectors/operators) to the public sector.

Requiring the public sector to bear some portion of this cost satisfies the policy goal of internalizing the increased societal costs of coal and energy consumption as part of an overall approach to price the actual cost of energy production. Further, climate change mitigation is ultimately society's burden to bear, so it is only proper that society heft some portion of this liability for the long-term.

V. CCS LIABILITY

Before presenting recommendations for a statutory and regulatory framework, it is useful to generally understand the liabilities inherent in CCS and possible regulatory analogs. Three primary sources of liability

169. Governor Dave Freudenthal, *Carbon Sequestration: A Lawyer's Cornucopia or Pandora's Box?*, 31 WYO. L. REV. 16, 18 (2008).
170. *Id.*

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arise from the geologic sequestration of CO_2: (1) liability from operational impacts; (2) liability from *in situ* risks; and (3) climate liability.[171] In addition to these broad categorical risks, a time-based risk component is also applicable across all three risk categories.[172]

Operational liability—stemming from the transportation, siting and injection, and storage of carbon dioxide and other waste materials—has been managed on a relatively large scale for decades by the U.S. oil and gas industry in the context of EOR and acid-gas disposal.[173] The operations phase of a CCS project begins with siting and injection and ends with closure (i.e., cessation of injection and well plugging). Some commentators argue that the liabilities and risks inherent in the operations phase of CCS can be sufficiently managed[174] through current statutes, regulations, and other forms of familiar liability and risk control mechanisms, such as insurance and other contractual agreements, that are already commonplace.[175] For example, EPA's UIC program "[e]liminates more than nine billion gallons of hazardous waste and a trillion gallons of oil-field waste from the environment each year,"[176] and depending on the injection well type, imposes on the operator financial responsibility for a certain number of years and general liability for an indefinite period.[177] Industry proponents have argued, therefore, that modifications to the current regulatory structure could be sufficient to address the unique nature, risks, and concerns relating to CCS.[178] While modification of the current regulatory framework might be marginally adequate to address concerns and risks relating to the operational phase of CCS—involving processes and risks familiar to industry and regulators—mere modification is insufficient for other phases of CCS. Because of the anticipated

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171. *See* M.A. de Figueiredo et al., *Framing the Long-Term* In Situ *Liability Issue for Geologic Carbon Storage in the United States*, 10 Mitigation and Adaptation Strategies for Global Climate Change 647, 648 (2005) [hereinafter Figueiredo I].

172. *See generally* Wilson et al., *supra* note 17.

173. *See, e.g.*, U.S. EPA's Program to Regulate the Placement of Waste Water and Other Fluids Underground, U.S. Envt'l Prot. Agency, June 2004, www.epa.gov/ogwdw/sdwa/pdfs/fs_30ann_uic_web.pdf (more than 800,000 injection wells have disposed of trillions of gallons of hazardous and non-hazardous fluids, including oil-field wastes, into subsurface formations through the SDWA's Underground Injection Control Program).

174. Figueiredo I, *supra* note 171, at 647–48.

175. Nettles & Conner, *supra* note 17, at 47–48.

176. *See, e.g.*, U.S. EPA's Program to Regulate the Placement of Waste Water and Other Fluids Underground, *supra* note 173.

177. *See, e.g.*, 40 C.F.R. § 144.63 (financial responsibility for Class I wells).

178. *See, e.g.*, IOGCC 2007, *supra* note 123, at 11 ("The Task Force considers the creation of an industry-funded and state-administered trust fund the most effective and responsive 'care-taker' program to provide the necessary oversight during the post-closure period.").

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scale of CCS, modification is very likely to be inadequate for the operational phase as well.

Climate liability relates to future carbon-control regimes and the risks associated with atmospheric leakage and the problem of accounting for those storage losses when credits have been assigned conditioned on permanent storage.[179] This liability boils down to a carbon accountability and tracking problem; ensuring carbon that has been sequestered remains that way so credits can be properly awarded, and if there are leaks, determining how they should be accounted for and discounted given the prevailing carbon pricing structure. This aspect of CCS and its associated policy concerns is beyond the scope of this paper and will not be addressed here, although it is a critical issue that needs to be fully considered for a comprehensive carbon management scheme to be workable.

In situ liability for CCS, unlike operational liability, creates unique problems because of the prolonged storage times contemplated[180] and the significant time until carbon-dioxide plume stabilization.[181] Long-term liability for CCS projects "presents a unique problem given the anticipated scale, both in terms of time (hundreds to thousands of years) and space [hundreds of square miles], required for successful CO_2 sequestration. . . ."[182] For this reason, long-term liability has been identified as one of the most significant barriers to the commercial-scale deployment of this critical climate change mitigation strategy.[183] Risks associated with this category of liabilities include environmental and human-health impacts from leaks to the surface, migration of CO_2 within the subsurface, contamination of groundwater, mobilization of subsurface pollutants, and seismic events.[184] Some risks, such as potential groundwater contamination, also fall within the operational risk category, and therefore, are probably sufficiently addressed by current regulations and procedures or by those being proposed, such as EPA's proposed UIC rule for CCS. It is the *in situ* risks associated with the later phases of a sequestration project—the extended period beginning with cessation of injection and closure, through the post-closure period to

179. Figueiredo I, *supra* note 171, at 647–48.

180. *See* Wilson et al., *supra* note 17, at 3; New Mexico CCS, *supra* note 66, at 55 (storage times anticipated to be hundreds to thousands of years).

181. *See* Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,519 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146) (noting that CO_2 plumes have been observed to stabilize in 10–100 years).

182. New Mexico CCS, *supra* note 66, at 55.

183. *See generally id.*

184. *See* Figueiredo I, *supra* note 171, at 647–648.

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plume stabilization—that are unique to CCS given its scale and require careful consideration.

The post-closure phase of a CCS project is essentially indefinite because, barring a future commercial use of the stored CO_2 that would require later extraction, sequestration of CO_2 is intended to be permanent.[185] Even with an operational phase of 50–100 years, therefore, the post-closure period of a sequestration project will be the predominant phase. As such, liability during this phase will be fundamentally different than liability during operations. For example, should an accident or damage occur after closure "there may be difficulty identifying responsible parties, delegating responsibilities for remediation, and apportioning damages given that corporations do not have lifetimes as long as the CCS stewardship period (hundreds of years)."[186] Therefore, it will be "necessary to clarify who will be responsible for long-term site care and for how long."[187] To avoid imposing unreasonable liability that would discourage CCS development, a unique approach is required to manage the resulting risks.

These long-term risks and liabilities, however, are not directly addressed by EPA's proposed rule, but are implicated by other environmental statutes, such as CERCLA, thereby compounding the liabilities and uncertainties. The result is unconstrained liability under the proposed UIC rule. Understanding these risks and liabilities, and how they trigger liabilities under the UIC program itself and implicate other environmental statutes and regulations, is critical to evaluating the appropriateness of EPA's proposed rule, as well as for proposing a more workable alternative.

A. Managing Liability—Proposed and Analogous Models

Liability need not be ignored, although EPA's proposed rule essentially ignores it.[188] Rather, CCS liabilities can be actively managed "to decrease firm [operator] risk and thereby increase market penetration,"[189] and in turn increase the climate mitigation success of any CCS program. In general, three broad options exist to manage liability: (1) transfer of liability, or some portion thereof, to the public sector; (2) private, contrac-

185. *See* Wilson et al., *supra* note, 17, at 3–4.
186. *Id.* at 4.
187. *Id.*
188. Approaches to Geologic Sequestration, *supra* note 161, at 4 (stating that EPA's proposal does not address liability relating to CCS impacts to air, ecosystems, and human health beyond the scope of the SDWA).
189. Figueiredo I, *supra* note 171, at 647.

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tual, liability-limiting mechanisms, such as insurance or indemnification; or (3) some combination thereof.[190]

Transferring liability to the public sector is one way to limit the private burden on individual injectors and the industry collectively.[191] Proponents of this approach argue that even with substantial technical knowledge and decades of experience injecting CO_2 into the subsurface, the contemplated scale of full commercial development of CCS introduces a breadth of unknowns that makes the risk of initiating a project too great for a commercial entity to bear alone. If that risk could be limited in time by transferring ultimate liability to the public sector—either the federal government or a state government—for the duration of the project's lifespan beginning sometime after closure, then injectors and operators would be encouraged to undertake CCS because the risks and liabilities would no longer extend indefinitely. Similarly, if financial liability also could be capped at some outer limit for individual operators and for the industry collectively, then the financial risks could be incorporated directly into business models. Without a cap, the financial liability is potentially enormous, given the size and scope of CCS projects, such that no private entity could solely bear the burden.

