RECONCILING KING COAL AND CLIMATE CHANGE: A REGULATORY FRAMEWORK FOR CARBON CAPTURE AND STORAGE

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INTRODUCTION

The root cause of climate change is the buildup of heat-trapping greenhouse gases (GHGs), most significantly carbon dioxide (CO_2), in the Earth's atmosphere.[1] The accumulation of these gases creates a "thermal blanket" of sorts, resulting in excessive solar heat and energy in our atmosphere.[2] Coal-fired electric power plants are responsible for almost forty percent of GHG emissions in the U.S.[3] Mitigating the onset of climate change, therefore, will require vast reductions in GHG emissions in the power generation sector.

Our article presupposes that coal will continue to provide a primary fuel for power generation for years to come. Accepting the reality of coal-based electricity, we examine an emerging technology referred to as carbon capture and storage or carbon capture and geologic sequestration (in either case, CCS). CCS may become an important strategy to combat climate change because it can minimize CO_2 emissions from fossil-fuel-powered sources.[4] CCS involves removing or "capturing" the CO_2 emissions that are a by-product of all fossil-fuel combustion, compressing that gas, and ultimately injecting the CO_2 deep underground where it cannot escape into the atmosphere as a climate change agent.[5] CCS is hailed as a "bridge

1. We prefer the term "climate change" to "global warming." While the phenomenon results in a general trend of increased global temperatures, the effects are not uniform. Because of warmer temperatures in some areas, ocean currents and atmospheric weather patterns will be disrupted, which could actually result in the cooling of some areas, such as western Europe. Thus "climate change" is more precise. *See* F. Giorgi et al., *Simulation of Regional Climate Change with Global Coupled Climate Models and Regional Modeling Techniques*, *in* THE REGIONAL EFFECTS OF CLIMATE CHANGE 427, 433 (Robert T. Watson et al. eds., 1998) (describing the potential for "a marked cooling over the northwest Atlantic throughout the year, which [could] . . . lead to a cooling over part of Europe in winter.").

2. Robert N. Stavins, *A Meaningful U.S. Cap-and-Trade System to Address Climate Change*, 32 HARV. ENVTL. L. REV. 293, 293 (2008).

3. Power plants alone generate approximately forty percent of total U.S. emissions. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK, 13 (2007), http://www.eia.doe.gov/oiaf/archive/aeo07/pdf/0383(2007).pdf.

4. The Electric Power Research Institute speculates that "[t]he greatest reductions in future U.S. electric sector CO_2 emissions are likely to come from applying carbon CCS technologies to nearly all new coal-based power plants coming on-line after 2020." ELECTRIC POWER RESEARCH INSTITUTE, THE POWER TO REDUCE CO_2 EMISSIONS, 3 http://mydocs.epri.com/docs/public/DiscussionPaper2007.pdf (last visited Dec. 16, 2009). The recently enacted American Recovery and Reinvestment Act, the so-called "stimulus package," includes $3.4 billion for coal research and development, a portion of which "is expected to be used to fund projects under the Clean Coal Power Initiative program, focusing on projects that capture and sequester greenhouse gases." ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, SR-OIAF/2009-03, AN UPDATED ANNUAL ENERGY OUTLOOK REFERENCE CASE (2009), http://www.eia.doe.gov/oiaf/servicerpt/stimulus/arra.html.

5. *See infra* Part II for a technical primer on CCS and its use in conjunction with coal plants.

technology," a technology that will allow us to minimize global CO_2 emissions from fossil fuels such as coal or natural gas while cleaner, more renewable, energy resources are developed. With widespread use in the generation sector, it is possible that as much as ninety percent of CO_2 emissions from coal-fired power plants could be captured and safely sequestered using CCS.[6]

The conventional wisdom is that either Congress or the Environmental Protection Agency (EPA) will exact a charge on GHG emissions in the near future, in the form of a cap-and-trade or carbon tax system, or through rulemaking under the Clean Air Act.[7] A charge on GHG emissions would have the effect of making power generation more expensive, which would prompt power generating companies to seek ways, such as CCS, to reduce their CO_2 emissions and save money.[8] In light of the looming prospect of federal regulation, CCS is a promising technology that could allow our economy's industrial base to continue functioning.

Geologists are optimistic that CCS, utilized broadly in conjunction with new or existing power plants and industrial emitters, can safely and effectively sequester colossal volumes of CO_2.[9] CO_2 injection has been used successfully for decades to assist in oil recovery operations, though not for the primary purpose of permanent storage.[10] Large-scale injection and storage would allow industry to sequester CO_2 in the short term, while "greener," more sustainable power sources are developed for long-term use. Additionally, CCS technology, once fully developed, can be exported to large emitters such as China and India—nations that must be partners in our efforts to curb the global release of GHGs.

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6. U.S. Dep't of Energy, Nat'l Energy and Tech. Lab., Technologies: Carbon Sequestration, http://www.netl.doe.gov/technologies/carbon_seq.

7. Legislation to establish a cap-and-trade program for CO_2 emissions is currently being debated in the 111th Congress and is likely to be passed and signed into law in 2010. American Clean Energy and Security Act, H.R. 2454, 111th Cong. (2009). The EPA is also developing rules, pursuant to the Supreme Court's order in *Massachusetts v. EPA*, 549 U.S. 497, 533 (2007), to regulate GHGs for the first time. EPA regulation may occur only in the absence of congressional legislation, which would likely preempt EPA's authority to regulate in the area. *See* Juliet Eilperin, *EPA Presses Obama to Regulate Warming Under Clean Air Act*, WASH. POST, Mar. 24, 2009, at A1.

8. The relative advantages or disadvantages of various methods of GHG regulation is beyond the scope of this article. We do believe, however, that GHG regulation in some form is a prerequisite to industry wide use of CCS. Without a "charge" on CO_2 emissions, it is unlikely that industry will invest in and utilize CCS. The MIT Coal Energy Study Committee speculates that CCS becomes "cost competitive" when CO_2 emissions reach a price of thirty dollars per ton. MASS. INST. OF TECH., THE FUTURE OF COAL SUMMARY REPORT, at xi (2007), *available at* http://web.mit.edu/coal/The_Future_of_Coal_Summary_Report.pdf [hereinafter MIT REPORT].

9. *See id.* at xi–xii.

10. The success of "enhanced oil recovery" (EOR) using CCS indicates that CO_2 can be injected and stored safely. RICHARD C. MAXWELL ET AL., OIL AND GAS 13–14 (8th ed. 2007).

Ironically, the major impediments to the widespread deployment of CCS are not scientific or technological, but legal and regulatory. While scientists are confident that it will soon be possible to build or retrofit "capture-ready" power plants that can safely store vast quantities of CO_2 underground, there is no consistent legal framework to regulate these projects. Utilities that may be inclined to invest in capture technology do not yet know the rules by which they will be bound. A uniform regulatory framework is a prerequisite to large-scale investment in CCS.

Federal regulations and state common law do not contemplate the infinite geologic storage of gas, which would be required to prevent the gas from escaping and contributing to climate change. There is no precedent for many of the property law questions that would arise if such an escape occurred. Issues might include conflicts between owners of the surface, mineral, and adjacent estates, or subsurface trespass claims resulting from "migration"[11] of CO_2 underground. Further, the infinite storage of CO_2 creates many liability issues, including the question of infinite liability for parties who undertake CCS. Industry is naturally risk-averse. It is unlikely that CCS will flourish as long as there is legal uncertainty surrounding the acquisition of storage space, the injection process, and liability for post-injection incidents. This article examines these and other issues that act as disincentives to the large-scale deployment of CCS in the United States. We address several of the major legal and regulatory barriers individually, ultimately proposing model legislation that will enable effective regulation.

Part I begins by framing the challenges posed by global climate change and the options available to mitigate its effects. We examine the available sources of electric power generation, concluding that coal-based generation will be necessary to support our energy needs for some time to come. Our discussion makes clear how crucial CCS coupled with coal-based generation is to stabilizing global CO_2 levels.

Part II describes in technical detail how underground injection and storage actually works. In this Part, we outline the major legal and regulatory barriers and disincentives to CCS, including the novel property rights issues that will arise, the absence of a post-injection liability system, and the lack of a comprehensive permitting scheme for CCS.