Public assumption of large private liabilities is not without precedent. A similar concept was originally employed briefly by CERCLA, which had in its original form created a "Post-Closure Liability Fund."[192] After a maximum five-year period, hazardous waste disposal facility operators could apply to have liability for the future costs of monitoring, care, and maintenance of the site transferred to the fund. If the hazardous waste disposal facility operator had received the proper permit and complied with all other regulatory requirements, the fund was then obligated to pay all costs arising from future liabilities imposed by CERCLA. The idea was that sites that operated within the constraints of their permit, remained trouble free, and did not pose a threat to public health, welfare, or the environment, qualified for transfer of liability to the fund. The fund was supported by appropriations, transfers, or credits and was capped at $200 million.[193] In many ways, such a tax was equated with premium payments for post-closure government liability insurance paid

190. See APPROACHES TO GEOLOGIC SEQUESTRATION, *supra* note 161, for a helpful review of some current statutory approaches to managing liability, as well as a summary of recommendations for managing CCS liability.

191. *See* IOGCC 2007, *supra* note 123, at 4 (recommending liability be transferred to the state following a post-closure period of monitoring); *see also* NEW MEXICO CCS, *supra* note 66, at 55; *Directive of the European Parliament and Council*, *supra* note 123.

192. 42 U.S.C. § 9641 *repealed by* Pub.L. 99-499, § 514(b), 100 Stat. 1767 (1986).

193. Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Pub.L. No. 96-510, § 232, 94 Stat. 2804 (1980); *see* CAROLE STERN SWITZER & LYNN A.

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by hazardous waste disposal site owners and operators.[194] Like many insurance policies covering high-risk and large liabilities, the fund had a cap. Unlike the situation when an operator is insured, however, when the cap was exceeded for a CERCLA action, the operator was free of all liability because liability had been transferred to the fund (i.e., the federal government). Conversely, when an insurance policy is exceeded, the policyholder remains on the financial hook.

Not surprisingly, when CERCLA was up for reauthorization in the mid-1980s solid waste operators sought to retain the post-closure liability fund,[195] primarily because it protected them against excessive liabilities. But opponents of the fund, such as the Hazardous Waste Treatment Council, argued that "[t]he more rapid the transfer of liability to a federally backed fund, the less incentive there is to pursue permanent and protective methods of management."[196] The Council argued that liability transfer "exacerbates the cost differential between treatment and disposal by allowing the long-term cost of facility liability, monitoring and maintenance to be assumed by the Federal government, rather than having these post-closure expenses internalized in the price of individual and land disposal transactions."[197] Environmental groups attacked the transfer, as well, arguing that it created "an incentive to do the most modest, minimal cleanup, [and] adopt the most minimal approach, that would get you by that first five years and not assume responsibility for the subsequent acceptability of the disposal practice."[198] They also argued that a trust fund was "less accountable" than operators themselves.[199] Opponents of the liability transfer ultimately prevailed and the provision was repealed.

While a public assumption of private risk might not have been appropriate in the case of hazardous waste, it is being considered as a viable option for CCS. Both the IOGCC and EU have recently advocated for a long-term liability model for CCS, similar to the now-defunct CER-

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BULAN, CERCLA: COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (SUPERFUND) 7 (2002).

194. *Superfund Amendments & Reauthorization Act of 1986 Hearing on S. 2892 Before S. Comm. On Finance*, 98th Cong. 67 (Sept. 19, 1984) (statement of Mikel M. Rollyson, acting tax legislative counsel, Dep't of the Treas.).

195. *Hearing on H.R. 5640 H. Subcomm. on Water Res. of the Comm. on Public Works and Trans.*, 98th Cong. 63 (1984) (statement of Richard L. Hanneman, Dir. of Gov. Affairs, Nat. Solid Waste Mgmt. Assoc.) [hereinafter *Hearing on H.R. 5640*].

196. *Id.* at 211 (statement of Richard C. Fortuna, Exec. Dir., Hazardous Waste Treatment Council).

197. *H. Subcomm. on Commerce, Trans. and Tourism, H. Comm. on Energy and Commerce*, 98th Cong. 197 (1984) (statement of Dr. Nelson Mossholder).

198. *Hearing on H.R. 5640*, supra note 195, at 474 (1984) (statement of Kenneth Kamlet).

199. *Id.*

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CLA post-closure liability fund that includes transfer of some, if not most, of the enduring risks to the public sector. Together these proposals offer important insights into how governments might incentivize CCS projects to jumpstart its application and benefits vis-à-vis climate change mitigation and serve to emphasize the importance of constraining liabilities relating to CCS for policymakers in order to facilitate its development and implementation.

The IOGCC, comprised of 30 member states and seven associate member states, issued a Model CO_2 Storage Statute with Model Rules and Regulations (Model) in 2007. The IOGCC cites the need to delimit the parameters of potential liability as a guiding principle. It does so when it proclaims that the statutory and regulatory framework must be "seamless to maximize economic and environmental benefits while providing a 'cradle to grave' framework with fully integrated regulatory oversight and *clearly identified risk parameters for industry*."[200] A further guiding principle is that the regulatory framework must be simple: "The temptation to over-regulate for the exotic needed to be avoided by developing a simple framework that initially addressed only those scenarios most likely to occur. It was recognized that, as necessary, regulations would be amended in the future based on the experience gained in the initial projects."[201]

Employing these principles, the IOGCC Model recommends that at the end of a 10-year, post-closure period—during which time the CO_2 plume would be monitored for signs of increasing stability and to see that project conditions continue to meet closure requirements for such specifications as formation pressure and CO_2 containment—the liability for the storage site should be transferred to the state.[202] This serves the IOGCC's principle of clearly identifying risk parameters for industry because it provides a temporal liability cap. After the transfer to the public sector, funding for the continued monitoring of the site, and for any compensatory disbursements that might be necessary for environmental or human-health impacts, would be paid for from a trust fund created by a tax or fee imposed on storage operators during the operations phase.[203] The trust fund, managed by the state regulatory agency currently in charge of CO_2 injection would then assume future management of the

200. IOGCC 2007, *supra* note 123, at 2 (emphasis added).
201. *Id.*
202. *Id.* at 11, 29 (recommending that states, not the federal government, maintain long-term care and control of sequestration sites because states have developed the regulatory and technical expertise relating to CO_2 injection).
203. *Id.* at 34.

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CCS project during the entire post-closure period, including future monitoring, verification, and remediation activities.[204]

Recognizing CCS as "a bridging technology that will contribute to mitigating climate change,"[205] the EU has also set about creating a regulatory framework "to incentivize Member State and private sector investments to ensure the construction and operation by 2015 of up to 12 CCS demonstration plants."[206] As part of this broad effort to incentivize CCS, the proposed EU Directive, adopted December 17, 2008, makes a recommendation similar to the IOGCC. Specifically, the EU recommends that a storage site should be deemed closed once specifications for closure conditions defined in the permit have been met and after a period of post-closure responsibility, during which the operator maintains full responsibility for maintenance, monitoring, and corrective measures.[207] After this post-closure period has elapsed, "[t]he responsibility for the storage site, including specific legal obligations, should be transferred to the competent [national] authority, if and when all available evidence indicates that the stored CO_2 will be completely contained for the indefinite future."[208] The EU Directive provides that the post-closure period "shall be no shorter than 20 years, unless the competent authority is convinced that" the stored CO_2 will be completely and permanently contained "before the end of that period."[209] As part of the transfer process, operators must establish that the CO_2 has been permanently contained by demonstrating "the conformity of the actual behaviour of the injected CO_2 with the modelled behaviour; the absence of any detectable leakage; that the storage site is evolving towards a situation of long-term stability."[210]

All costs associated with future monitoring and corrective measures[211] are to be born by the public sector: "There should be no recovery of costs incurred by the competent authority from the former operator after the transfer of responsibility except in the case of a fault or negligence of the operator prior to the transfer of responsibility for the storage site."[212] To offset anticipated costs to the public sector, the EU recom-

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204. *Id.* at 11, 29.

205. *Directive of the European Parliament and Council*, *supra* note 123, ¶ 5.

206. *Id.* ¶ 10.

207. *Id.* ¶¶ 31, 32.

208. *Id.* ¶ 33; *see also id.* art. 18 (Transfer of Responsibility).

209. *Id.* art. 18 1(b).

210. *Directive of the European Parliament and Council*, art. 18 2(a)–(c).

211. *Id.* ¶ 37.

212. *Id.* ¶ 35; *see also id.* at 170, art. 18, ¶ 7 ("In cases where there has been fault of the operator, including cases of deficient data, concealment of relevant information, negligence, willful deceit or malpractice the competent authority shall recover from the former operator the costs incurred after the transfer of responsibility has taken place," otherwise, "there shall be no further recovery of costs after the transfer of responsibility.").

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mends that "[a] financial contribution . . . be made available by the operator to the competent authority . . . [that] should at least cover the anticipated cost of monitoring for a period of 30 years."[213] After transfer to the public sector, "routine inspections . . . shall cease and monitoring may be reduced to a level which allows for identification of leakages or significant irregularities. If any leakages or significant irregularities are detected, monitoring shall be intensified as required to assess the scale of the problem and the effectiveness of corrective measures."[214]

Another means of constraining liability is through a tiered liability scheme, where costs covered in the first tier are solely the responsibility of the individual operator, costs within the second tier are the responsibility of the industry as a whole, and any costs in excess of the first two tiers are born by the public sector. The Price-Anderson Nuclear Industries Indemnity Act (Price-Anderson Act)[215] essentially does this by limiting operator liability to a $300 million insurance policy, plus a $95.8 million cap for each incident (not to exceed $15 million in any given year) that comprises a pooled-risk fund to cover the industry's aggregate public liability, which now stands at approximately $10 billion. This approach implicitly establishes the public sector as the default bearer of operator liability beyond that covered by the first two tiers—individual operators' private insurance and the industry's aggregate public liability.[216]

By enacting the Price-Anderson Act, Congress sought to help encourage private investment in commercial nuclear power by placing a cap on the total liability each nuclear plant operator faced in the event of a catastrophic accident and the total liability the industry would bear collectively.[217] The Price-Anderson Act provides that, in the event a nuclear incident results in damages in excess of the amount of the industry's aggregate public liability, "Congress will thoroughly review the particular incident . . . and take whatever action is determined to be necessary (including approval of appropriate compensation plans and appropriation of funds) to provide full and prompt compensation to the public for all public liability claims resulting from a disaster of such magnitude."[218]

213. *Id.* ¶ 37.
214. *Id.* art. 18 6.
215. 42 U.S.C. § 2210 (2000).
216. New Mexico CCS, *supra* note 66, at 41.
217. U.S. Nuclear Regulatory Commission, Fact Sheet on Nuclear Insurance and Disaster Relief Funds, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/funds-fs.html.
218. 42 U.S.C. § 2210(e)(2) (2000).

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The Price-Anderson Act, however, is designed to provide coverage during the *operational phase* of commercial nuclear reactors, when the risk of catastrophic events is greatest. What this approach does not address, unlike the CERCLA post-closure liability fund or the IOGCC or EU proposals, therefore, is responsibility for long-term liability. The Price-Anderson Act contemplates a viable, solvent industry of entities to maintain insurance premiums and from which the an aggregate public liability, or pooled-risk fund can be generated. So, while the risks for CCS are greatest during the operational phase, making the Price-Anderson Act a viable analog for constraining liability during operations, the Price-Anderson Act is unsuited to address long-term liabilities unique to CCS. Because of the long-term nature of the risks inherent in CCS, any liability framework must contemplate a mechanism that will outlive the life of an operator.

Alternatively, numerous private mechanisms, such as self-insurance, bonding, and requirements for financial assurance, insurance, and pooled risk, exist to defray risk and to cover liabilities that arise from such projects. Generally, self-insurance, bonding, and financial assurance mechanisms are best suited for covering liabilities during the operations phase of projects because these mechanisms contemplate a viable entity capable of generating and sustaining funds to cover liabilities. Because these risk-management devices do not address long-term *in situ* liabilities, they will not be considered in any further detail.

Insurers indemnify individuals and operators against a dizzying array of risks through traditional insurance policy approaches and, increasingly, through innovative insurance products, such as catastrophe bonds.[219] Given these innovations in insurance products and years of technical data on CO_2 injection, some insurance companies may be willing to bear the risk of indemnifying some parts, if not all, of a CCS project.[220] The availability of insurance for CCS and its affordability will probably ultimately depend on how well the indemnified risks can be quantified.[221] While general risk assessments of CCS technology may prove helpful initially, site-specific assessments will ultimately be required for each operation[222] given the variability in geologic conditions and associated risk factors (e.g., faulting and seismic zones; number and location of perforating wells; quality of primary geologic containment strata; existence, if at all, of secondary containment; and distance to near-

219. Christina Ross et al., *Limiting Liability in the Greenhouse: Insurance Risk-Management Strategies in the Context of Global Climate Change*, 43A STAN. J. INT'L L. 251, 311 (2007).

220. *See* Figueiredo I, *supra* note 171, at 654.

221. *Id.*

222. *Id.* at 654.

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est underground source of drinking water), as well as the potential interests and property at stake (e.g., remote location with low property values, or numerous, densely occupied structures with high property values) for each site.

It is worth noting, in this regard, the experience of CERCLA and the concerns raised by insurers and the hazardous materials and chemical industry at the time of its reauthorization in the mid-1980s. The courts have interpreted CERCLA to impose strict, joint and several liability that is retroactive,[223] creating nearly unlimited liability on the part of any and all parties associated with a hazardous waste site. Coupled with the near certainty of leakage at these sites, insurers testified that CERCLA made many hazardous waste activities uninsurable.[224] In the case of hazardous waste, insurers argued that numerous parties might be responsible for delivering waste to a given site over subsequent decades, so identifying parties and allocating their culpability would be difficult and would be arbitrary if done through joint and several liability.[225] Imposition of strict liability was also an impediment to insurance because even if an insured acted with reasonable care and according to industry practice and procedure, violating no regulations, they could still be held liable for harm done through no fault of their own.[226]

Insurers also argued during Senate hearings on CERCLA's reauthorization that "because of the near certainty that leakage will occur and the open-ended nature of the resulting liability," it was impossible for the private sector to provide insurance.[227] As a consequence, pollution insurance became difficult to acquire. Following the reauthorization of CERCLA and RCRA, one legal commentator noted that "[i]nsurers no longer offer pollution policies because of unpredictable judicial determinations of the scope and extent of insurer liability. The future availability of pollution insurance is doubtful."[228]

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223. Lewis M. Barr, *CERCLA Made Simple: An Analysis of the Cases Under the Comprehensive Environmental Response, Compensation and Liability Act of 1980*, 45 Bus. Law. 923, 976 (1990).

224. Judith M. Nixon, *The Problem with RCRA—Do the Financial Responsibility Provisions Really Work?*, 36 Am. U. L. Rev. 133, 156 (1986) ("Open-ended insurer liability forced insurers out of the pollution insurance market by the early 1980s.").

225. *Superfund Amendments and Reauthorization Act of 1986: Before the S. Comm. On Environment and Public Works*, 99th Cong. 87–95 (1985).

226. *Id.* at 140–41.

227. *Insurance Issues and Superfund: Hearing Before the S. Comm. on Environment and Public Works*, 99th Cong. 35 (1985) (statement of William O. Bailey, president of Aetna Life & Casualty and the immediate past chairman of the American Insurance Assoc.) [hereinafter *Insurance Issues and Superfund Hearing*].