Part III seeks to provide solutions—in the form of a model regulatory framework—that will facilitate the development of CCS technology. We explain how the current patchwork of state and federal regulations, most of which were drafted to regulate natural gas storage and transport or small-scale CO_2 injections in oil recovery operations, are inadequate for large-

11. "Migration" refers to the underground movement of sequestered CO_2.

scale CO_2 injection and perpetual storage. We evaluate two existing CCS bills, introduced in Wyoming and Kansas, and model legislation proposed by the Interstate Oil and Gas Compact Commission (IOGCC). Finally, expanding on these existing models, we provide our own legislative recommendations to clarify property rights questions and provide for the government assumption of long-term liability. Our goal for this article is to help create an effective regulatory framework that will allow CCS technology to develop and flourish and, ultimately, be used as a way to sequester GHG pollution worldwide.

I. CLIMATE CHANGE & CCS

There are many climate-altering GHGs, including CO_2, methane, nitrous oxide, and water vapor.[12] When concentrated in the Earth's atmosphere, these gases allow in solar heat and energy but prevent much of that energy from leaving the atmosphere, which results in a "greenhouse effect."[13] This phenomenon prevents the natural process in which solar heat that enters the atmosphere to warm the planet is then radiated or reflected back into space.[14]

Of the many climate-altering GHGs, CO_2 has the most significant impact. CO_2 from transportation and energy sources such as power plants comprises over eighty percent of climate-altering gases.[15] The accumulation of CO_2 is the primary driver of the greenhouse effect and climate change. Therefore, mitigating the effects of climate change will require reducing CO_2 emitted from energy sources, thereby reducing the buildup of atmospheric CO_2.

The Intergovernmental Panel on Climate Change (IPCC), Princeton's Carbon Mitigation Institute, and other prominent organizations suggest that annual GHG emissions will have to be significantly reduced from their current levels to stabilize the global climate and prevent the worst effects of

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12. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 1995: THE SCIENCE OF CLIMATE CHANGE 14 (J.T. Houghton et al. eds., 1995).

13. To a certain extent, the greenhouse effect is a natural function and is necessary to sustain human life on the planet. The problem, however, is that today's "greenhouse" is trapping too much heat, and the earth is getting too warm. *See* U.S. Envtl. Prot. Agency, Climate Change Science, http://www.epa.gov/climatechange/science/index.html (last visited Oct. 26, 2009) (providing a basic overview of the process of climate change).

14. *Id.*

15. U.S. DEP'T OF ENERGY, ENERGY INFO. ADMIN., GREENHOUSE GASES, CLIMATE CHANGE, & ENERGY POLICY (2008), http://www.eia.doe.gov/bookshelf/brochures/greenhouse/Chapter1.htm (last visited Oct. 26, 2009).

climate change.[16] We use these stabilization models as a guide in our analysis. This part will first describe the options that exist to reduce CO_2 emissions and stabilize global GHG concentrations at sustainable levels, ultimately concluding that coal-powered generation with CCS will have to be part of a comprehensive GHG reduction strategy.

A. Global GHG Emissions and the Princeton Model

Of the myriad climate models and analyses, the Carbon Mitigation Initiative's "stabilization" concept, the so-called "Princeton Climate Game," provides the best illustration of the options available to address climate change.[17] The concept, created by Princeton's Carbon Mitigation Institute, sets a GHG target and then provides options for how to achieve that target.[18] As a starting point, the Princeton model suggests that to avoid the most catastrophic effects of climate change, global GHG concentrations will have to be stabilized at current levels for the next fifty years and then be reduced after 2060.[19]

Princeton's "stabilization first, reduction later" model may sound readily attainable, but it is actually quite ambitious. To reach a flat line of global GHG concentrations, we will have to reduce the projected global CO_2 emissions by seven billion tons each year, which will result in approximately 175 billion tons of carbon avoided by 2055.[20] This is the critical amount necessary to avoid the worst forecasted effects of climate change.

Princeton's interactive game allows users to determine which mitigation technologies or sources of power generation to use to reach stabilization.[21] The goal is an annual global reduction of seven billion tons of CO_2, but there are several ways to reach this number.[22] The choices available include nuclear power, renewable resources such as wind and solar farms, hydrologic and geothermal generation, reforestation or

16. *See* LENNY BERNSTEIN ET AL., CLIMATE CHANGE 2007: SYNTHESIS REPORT (Abdelkader Allali et al. eds., 2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (summarizing the effects of climate change and options for adaptation and mitigation).