228. Nixon, *supra* note 224, at 136.

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Where independent insurers offer no coverage or when coverage falls short, numerous private options remain available to operators, including an industry pooled-risk approach. The Price-Anderson Act,[229] discussed above in the context of liability caps, employs such a pooled-risk approach by requiring licensed operators to contribute to a fund to cover public compensation claims for personal injuries and property damage in excess of privately available insurance—which they are also required to hold in the amount of $300 million. Each licensee is responsible for a maximum contribution to the fund of up to $95.8 million for any single accident, but no licensee must pay more than $15 million for any given accident in a single year.[230] Further, the contribution can be a deferred premium guaranteed through a variety of credit options, such as a surety bond, letter of credit, revolving credit or a term-loan arrangement, maintenance of escrow deposits of government securities, annual certified financial statement showing that cash can be generated and made available, or other type of guarantee "as may be approved by the [Nuclear Regulatory] Commission."[231] Because there are more than 100 commercial nuclear reactors in the United States, the fund stands to raise approximately $10 billion for a single nuclear incident in addition to the $300 million in insurance held by each individual reactor operator.

But all of these private mechanisms implicitly, if not expressly, contemplate coverage during the operations phase of a project because the nature of each mechanism generally requires a solvent entity to be in existence in order to initiate the funding mechanism in question. One possible exception are funds created through a tax or pro-rata payments. These funds ostensibly are contemplated to endure, possibly as a trust, beyond the lifespan of the operators, such as the funds proposed by the IOGCC and the EU. This is a critical shortcoming of private mechanisms. No one contemplates or expects operating companies that undertake CCS to be persistent, at least not to the extent that they might still be extent one or two centuries after closure. For this reason, as well other institutional reasons, the public sector is seen as the default holder of long-term liability.[232] But at what point that transfer should occur and how much liability ought to be transferred are critical questions that need to be addressed so the public can have confidence entrusting operators to undertake these projects.

229. 42 U.S.C. § 2210 (2000).
230. 42 U.S.C. § 2210(b)(1) (2000).
231. 10 C.F.R. § 140.21 (2008).
232. Much in the way the federal government has become the default holder/shepherd/caretaker of commercial nuclear waste in the form of spent nuclear rods intended for the federal underground repository at Yucca Mountain.

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B. Legislative Limits to Liability

In addition to assigning liability by defining financial responsibilities or by transferring liability after a specified time to the public sector, liability can also be constrained or managed by statutorily defining the legal standard of proof necessary to establish fault for various triggering events, such as catastrophic leaks, subsurface trespass, nuisance, and contamination of drinking water sources. Among the benefits of this approach are "the predictability and public confidence gained that could eliminate to some extent the uncertainty that would otherwise serve as an impediment to [CCS] development."[233] Without clear statutory language dictating liability standards, "injectors, insurers, and the public must await the uncertain process of litigation for the courts to determine applicable liability standards."[234] Below are five possible ways to statutorily constrain CCS liability.

1. Negligence

In general, "[w]hen a legislative provision protects a class of persons by proscribing or requiring certain conduct but does not provide a civil remedy . . . the court may . . . accord to an injured member . . . a right of action, using a suitable existing tort action or a new cause of action analogous to an existing tort action."[235] When determining whether the standard of care was breached for such actions, courts may treat statutory or regulatory standards as the standard of care if the legislature did not specify one. If the action in question is demonstrated to violate the statute or regulation, then a court may find that the action is negligence per se, which applies only when "the actor violates a statute that is designed to protect against the type of accident the actor's conduct causes, and if the accident victim is within the class of persons the statute is designed to protect."[236] Negligence per se may be susceptible to traditional tort defenses.[237] Courts may also find that the action violating a statute or regulation establishes strict liability on the part of the defendant.[238] A third possibility is that violation of the statute or regulation

233. NEW MEXICO CCS, *supra* note 66, at 59–60.
234. *Id.* at 61.
235. RESTATEMENT (SECOND) OF TORTS § 874A.
236. RESTATEMENT (THIRD) OF TORTS § 14 (Tentative Draft No. 1, 2001).
237. *Id.* § 14 cmt. (b).
238. RESTATEMENT (SECOND) OF TORTS § 874A cmt. j (noting that violation of a statute or regulation may be treated by courts as creating strict liability).

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merely serves as evidence of negligence, but that is the case, generally, only when the statute specifies such.[239]

Either of these three approaches to statutory negligence, which are often court imposed and vary by jurisdiction, can be adopted legislatively to create a mandated standard of care. This approach would give Congress further control to fine-tune liability for private claims of negligence ranging from the most burdensome, per se liability, to the least, as when a statutory or regulatory violation is mere evidence of negligence. Depending on the public policy goal, each has its place. In the case of CCS, any statute or regulation guiding its development will be somewhat untested. As such, it might be presumptuous to allow CCS statutes or regulations to establish a firm standard of care in negligence actions or for the standards to be legislatively mandated. For this reason, expressly providing that violations of the applicable statutes and regulations are mere evidence in support of negligence might provide the greatest flexibility at the outset of this technology.

2. Strict Liability

The hazardous waste industry has long held that strict liability is a harsh standard as applied under CERCLA and RCRA. Unlike a negligence standard, operators are held liable even if they follow the applicable standard of reasonable care and violate no regulation or industry practice. The American Insurance Association has argued that strict liability as applied in CERCLA verges on a standard of *absolute* liability and improperly lacks any contextual evaluation of the conduct or nature of the activities of the defendant.[240] The Association has also argued that strict liability "necessarily depreciates incentives otherwise available to encourage defendants to act carefully and responsibly," because they are held liable regardless of their actions.[241]

Two important public policy goals, however, are clearly served by imposing strict liability: (1) hazardous waste clean up; and (2) deterrence.[242] The theory behind imposition of strict liability is that it increases the accountability of responsible parties, which in turn motivates operators to enact conservative operating procedures and protective measures to avoid leaks, spills, or other events triggering liability. In the case of

239. *Id.* at § 288B(2), cmt. (d) ("Under some circumstances, however, the fact of the violation may still be accepted as relevant evidence bearing upon the conduct of a reasonable man in the actor's position.").

240. *Hearing on H.R. 5640, supra* note 195, at 628 (statement of The American Insurance Ass'n).

241. *Id.*

242. Edmund B. Frost, *Strict Liability as an Incentive for Cleanup of Contaminated Property*, 25 Hous. L. Rev. 951, 951 (1988).

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CERCLA, the strict liability standard "is both broader and narrower than the owner's liability under the common law" strict liability standard.[243] "It is broader because it can attach whenever a facility is contaminated with any hazardous substances warranting response costs," and "narrow[er] because it applies only to response costs (costs of investigation and cleanup), natural resources damages, and the cost of health assessments," but does not apply "to any liability for personal injury or any third party economic damages which may be attributed to the condition."[244] CERCLA's application of strict liability, therefore, achieves the public policy goal of ensuring operator accountability for high-priority trigger events focused on public health and environmental protection, while essentially limiting liability for claims arising from individual or economic impacts on the private sector, which can reasonably be expected to be more properly and efficiently handled through private tort actions. Further, strict liability also tends to reduce uncertainty for responsible parties and "probably makes claims more predictable than they would be under a negligence standard" for example.[245] Claims would be more predictable because it is generally easier to foresee when and under what conditions the subject parties will be held accountable, due to the fact that the extent of responsibility is more clearly defined, even if the liability is greater.[246] But because strict liability imposes substantial liability on responsible parties, its imposition is properly reserved, at least in its application at common law, for activities deemed to be abnormally dangerous or ultra-hazardous.[247]

3. Joint and Several Liability

Joint and several liability, depending on how expansive or constrained the applicable statutory language is, holds multiple parties fully responsible for all applicable consequences of a triggering event no matter their degree of fault. In the context of environmental protection, joint and several liability creates assurance for the public that *someone* will be held responsible for natural resource damages, similar to the strict liability standard, and so achieves the important public policy goal of accountability. Also like strict liability, joint and several liability can result in a significant expansion of liability because, and depending on how the applicable statute is drafted, any party may be held wholly responsible

243. *Id.* at 952.
244. *Id.* at 952–53.
245. Jeffrey Kehne, *Encouraging Safety Through Insurance-Based Incentives: Financial Responsibility for Hazardous Wastes*, 96 YALE L.J. 403, 419 (1986).
246. *See generally id.*
247. *See* BLACK'S LAW DICTIONARY 932–33 (8th ed. 2004).

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for damages relating to an environmental impact regardless of fault. Of the well-known federal environmental statutes, joint and several liability is probably best known through CERCLA.