17. *See* Carbon Mitigation Initiative, Princeton University, Stabilization Wedges, http://cmi.princeton.edu/wedges (last visited Oct. 26, 2009).

18. *Id.*

19. *Id.* at 1 (Potential catastrophic consequences of climate change include the loss of polar ice sheets, rising sea levels, and an increase in category five hurricanes. Changes in the sea level and weather patterns would have serious consequences on coastal communities, agriculture, and climate worldwide.).

20. *Id.* at 3.

21. *Id.*

22. *Id.*

afforestation, and coal combustion with CCS.[23] The Princeton game, which forces users to make choices about how to reach the necessary reduction level, reveals just how difficult of a challenge we face. The game illustrates that, even if we are able to maximize generation from renewable sources such as solar and wind power, coal with CCS will almost certainly have to be a part of the energy equation for years to come.

B. Coal as a Fuel Source[24]

Princeton's dispassionate assessment leads us to the conclusion that coal will not disappear as an energy source in the immediate future. Coal produces such a large percentage of electricity generation that other sources alone cannot meet the country's demands in the short term. Coal-burning power plants currently provide half of the electricity produced in the U.S. and are responsible for one-fourth of global carbon emissions.[25] Cleaner, carbon-neutral sources such as wind and solar energy, or the more controversial expansion of nuclear power generation, have the potential to replace most or all coal-generated power in the future.

But at present, the U.S. is not able to meet its base load power needs solely with renewable or carbon-neutral options.[26] The nation simply does not have the infrastructure to allow renewable energy sources such as wind and solar to replace fossil-fuel power generation in the near term. The expansion of nuclear generation faces still greater opposition across the political spectrum due to concerns over public health and national security.

Coal has strong political support throughout the country as America's only abundant domestic fossil energy resource. The coal industry is responsible for more than 80,000 jobs nationwide, contributing billions to the economies of coal-producing states.[27] Legislators from these regions will fight vigorously to ensure the continued viability of the coal industry.

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23. *Id.*

24. This article principally discusses the deployment of CCS in the context of coal-fired power plants. Although CCS technology can be applied to other industrial sources, such as ethanol and cement plants, power plants are by far the largest CO_2 emitters and thus are the focus of our discussion.

25. U.S. DEP'T OF ENERGY, ENERGY INFO. ADMIN., DOE/EIA-0383 (2009) ANNUAL ENERGY OUTLOOK, 52, 71 (2009), http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2009).pdf.

26. Renewable generation, excluding hydrologic power, constituted only 2.5 percent of the U.S. energy portfolio in 2007. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, OFFICE OF COAL, NUCLEAR, AND ALTERNATE FUELS, ENERGY POWER ANNUAL 2007, at 3 (2009) http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html (last visited Oct. 29, 2009).

27. The industry's payroll is approximately $2 billion in West Virginia alone, and coal companies provide hundreds of millions in tax revenue to the state. WEST VIRGINIA OFFICE OF MINERS' HEALTH, SAFETY AND TRAINING, WEST VIRGINIA COAL MINING FACTS, http://www.wvminesafety.org/wvcoalfacts.htm (last visited Dec. 16, 2009).

As Mike Morris, Chief Executive Officer of American Electric Power, has stated, "We have 25 'coal states.' That's 50 Senators whose states depend on this economy."[28]

Another factor that is rarely considered is coal's prevalence as a fuel source in China, India, and the unindustrialized world. These nations, which account for three-fourths of global GHG emissions, will likely remain dependant on coal even while the U.S. is transitioning to carbon-neutral technology. During the transition period, advanced coal and capture technology must be fully developed and utilized in developing nations to mitigate their significant contribution to climate change.

Given these facts, it is prudent to assume that coal will be a substantial part of our global energy portfolio in the short term. We reject, as a false binary, the idea that confronting climate change requires a choice between promoting renewable resources *or* supporting carbon capture and advanced coal technology. In reality, reducing GHG emissions may require an "all of the above" approach that includes renewable energy, CCS, expanded nuclear generation, reforestation and afforestation, energy efficiency, and simple conservation. Therefore, it is prudent to consider ways to make coal combustion carbon-neutral in the short term while simultaneously working to develop truly clean, efficient sources of energy for deployment in the coming decades.