Hazardous waste site managers, handlers, and transporters—all liable under CERCLA's joint and several liability standard—chaffed against its application to them because the standard held small handlers and transporters, who may have contributed only nominal quantities of hazardous substances to release sites, liable for the full amount of cleanup costs and resource damages.[248] The hazardous waste industry argued that contrary to congressional intent, "[b]y imposing joint and several liability, potentially responsible parties have no incentive to come forward, absent an enforcement action, to initiate a voluntary cleanup . . . [so this] not only discourages responsible corporate behavior, but it also guarantees cleanups will have to be initiated under adversarial conditions."[249]

Others have argued that Congress imposed joint and several liability in CERCLA as a means to ensure accountability and responsibility, and to achieve a speedy, extra-judicial settlement among the potentially responsible parties.[250] The idea is that the parties who handled the waste, or managed the waste sites, have the best and most accurate information regarding who was responsible for what and when. Therefore, the parties should be able to work out amongst themselves their contributions, without having to litigate the matter.[251] Joint and several liability "appropriately reverses or transfers the burden of proof to those who do have the knowledge or should have the knowledge of what materials went to those sites and that it is in their best interest to negotiate among themselves and come forward with a settlement."[252] For this reason in particular, joint and several liability is arguably a logical, perhaps even a necessary standard of liability when applied to situations where there is much factual information to sort out, such as at hazardous waste sites, and where numerous parties might be responsible over a period of decades.

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248. *See Hearing on H.R. 5640*, *supra* note 195, at 628.

249. *Id.* at 518–19 (statement of John J. Fitzpatrick, Jr., American Petroleum Institute).

250. *See Insurance Issues and Superfund Hearing*, *supra* note 227, at 87–95 (statement of F. Henry Habicht, II, Assistant Attorney General, U.S. Dep't of Justice).

251. *See id.*

252. *Insurance Issues and Superfund Hearing*, *supra* note 227, at 29 (statement of Thomas C. Jorling, Professor of Environmental Studies, Williams College).

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4. Alternative Liability

Alternative liability shifts the burden of proving causation from the petitioner or plaintiff to the respondents or defendants—but only after the petitioner has met an initial threshold of proof—in situations where it is clear that a harm occurred and that one of the defendants is responsible, but when it is unclear which defendant.[253] Alternative liability is especially useful when there are multiple defendants and the evidence is not sufficient to establish which are responsible. If the defendants are not able to produce evidence that is exculpatory or demonstrate that another defendant is responsible, then all the defendants bear equally full responsibility. While alternative liability is not employed universally at common law, it has been urged as a viable solution for difficult toxic tort cases when establishing responsibility for the environmental harm is often a bar to recovery.[254] The plaintiff must still establish a harm and must demonstrate that one of the alleged defendants is responsible, but the plaintiff need not prove which one. Once that proof has been made, the burden shifts to the defendants to exculpate themselves or to establish culpability in another, much like the common law doctrine of res ipsa loquitur.[255] Comments to the Restatement specify that alternative liability applies only "where it is proved that each of two or more actors has acted tortiously."[256] The Restatement also notes that in the common law application of alternative liability "all of the actors involved have been joined as defendants . . . [and] [a]ll . . . have involved conduct simultaneous in time, or substantially so, and all of them have involved conduct of substantially the same character, creating substantially the same risk of harm, on the part of each actor."[257]

Alternative liability serves several important policy goals worthy of consideration. First, in its absence, wrongdoers who actually cause harm to plaintiffs likely avoid liability "merely because the harm which he has inflicted has combined with similar harm inflicted by other wrongdoers," creating what is arguably an injustice.[258] Given an estab-

253. RESTATEMENT (SECOND) OF TORTS § 433(B)(3).

254. *See, e.g.*, Melinda H. Van der Reis, *An Amendment for the Environment: Alternative Liability and the Resource Conservation and Recovery Act*, 34 SANTA CLARA L. REV. 1269 (1994).

255. RESTATEMENT (THIRD) OF TORTS § 17. Res ipsa loquitur has several court-imposed formulations that vary by jurisdiction. The approach intended here, and that overlaps with alternative liability, follows the reasoning that "if the type of accident usually happens because of negligence, and if the negligence, when it occurs, is usually that of the defendant, rather than of some other party," then such circumstantial evidence may be sufficient to establish a prima facie case of negligence. *Id.*

256. RESTATEMENT (SECOND) OF TORTS § 433(B) cmt. (g).

257. *Id.* § 433(B)(3) cmt. (h).

258. *Id.* § 433(B)(3) cmt. (d).

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lished wrong and proof that one of several potentially responsible parties is at fault, a defendant "may justly be required to assume the burden of producing that evidence, or if he is not able to do so, of bearing the full responsibility."[259] Alternative liability, then, may hold responsible parties more accountable and "permits and encourages enforcement of environmental protection statutes," leading to "greater compliance . . . and to more careful action by those handling, storing, and transporting"[260] regulated materials.

California has extended alternative liability to environmental cases in which proving causation among numerous potential defendants has proved impossible.[261] Alternative liability can also be statutorily imposed, especially in situations where more traditional burdens of proof might be difficult to meet, despite clear wrongdoing, and where a significant lapse of time between an event and the resulting injury is likely.[262] Alternative liability can also make many environmental laws more workable by making parties more certain of their responsibility[263] and by encouraging enforcement by lowering the burden of proof.

5. Liability Caps

As discussed in the context of transferring liability to the public sector, legislatively imposed liability caps—either limits on the time of responsibility or financial caps—can be an important means of constraining the liability of potentially responsible parties.

Temporal liability caps, such as those proposed by the IOGCC (a 10-year closure period of responsibility after the operations phase) and the EU (a minimum 20-year, post-closure period of responsibility after the operations phase to terminate after certain conditions are met), serve to effectively cut off the legal and financial liability of responsible parties in a clear and effective way. With temporal liability limits, insurers, investors and principals, regulators, and the public all have advanced knowledge about the extent of party liability and when responsibility may be severed. In the IOGCC and EU proposals, the temporal liability caps are conditional and assume termination of liability only when sequestration projects effectively demonstrate that they have met pre-determined conditions. All of this certainty provides stakeholders the foreknowledge necessary to plan and to anticipate responsibilities and

259. *Id.*
260. Van der Reis, *supra* note 254, at 1270, 1287.
261. *Id.* at 1284–87.
262. *Id.* at 1287–89 (recommending Congress to amend RCRA to impose alternative liability).
263. *Id.*

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risks for various scenarios, but most importantly, to plan and anticipate worst-case scenarios. That is, the risk is not open ended and, assuming regulatory storage conditions can be met, all potential risks have a terminus. Financial caps on liability serve the same purpose, but in many ways provide greater certainty because responsible parties know that they cannot be held accountable for damages in excess of the cap. For investment purposes and calculating a potential return on investment, such certainty is significant. The critical feature of both caps, especially when employed together, is that they have a strong tendency to encourage development of technologies and projects that might not otherwise be undertaken due to significant uncertainties regarding ultimate liability.

By employing some combination of each of these statutory constraints on liability—negligence, strict liability, joint and several liability, alternative liability, and financial liability caps—a CCS scheme can be crafted that is both flexible and sensitive enough to impose appropriate burdens on the highest risks associated with CCS.

VI. STATUTORY AND REGULATORY RECOMMENDATIONS

A statutory and regulatory framework implementing CCS ought to balance the dual policy goals of encouraging private investment with the overriding aim of protecting critical natural resources, the environment, human health and property by holding polluters accountable. To encourage private investment, a statutory and regulatory framework for CCS must limit long-term and catastrophic liabilities but, at the same time, it must avoid an undue liability transfer to the public sector for public policy reasons. For any CCS development, critical environmental and natural resource values must be protected for current and future uses. This means that all potential drinking water sources, including brackish waters, petroleum and natural gas reserves and other mineral deposits, as well as surface resources, such as crops and vegetation, must be considered and protected within a regulatory paradigm that contemplates the unique environmental impacts of carbon. However, the regulatory paradigm must also anticipate potential future subsurface and surface conflicts with other resources and the environment.