C. Carbon Capture and Storage Technology

If we accept the two fundamental premises already advanced in this article,[29] then we must work to facilitate the use of CCS in conjunction with existing and new power plants. CCS is currently the only technology that will allow power plants to burn coal without putting more CO_2 into the atmosphere.

This section begins with a necessary primer on CCS technology, including a discussion of pre-combustion and post-combustion capture, compression and transport, and underground injection and storage. This technical discussion lays a foundation for Part II, where we turn our attention to the two major obstacles and disincentives that prevent the widespread use of CCS.

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28. Alan Petrillo, Coal Is Still King, for Now: American Electric Power Discusses Sustainability at KLD Forum, http://blog.kld.com/climate-change/coal-is-still-king-for-now-american-electric-power-discusses-sustainability-at-kld-forum-part-one (Feb. 27, 2009).

29. First, drastic GHG reductions are immediately necessary to prevent the most dire consequences of climate change. Second, coal will remain a major source of global power generation during the coming decades.

1. CCS Technology Primer

Carbon capture and geologic sequestration, as discussed above, refers to the capture or removal of the carbon content from the combustion of fuels such as coal and the subsequent injection and storage of CO_2 underground. Capturing all or most of a power plant's CO_2 before it can be released into the atmosphere would allow the continued use of coal for power generation with significantly reduced GHG emissions. Typical CCS has four main phases: capture; compression; transport; and storage.

2. Gasification & Capture

Capture simply refers to the removal of the carbon content of coal before it is emitted as a GHG. The removal of the carbon from coal can occur either before or after combustion has taken place. Although CCS can be used with almost all power plants, the most efficient and cost-effective carbon capture occurs pre-combustion in conjunction with an Integrated Gasification and Combined Cycle (IGCC) power plant.[30]

IGCC plants are unique in that the coal fuel is heated and converted into a synthetic natural gas in a process called gasification before it is burned for power generation.[31] This process, which breaks down a carbon-based fuel into its chemical elements, allows for the pre-combustion removal of pollutants such as sulfur and nitrogen oxide (NO_X).[32] Removing impurities such as sulfur and NO_X makes combustion more efficient, yielding more heat and energy per combustible unit of fuel.[33]

The gasification process also produces a more concentrated, highly pressurized CO_2 stream, making CO_2 capture at an IGCC plant easier and more efficient.[34] A traditional pulverized coal (PC) plant, by contrast, burns coal without removing impurities such as sulfur and NO_X, resulting in less

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30. While it is possible to "retro-fit" traditional pulverized coal (PC) power plants, gasification technology lends itself most easily to CCS. Retrofitting a traditional pulverized coal plant could increase the cost of generation by eighty percent, while using CCS at an IGCC plant would only increase costs by twenty-five percent, or five to six cents/ kWh. Most utilities that plan to utilize CCS will almost certainly use CCS in conjunction with gasification plants. For these reasons, we will discuss the capture process in the context of IGCC plants. National Energy Technology Laboratory, Carbon Sequestration FAQ Information Portal, http://www.netl.doe.gov/technologies/carbon_seq/FAQs/benefits.html (last visited Dec. 29, 2009).

31. Most coal-fired power plants are classified as pulverized coal (PC) plants, which burn coal without gasification. *See* U.S. Dep't of Energy, Gasification Technology R&D, http://www.fossil.energy.gov/programs/powersystems/gasification/index.html (last visited Oct. 25, 2009) (describing the gasification process).

32. *Id.*

33. *Id.*

34. *Id.*

energy-efficient combustion and impure CO_2 emissions that are more difficult to capture and store. While there are currently only a few IGCC plants operating today, many more are proposed. This number could multiply exponentially should the U.S. place a charge on carbon emissions. The U.S. Department of Energy (DOE), moreover, is very supportive of gasification and has invested billions in IGCC development.[35]

3. Compression and Transport

After the CO_2 by-product is captured from coal combustion at an IGCC or PC plant, it must be compressed and transported via pipeline to an area where it can be safely sequestered and stored underground. Captured CO_2 is compressed, using an electric or steam-powered turbine, to pressures as dense as 2,000 psi.[36] The compressed CO_2 can be transported using a pipeline to an appropriate injection and storage location.[37] The length of the pipeline would depend on the location of an injection site possessing underground geology appropriate for CO_2 storage. Over 3600 miles of CO_2 pipeline currently exist for enhanced oil recovery (EOR) operations, and over 500,000 miles of pipeline exist for natural gas transport. Nonetheless, the country's pipeline infrastructure would have to be expanded dramatically to accommodate large-scale CCS.