For the reasons discussed herein, EPA's proposed rule fails to achieve this balance, in large part, because EPA's selected regulatory vehicle, the SDWA, is too narrowly focused on the protection of subsurface drinking water sources. It was created for that purpose, not to address CCS and climate mitigation, so it does not contemplate the full range of potential impacts and liability issues presented by CCS. Therefore, EPA's proposal is ill-suited for CCS.

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Rather than attempt to cram CCS and climate mitigation into federal statutes that never contemplated such an application, a wholly unique statutory and regulatory framework should be developed. This regulatory framework should comprehensively manage carbon or, at least, regulate carbon from the point of its emission until it is successfully sequestered and stabilized within the earth's subsurface.

To achieve the requisite impetus for private development of CCS, a legal framework overseeing its operation must, where feasible, decrease the legal and regulatory uncertainties inherent in an undertaking of the size and scale of CCS. A legal and regulatory framework must exempt CCS from certain key environmental statutes and regulations that were never intended to regulate CCS. These statutes and regulations are ill-suited to regulate CCS, particularly, because of the liability standards that are onerous or uncertain when applied to CCS. A CCS framework, therefore, must limit operator liability, in terms of time of responsibility and in terms of an absolute dollar figure. As part of this effort to decrease uncertainty and to control liabilities, a CCS framework ought to impose clear standards of liability on specific parties for specific occurrences.

Below is an outline of key statutory and regulatory recommendations that are explored in the following section:

1. Exempt CCS from the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Safe Drinking Water Act (SDWA), as well as from the Clean Air Act (CAA) and the Clean Water Act (CWA).

2. Regulate climate change through a unique, comprehensive, and integrated statutory and regulatory framework from emissions to mitigation.

3. Statutorily limit CCS operator liability by:

A. Providing for the transfer of legal and financial liability to third parties, as well as for the transfer of long-term care, monitoring, and remediation to the federal government after sufficient time has elapsed and data collected to ensure successful containment; and

B. Capping the total amount of damages for each individual operator and for the CCS industry as a whole through the federal indemnity of occurrences exceeding a pre-defined amount.

4. Statutorily define legal liabilities through a tiered framework

A. Limit demonstrable violations of CCS statutes and regulations to mere evidence of negligence or to establishing prima facie negligence, rather than establishing negligence per se;

B. Impose strict liability in a limited number of cases, to be defined as extraordinary circumstances, such as contamination of under-

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ground sources of drinking water or catastrophic releases of CO_2 to the surface or overlying geologic strata;

C. Apply alternative liability, shifting the burden of proof to the CCS operator after a nominal demonstration of impact or damage by the petitioner or movant for certain circumstances probably related to CCS activities; and

D. Impose a negligence standard for all other impacts and occurrences.

A. Statutory Exemptions

While it appears possible that CCS can be exempted from RCRA by EPA itself through a carefully restrictive definition of "CO_2 stream," the same approach does not appear to work for CERCLA for which a statutory exemption is likely necessary to preclude operator liability. Therefore, the uncertainty of CERCLA's applicability and its crippling strict, joint and several liability will likely serve as a strong deterrent to robust private development of CCS. Such a disincentive will make the prospects of achieving CO_2 reductions necessary to stabilize climate change more unlikely. Further, under the SDWA, EPA has regulatory authority through the UIC over all underground injections but for a few exceptions, including "storage of natural gas . . . and specific hydraulic fracturing fluids."[264] Because CCS is not contemplated to fit within one of these statutory exceptions and because EPA expressly believes that it was Congress' intent for it to regulate CCS through the UIC,[265] CCS operators will be subject to the liability framework of the UIC and essentially subject to unlimited legal liability.[266] This merely compounds the uncertainty of the proposed CCS regulatory framework.

Consequently, it is in the best interests of national climate change policy to exempt CCS from all potentially applicable federal environmental statutes and to craft a statutory and regulatory framework with the unique environmental and liability factors of CCS in mind. Such a framework must balance the policy goals of encouraging CCS development to achieve significant near-term CO_2 emissions reductions with concerns for transferring an undue share of project liability to the public

264. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,491, 43,496 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

265. *Id.*

266. *Id.* at 43,522 ("[O]wners or operators may still be held responsible after the post-injection site care period has ended" and the "[t]rust responsibility for potential impacts to USDWs remains with the owner or operator indefinitely under current SDWA provisions.").

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sector, all against the backdrop of protecting against degradation of human health, the environment, and critical natural resources.

In consideration of these countervailing factors, a comprehensive CCS framework should impose environmental standards on CCS development of equal or greater rigor as the statutes from which it would be exempted. So while CCS should be exempted from the SDWA, RCRA, and CERCLA, among possibly other federal statutes, such as the CAA and the CWA, it should not be exempted from the principles contained within them; protection of human health, the environment, and critical natural resources are to be the paramount concerns.

B. Comprehensive Regulation of Anthropogenic CO_2 from Emissions to Mitigation

CCS regulation should be integrated within a comprehensive legal framework addressing emissions of anthropogenic carbon and its mitigation. Carbon probably ought not be regulated as an air pollutant within the framework of the Clean Air Act. While the reasoning for this particular statement is beyond the scope of this paper, the gist is that while the Clean Air Act is well-suited to control and regulate emissions of toxic pollutants with localized effects, it may be less adept at regulating greenhouse gas emissions that are not toxic and do not have localized effects. It is also not at all clear that the Clean Air Act is well-suited to regulate emissions from dispersed and mobile sources, which account for a significant portion of carbon dioxide emissions.[267] Emissions reductions are but one aspect of CO_2 control and management. Any framework that seeks to limit CO_2 must go beyond emissions controls to employ a broader management scheme.

CO_2 is emitted from a vast array of sources that the Clean Air Act was not designed to regulate and would be inept at controlling, such as homes and buildings, as well as individual cars, trucks, and other mobile sources. In the United States, these sources account for more than 1.8 megatons of greenhouse gas emissions, the second-largest source of greenhouse gas emissions.[268] Whether carbon emissions are regulated

267. *See* Editorial, *Regulating Carbon: EPA rules under the Clean Air Act aren't the way to do the job, but a carefully crafted tax might be*, WASH. POST, Mar. 24, 2009, at A12 (arguing that the Clean Air Act "enacted in 1970, was never intended to deal with greenhouse gases and is not suited to that task"), *available at* http://www.washingtonpost.com/wp-dyn/content/article/2009/03/23/AR2009032302024.html.

268. U.S. EPA, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2007 ES-4 (EXECUTIVE SUMMARY) (2009) (EPA measures carbon dioxide equivalent in teragrams, which is the same numeric value as megatons), *available at* http://www.epa.gov/climatechange/emissions/downloads09/07Inventory.pdf.

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through an industry-specific, cap-and-trade scheme or through a broad-based carbon tax, the regulation of anthropogenic carbon ought to be approached holistically to achieve maximum effect, targeting mitigation and emissions reductions throughout CO_2's life-cycle. Because CO_2 is unlike any emissions regulated, it requires a unique regulatory framework for climate change mitigation to be effectively realized.

Including CCS within a unitary comprehensive legal framework would essentially allow Congress to approach the regulation of CCS from scratch and avoid having to work within multiple statutory frameworks that might be implicated by the regulation of CO_2. Rather than implicating multiple environmental statutes—regulations that failed to contemplate mitigating or reducing greenhouse gas emissions and that have specific purposes and goals, which may conflict with carbon regulation and mitigation—Congress should instead approach carbon emissions as a distinct and discrete environmental challenge.

This approach is no different than the way all previous major environmental problems were originally addressed legislatively. Pollution in America's waterways was addressed by the CWA, which regulates the discharge of pollutants into water bodies; air pollution was curtailed by the CAA; drinking water sources are now protected by the SDWA; solid waste is regulated by the Solid Waste Act; and hazardous materials are regulated by RCRA and CERCLA. The list goes on. Addressing the growing problem of carbon emissions should be no different; there should be a Climate Change Mitigation Act that specifically addresses carbon emissions, controls, and mitigation.

C. Statutory Limits on Liability

Within this unitary framework, CCS will play a significant role in the early stages of climate mitigation until the global economy is able to shift away from fossil-based fuels. Despite this prediction, the implementation of CCS on a commercial scale has been stunted; notwithstanding strong technical understanding of the process and years of experience injecting significant volumes of CO_2 into various subsurface formations. As discussed above, the chief impediment to commercial deployment is uncertainty regarding the legal and regulatory framework guiding its development and questions about what level of liability will be imposed. This uncertainty can be addressed directly through clear statutory limits on liability drafted in a way that still imposes responsibility on operators and other principles, but that does not create open-ended liability.