4. Underground Injection and Storage

Actual sequestration occurs by injecting the compressed CO_2 deep underground into suitable rock formations, generally those formations that are porous enough to allow storage of large quantities of CO_2 and that are overlaid by an impermeable "caprock" to prevent leaking.[38] An ideal formation would be one capable of sequestering ninety-nine percent of injected CO_2 for a period of 1,000 years.[39] When injected at high pressure to depths in excess of 3,000 feet, the compressed CO_2 is in a supercritical

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35. DOE's clean coal research and development project, FutureGen, provides funding for IGCC plants equipped with CCS technology. U.S. Dep't of Energy, DOE Announces Restructured FutureGen Approach, *available at* http://www.energy.gov/news/5912.htm (last visited Oct. 25, 2009).

36. 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, 435 (2008).

37. *See id.* While it is possible to transport CO_2 by truck or ocean tanker, pipelines will be necessary to support large, continuous sequestration.

38. A deep saline aquifer, underneath an impermeable "caprock," is the preferred geology in which to store CO_2 because of its size, porosity, and depth. Deep saline formations allow sequestration thousands of feet below the surface, far below drinking water sources or other extractable minerals. *Id.* at 439.

39. *Id.* at 436.

state—making the gas behave more like a liquid—which allows permeation and absorption in porous rock.[40] After absorption in an appropriate rock formation, sequestered CO_2 will rarely move vertically, and all testing has indicated that stored CO_2 is unlikely to escape.[41] However, injection and storage can continue in a particular location only as long as there is remaining available pore space.

Once it is determined that the location has reached capacity and has sequestered the maximum amount of CO_2, the hole will be "plugged" with cement. Plugging the hole post-injection should prevent one of the biggest risks associated with CCS: non-performance. A non-performing site is one that allows injected CO_2 to migrate or escape from its underground storage space into the atmosphere.[42]

5. Existing Operations

Often the most readily available injection sites are those formations in which EOR operations have occurred. EOR involves injecting compressed CO_2 to aid in oil recovery and has been widely used since the 1970s. The same porous formations in which oil is stored are often suitable for CO_2 storage.[43] The geology of an area where there has been oil recovery, including its porosity, is also usually well known. For these reasons, and because gas pipeline infrastructure already exists in many of these locations, CCS pilot projects have often been coupled with existing EOR operations.[44]

The largest capture and storage operation in the world is at the Sleipner gas recovery facility in the North Sea. The Sleipner project is part of a natural gas (NG) production operation off the coast of Norway. NG is mined from beneath the ocean floor but, as is often the case with NG

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40. *Id.* at 426.

41. *Id.* at 436.

42. The need to avoid non-performance—which refers to any escape of sequestered CO_2—is driven by resource and economic safety concerns. For example, non-performing injection sites could cost operators money in a carbon charge scenario, and escaping CO_2 could also pose risks to groundwater supplies. See *infra* Part II.B.2 for a discussion of the risks and property law questions raised by CCS.

43. At an EOR site, compressed CO_2 is injected into the pore space for the purpose of displacing oil particles so that the minerals can be recovered at the surface. *Id.* at 427.

44. Battelle, a global engineering and research firm that has taken the lead in CCS development, operates several demonstration projects utilizing existing EOR infrastructure. One such project, in northern Michigan, utilizes a natural gas processing plant that is connected by pipeline to a deep injection well. MIDWEST REGIONAL CARBON SEQUESTRATION PARTNERSHIP, MICHIGAN BASIN FIELD DEMONSTRATION BRIEFING, 4 (2007), *available at* http://216.109.210.162/userdata/Michigan/Michigan%20Basin%20Briefing%203-20-07.pdf.

recovery, the recovered gas contains a high percentage of CO_2.[45] In order to reduce the NG's CO_2 content to a combustible and marketable level, the CO_2 is removed.[46] The Sleipner project is unique because the CO_2 that must be removed is not emitted into the atmosphere; instead it is captured and injected into permeable rock formations beneath the ocean floor.[47] At present, Sleipner and other similar projects safely sequester several million tons of CO_2 that would otherwise escape into the atmosphere.

Excluding EOR and NG operations, there are few CCS demonstration projects operating today in conjunction with existing power plants. American Electric Power's Mountaineer power facility in New Haven, West Virginia will be the first commercial use of CCS in conjunction with a coal-fired power plant in the United States.[48] The power plant was retrofitted for post-combustion capture, which will allow its existing exhaust stacks to capture CO_2 for underground injection.[49] Although the Mountaineer plant will be the nation's largest, it is not expected to sequester more than two percent of the plant's annual CO_2 emissions.[50]

6. Markets for Expansion

There are several reasons that the interest in geologic storage projects will increase dramatically in the near future. As described above, it is likely that Congress or EPA will exact some price on CO_2 emissions in an effort to attack climate change.[51] CCS becomes cost-competitive quickly when there is a charge on currently unregulated carbon emissions.[52] Regulation would also spur, as the threat of a carbon price appears to have done, the

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45. *See generally* KATIE WALTER, LAWRENCE LIVERMORE NAT'L LAB., A SOLUTION FOR CARBON DIOXIDE OVERLOAD (2000), https://www.llnl.gov/str/Johnson.html (last visited Nov. 3, 2009).

46. *Id.*

47. *Id.*

48. Melanie Warner, *Is America Ready to Quit Coal?*, N.Y. TIMES, Feb. 15, 2009, at BU1.

49. The Mountaineer plant will use a "chilled ammonia" process, whereby exhaust is cooled to allow the CO_2 to be absorbed and removed by an ammonia-based solvent called ammonia carbonate. *Id.*

50. *Id.*

51. EPA has publicly stated that CO_2 and other GHGs constitute a danger to human health, and the agency is beginning rulemaking to regulate the emission of these gases. *See* Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 18,886 (Apr. 24, 2009).

52. If carbon regulations reach thirty dollars per ton of emissions or higher, industry may choose to utilize CCS as opposed to pay for emissions. *See* MIT REPORT, *supra* note 8, at xi. Moreover, the world's largest CCS operation was prompted by European carbon markets. The Sleipner project off the coast of Norway removes excess CO_2 from natural gas recovery and then injects the excess CO_2 beneath the ocean floor. The sequestration project was a direct response to Norway's fifty dollars per ton charge on CO_2 emissions. Bill Jeffrey, *Carbon Capture and Storage: Promising Technology, But Many Legal Questions Remain*, 29 ENERGY &. MIN. L. FOUND Ch. 1 (2008).

construction of new IGCC plants.[53] Thus, the potential for CCS greatly increases as more IGCC plants that can be readily configured for carbon capture come on-line.

II. Unresolved Legal and Regulatory Concerns: Barriers to CCS Deployment

The market potential for industry-wide CO_2 capture is promising, but many important questions remain. Although CO_2 has been injected for EOR operations for decades, injection for the specific purpose of long-term storage has only recently been contemplated. Sequestration of a meaningful portion of climate-altering GHGs will necessarily require CCS in conjunction with the very largest emitters, coal-fired power plants. CO_2 injection for permanent storage is very different from EOR, both in purpose and magnitude. The statutes and regulations that govern EOR operations are inadequate to properly regulate CCS operations because they do not account for long-term liability or property rights determinations for storage in formations deeper than oil deposits.

This regulatory void between seemingly analogous but inadequate EOR regulation and non-existent CCS regulation will not just result in inadequate government oversight. A lack of consistent rules for CCS could also prevent the widespread use of this technology. Even if carbon markets help make sequestration profitable, we believe that industry sources may not immediately invest in the technology without confidence in a regulatory framework that specifically addresses CCS. Further, it is important to implement a regulatory structure to govern CCS when a carbon emissions market is instituted so that there will be no delay in industry investment.

This section will discuss rules governing property rights and post-injection liability and monitoring, two critical issues that must be addressed before CCS technology can be widely deployed. These issues could be characterized as direct barriers and indirect disincentives. While uncertain liability is a significant disincentive and a de facto barrier to CCS, some unresolved property rights issues represent more direct obstacles. The unresolved issues we examine in Part II will form the basis for our legislative recommendations in Part III.