There are two important and general ways a CCS statute should limit operator liability: (1) provide for the transfer of liability generally, as well as for the transfer of long-term care, monitoring, and remediation

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of the project site to the federal government,[269] after sufficient time has elapsed and data have been collected to ensure that injected CO_2 has been successfully contained and after the risk of catastrophic failure has significantly decreased; and (2) cap the total amount of damages each operator would be individually responsible for and that the CCS industry would be collectively responsible for.

Providing for the transfer of liability generally promotes an efficient market. Operators ought to be able to freely transfer their financial liabilities to entities that might be better positioned to manage the risk. This approach, as discussed above, promotes a more efficient distribution of risk and liability and encourages operators with expertise in CCS to undertake a project without fear that they will be unable to extricate themselves at a later date.

Transferring full financial and legal liability to the public sector, assuming the project meets certain permit conditions as prerequisites, sets a finite time frame during which an operator could be responsible for the project. Having clearly defined and highly protective transfer conditions provides operators a strong incentive to employ best practices so long-term, indefinite liability can be relinquished and avoided. The time to transference must not be too short so that stability of the CO_2 plume is still uncertain or shifting, or so operators are encouraged to operate shortsightedly. A period of 50 years, as recommended by EPA in its proposed rule as the period for post-closure financial responsibility, is probably a reasonable time frame given the paucity of data on time to stability, with the possibility of transfer occurring sooner if the operator can demonstrate that the CO_2 plume is adequately contained. Critical to this free-and-clear transference to federal responsibility is the exception that an operator will remain liable should there be a subsequent finding of negligence, as recommended by the proposed EU directive.

These mechanisms address the problem of incurring indefinite liability over time, but do not address the potentially enormous near-term financial risks posed by a full-scale commercial CCS development. To address this concern, financial liability must also be carefully managed.

The Price-Anderson Act was enacted to encourage private development of nuclear power at a time when the liabilities for managing nuclear facilities were prohibitive and unknown. That framework has served the nuclear power industry well. As of 2008, 104 nuclear facilities

269. The Lieberman-Warner Climate Security Act of 2008, S. 3036, 110th Cong., § 8004(a) (2008) (requiring EPA to study the feasibility of "potential Federal assumption of liability with respect to" CCS).

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are licensed to operate in the United States.[270] Since the Act's inception in 1957, all liability claims have been covered by each facility's individual liability insurance coverage,[271] and no claim has had to draw from the pooled-industry fund. Consequently, the third tier that caps industry liability—granting federal indemnity—has also never been required.[272]

Given the success of the Price-Anderson model—nuclear facilities were built and adequate financial and legal liability has been maintained throughout the operation of each nuclear facility—an analogous liability framework could similarly be employed to encourage CCS development. Each operator would be individually financially responsible for an initial tier of liability, capped at the maximum commercially insurable amount. Each operator would also then be responsible for deferred premium contributions to an industry-funded risk pool in the event an occurrence exceeds the operator's first tier of liability. Similar to the Price-Anderson Act, CCS operators would have to demonstrate through one of several alternative means that they have the financial capacity to pay the premium contribution amount. Beyond this second tier of liability, the federal government would then indemnify the industry against all additional claims in excess of the combined value of the first two tiers of financial liability. To protect the public sector (i.e., the taxpayer) against indefinite financial liability, Congress could simply cap federal financial liability on a per-project or annual basis.

A tiered approach maintains primary responsibility on the operator, so the requisite incentives for performance remain, but the whole industry's financial resources are brought to bear for larger and more dynamic impacts than one entity could mitigate. This strategy also encourages the industry to self-regulate and to apply peer pressure within the industry group, encouraging higher performance to avoid industry-wide responsibility for larger occurrences. Further, the immediate burden on the industry is not so great because the pooled-risk funding requirement, as for the Price-Anderson Act, is retroactive and only activated at the time of a triggering occurrence (i.e., when the occurrence costs exceed the first tier of liability). So, while demonstration of financial capacity is still necessary, the second-tier costs need not be incurred until an event triggers the risk-pool's funding. Only after the first two tiers of financial liability are exceeded would federal indemnity be engaged. For a nascent industry with many unknowns when operating at

270. U.S. Nuclear Regulatory Commission, Map of the United States Showing Locations of Operating Nuclear Power Reactors, http://www.nrc.gov/info-finder/reactor (last visited Mar. 29, 2009).

271. Approaches to Geologic Sequestration, *supra* note 161, at 14.

272. *Id.*

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full scale, a three-tiered liability approach employed during operations and injection—by far the riskiest period for CCS development[273]—provides optimal assurance that adequate financial resources and the necessary liability caps are in place to encourage responsible development.

Determining the proper financial responsibilities at each tier will require some detailed economic investigations and analyses of the costs, potential impacts, and availability of insurance coverage. Similarly, studies on how these costs would in turn affect a project's financial viability for a wide range of CCS projects and environments would need to be conducted. Such investigations should be undertaken by Congress, industry, independent research groups, and advocates during the fact-finding stage of the legislative process.

While a Price-Anderson analog would account for the periods of operations, injection, and post-closure prior to transfer of liability to the federal government, a liability framework must still be employed to constrain long-term risk and to avoid burdening the public sector with the full costs of indefinite monitoring, verification, and remediation. Probably the most commonly recommended means of achieve this is through an industry-funded, post-closure tax or fee, assessed on a per-volume basis throughout the life of the CCS project while it remains the responsibility of the operator. Funds for each CCS project would remain tied to that project and would be used only for monitoring, verification, and remediation for the period following transfer to the federal government.

D. Statutorily Defined Liabilities

One of the major drawbacks of the UIC program as a regulatory framework for CCS is that it does not clearly define the legal liability of operators or injectors, though it appears to impose strict liability.[274] An across-the-board imposition of strict liability for CCS might make more sense if CO_2 were a hazardous material and if the technology were truly untested. The oil and gas industry, however, has developed some expertise in CO_2 over decades of injection and, for nearly as long, has been injecting large volumes of truly hazardous substances, such as acid gas, without significant or widespread problems. Nonetheless, the primary unknowns regarding CCS remain its viability and effectiveness at scale. Therefore, selective imposition of higher standards of liability to protect critical resources, such as underground sources of drinking water and

273. *See* Cédric Philibert et al., Org. for Econ. Co-Operation and Dev. and International Energy Agency, Carbon Capture and Storage in the CDM 5 (2007) ("The risk of CO_2 leaks is higher during and shortly after the injection phase, when the gas pressure is high."), *available at* http://www.iea.org/papers/2007/CCS_in_CDM.pdf.

274. New Mexico CCS, *supra* note 66, at 53.

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perhaps oil and gas reserves, supports a policy that is protective of critical natural resources and imposes a high level of liability where it belongs. However, the imposition of a high level of liability should be targeted and selective.

In this approach, strict liability should be imposed in cases of extraordinary circumstances, such as when underground sources of drinking water are contaminated, or when there is a catastrophic release of CO_2 to the surface or to an overlying geologic formation. Extraordinary circumstances can be statutorily defined through a non-exhaustive list of occurrences. The value of this approach is that it constrains an operator's liability to only those events which have been identified as having potentially the most significant negative impacts, while assuring the public that these critical resources are protected by a high standard.

Similarly, operators should be responsible for total response costs and mitigation if operators of a CCS site are found to be negligent or to have violated a standard or regulation during the operations and post-closure phases—even if that finding comes after transfer of liability to the federal government. Furthermore, if initial pilot and demonstration projects yield data suggesting that there are greater risks for certain occurrences than anticipated, additional liability can be imposed on operators for those particular occurrences.

Because of the unique characteristics and environmental impacts of CCS and CO_2, it is possible that certain occurrences within a CCS project's area of review can be presumed to be a consequence of CCS (such as subsidence, increased seismicity, or vegetation die off) depending on the geological setting. In general, these impacts may not rise to the level of requiring the imposition of strict liability, which might arguably impose too great a burden, but they still elicit heightened public policy concerns because of their potential seriousness. Presumptions that particular effects result from CCS acquire greater validity with increased knowledge of the project area's history, its geology and subsurface structures and strata, as well as with monitoring over time. Strict liability, however, might be too great a burden for such impacts because the balance between the probability of the cause and the importance of the impacted natural resource or property is too narrow. In the case of impacts to subsurface drinking water sources or catastrophic releases of CO_2, the importance of the natural resource is substantial so the policy goal of protecting it and holding responsible parties accountable sufficiently tips the scale to justify imposition of strict liability. For impacts that are arguably presumptively CCS related, but for which the balance between the relative certainty of the cause and the importance of the impacted natural resource is closely weighted, a less onerous liability option that is still highly protective is alternative liability.

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As discussed above, alternative liability requires the petitioner or movant to establish some nominal level of proof of impact or damage (such as demonstrating that increased seismicity has damaged building foundations) which would then shift the burden to the operator, who must prove that CCS was not the cause. Proving a negative is often a formidable challenge and one that operators may choose to forgo, but rebuttable presumptions are far less burdensome than strict liability.

One benefit of employing alternative liability is that operators will have substantial incentive to collect a broad range of baseline data to fully characterize the project area and to take measures prior to injection that head off potential future liability problems. As discussed above, alternative liability is protective of the environment and natural resources because it shifts the burden of proof to the operator and because establishing a negative, even by a mere preponderance of the evidence, can be difficult. By shifting the burden to the operator, alternative liability puts the burden where it justly belongs, with the entities that have the most information and knowledge regarding their impacts and the injection of CO_2. Further, it reduces the likelihood that an operator could avoid liability when harmed parties are unable to muster evidence to establish cause, despite a significant and obvious harm that is more likely than not due to the operator's activities.

It is possible under alternative liability that some operators will be held accountable for "false positives" because they are unable to meet the standard of proof required to be held blameless. To reduce this possibility, the applicable standard for operators to meet, once the burden has shifted to them, could be a preponderance of the evidence. This would serve the dual policy goal of placing the burden with the party holding the bulk of the information on the alleged impacts, but would also avoid making liability for such harms unavoidable. Imposing a reasonable standard of proof could be especially important given the complexity of subsurface geologic structures and the numerous causes of harm that operators cannot control.

Finally, while alternative liability at common law has been especially useful when there are numerous potential responsible parties, it could just as easily achieve the same policy goals if there is but one potential responsible party. In the CCS industry, it is much more likely that there will be one primary operator per injection project, which is dissimilar to the hazardous waste industry or other environmental fields for which multiple parties may have contributed to harm. In CCS, there may be numerous emissions sources and numerous transporters, but there will likely be only one operator bearing sole responsibility for the content of the injected CO_2 stream and its subsurface and surface effects. This would make application of alternative liability to CCS somewhat

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unique, but it would still accomplish the primary goal of shifting the burden of proof to the party with the critical information on in order to avoiding injustice. For these reasons, alternative liability should be employed for a specified set of injuries or occurrences that can be identified as uniquely related to CCS but that are not so significant that they justify strict liability.

In a related matter and for the reasons discussed above, joint and several liability is ill-suited and unnecessary as applied to CCS. Congress imposed joint and several liability in CERCLA, for example, as a means to ensure accountability and responsibility at sites where multiple parties over many years might have some culpability. The liability standard was also imposed as an incentive for potentially responsible parties—the entities with all the critical information to determine responsibility—to reach extra-judicial settlement. Joint and several liability might make sense as a highly protective standard for sites with complex transactional histories and numerous parties, but nearly all of the policy justifications can be achieved through selective imposition of alternative liability.

This approach has the additional benefit of constraining liability to ensure CCS is not discouraged. CERCLA imposes joint and several liability across the board indiscriminately. That standard is probably unnecessary and even damaging in the case of CCS for which a tiered liability approach—ranging from strict liability for a few significant impacts, to alternative liability for less significant harms, and to a straight negligence standard for everything else—provides a more controlled approach to managing and constraining liability, while still providing highly protective standards for critical resources and the most likely impacts.

VII. CONCLUSION

Average global temperatures are rising and, regardless of the emissions reductions society achieves in the immediate future, temperatures will continue to rise. Only if society manages significant reductions, on the order of 85 percent of current emissions levels, can atmospheric concentrations of greenhouse gases be stabilized to around a doubling of pre-industrial levels. That effort will help limit warming to roughly 2°C—still a significant global temperature increase with significant ecological and economic impacts.

To maintain that stability, fossil fuels must be jettisoned as society's primary energy source. But to achieve those emissions cuts without provoking a vast and precipitous disruption of social and economic networks, burning of fossil fuels must be phased out over time—especially since the abundance, accessibility, relative affordability, and reliability of coal, can help meet the projected growth in energy demand. Addition-

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ally, no alternative energy source, or combination of sources, stand at the ready for full, commercial-scale deployment to replace fossil fuels. Therefore, to achieve the necessary emissions cuts, technologies must be employed that allow for continued reliance on fossil fuels but that can achieve significant reductions in CO_2 emissions.

The benefits of CCS can be substantial and should be seriously considered as a requirement for any permitted fossil-fuel electricity generating plant, but especially for proposed coal-fired plants. For example, if all current coal-burning power plants were replaced by Integrated Gasification Combined Cycle plants with CCS, "total emissions of CO_2 would decline by 60 percent to about 0.9 Gt per year. If, in addition, all carbon emissions from natural gas plants were also captured and sequestered, overall emissions would drop further, to 0.4 Gt per year or 80 percent below current levels."[275]

Because CCS is highly analogous to technologies and methods long-employed in the oil fields for EOR, it is a ready technology that can theoretically achieve required emissions reductions immediately and for the foreseeable future. For CCS to be realized on a commercial scale of sufficient magnitude, however, a statutory and regulatory framework must be developed that is protective of natural resources, the environment, and human health; yet, the framework must also manage CCS operator liability. Without some judicious limitations on operator liability, private enterprise and investment will not support a timely implementation of this critical technology. To achieve the right balance of accountability and environmental protection necessary to garner public support for an industrial undertaking of such an enormous scale, a wholly unique statutory and regulatory paradigm ought to be developed. Such a framework would apply tiered approaches to both legal and financial liabilities, holding operators most accountable when critical natural resources are at risk or jeopardized.

This approach is at odds with some analyses that perceive the current regulatory paradigm as sufficient.[276] Such arguments derive from a concern that early over-regulation can have the unintended consequence of stifling CCS development by erecting barriers to its natural development.[277] While it is undoubtedly important to tread carefully to avoid over-regulating an industry that has had no time to evolve on its own,

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275. Morgan et al., *supra* note 6, at 59 (noting that an 80 percent reduction is "roughly the magnitude of the electric sector's share of the long-term emissions reduction that scientists estimate will be required to stabilize CO_2 concentrations in the atmosphere at twice pre-industrial levels").

276. *See, e.g.*, Marston & Moore, *supra* note 35, at 421.

277. *Id.* at 490.

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none of the foregoing recommendations are significantly divergent from the regulations that would otherwise apply. Rather, these recommendations seek to streamline CCS regulation within a comprehensive and fully integrated carbon management scheme. This comprehensive CCS regulation scheme can achieve the foundational policy goals by clarifying applicable environmental and regulatory requirements while also exempting CCS from key federal environmental provisions. The fundamental benefit of comprehensive CCS regulation is that the above recommendations impose liability more selectively, which incentivizes and promotes CCS development.

Of course, the liability scheme should be reviewed frequently at the outset of CCS deployment, perhaps as often as every year for the first decade or so but then less frequently as the technology becomes more robust. If CCS is to succeed, it must be publicly acceptable, which means the public benefits must outweigh the costs, the environmental risks must be disclosed, and the process needs to be transparent and comprehensible. Perhaps most importantly, however, the injectors and operators of CCS facilities must be held accountable.[278] The foregoing recommendations, though skeletal in their presentation, provide such a framework with the proper balance of accountability and incentive.

278. *See* Wong-Parodi et al., *supra* note 43, at 5 ("[P]ositive perceptions of geologic sequestration by the public [are] important to its success, because as we have seen, (negative perceptions) can be enough to kill a technology.") (internal quotes omitted).

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