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53. For example, American Electric Power has indicated that it will build more IGCC plants in the future, which would be equipped with capture technology. *See* Press Release, American Electric Power, Statement of Michael Morris, CEO (June 18, 2007), *available at* http://www.aep.com/newsroom/newsreleases/?id=1377 (describing the reasons his company has chosen to pursue IGCC technology).

A. Unresolved Property Law

1. Storage Space Ownership and Mineral Severance

Ownership of the right to the underground pore space in which CO_2 would be stored is the most important unresolved property law question applicable to CO_2 storage. Does a landowner have a right to use the pore space that extends to the center of the earth, which may be granted to or withheld from others? Do holders of mineral rights or other subsurface interests have the right to underground storage as well as underground extraction? Does the public benefit of sequestering GHGs justify public ownership? The case law on these questions is largely unsettled.

Two types of storage space are most promising for CO_2 storage: (1) deep saline aquifers; and (2) depleted oil and gas fields.[54] As discussed elsewhere in this article, in EOR operations, CO_2 is pumped underground to displace cavern space and push oil or natural gas to the surface to increase drilling yields. This is a long-established technique for oil and gas development and inadvertently results in CO_2 storage in depleted oil and gas fields.[55] Injections dedicated to storage in deep saline aquifers are generally much deeper than those for EOR, which raises new property questions. For example, deep saline injections occur thousands of feet below the surface, largely beyond any strata associated with mineral or natural resource extraction. This distinction is important to understand the proper legal framework for sequestration as a large-scale carbon emission mitigation strategy.

We first turn our attention to deep saline aquifers. There is no reasonable expectation that these deep saline deposits will ever be utilized for any purpose other than the permanent sequestration of CO_2. As such, we should first look to the *ad coelum* doctrine for guidance on storage space rights in these deep rock formations.

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54. Deep saline aquifers are deep formations that exist far below usable water or hydrocarbon resources. Mark de Figueiredo & Adeeb Fadil, *Emerging Property and Liability Issues for Carbon Sequestration*, Bloomberg Sustainable Energy Law Report, Sept. 2008, *available at* http://www.stblaw.com/content/publications/pub762.pdf.

55. "The amount of CO_2 that has been incidentally stored in this fashion over the last several decades dwarfs the volumes injected by CCS pilot projects around the world." Marston & Moore, *supra* note 36, at 424–25.

a. Reconsidering the *Ad Coelum* Doctrine[56]

U.S. v. Causby, a takings case, is the first modern re-examination of the *ad coelum* doctrine by the United States Supreme Court.[57] In *Causby*, landowners near an airport used by the military alleged that frequent low-level flights interfered with the reasonable use of their property, resulting in a taking.[58]

In defense, the U.S. Government pointed to an aeronautical statute that granted any citizen of the United States "a public right of freedom of transit in air commerce through the navigable air space of the United States."[59] This act defined "navigable air space" as "air-space above the minimum safe altitudes of flight prescribed by the Civil Aeronautics Authority."[60] The Court found that even though the flights did occur at or above the minimum safe altitude, a taking had occurred.[61] For the purposes of our examination, the important aspect of *Causby* is not the takings determination, but the abandonment of the *ad coelum* doctrine:

> It is ancient doctrine that at common law ownership of the land extended to the periphery of the universe—*Cujus est solum ejus est usque ad coelum*. But that doctrine has no place in the modern world. The air is a public highway, as Congress has declared. Were that not true, every transcontinental flight would subject the operator to countless trespass suits. Common sense revolts at the idea. To recognize such private claims to the airspace would clog these highways, seriously interfere with their control and development in the public interest, and transfer into private ownership that to which only the public has a just claim.[62]

The Court abandoned the traditional doctrine of *ad coelum* with this holding. The prudential concerns of modern air travel, and the need to navigate through countless tracts of what the common law had once

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56. BLACK'S LAW DICTIONARY 378 (6th ed. 1990) (translating "Cujus est solum, ejus est usque ad coelum" as ownership of land that extends from the absolute depths of the earth to the periphery of the universe).

57. *See generally* United States v. Causby, 328 U.S. 256 (1946); John G. Sprankling, *Owning the Center of the Earth*, 55 UCLA L. REV. 979, 1000–01 (2008) (outlining ambiguities in the *ad coelum* doctrine as used in the lower courts before *Causby*).

58. *Causby*, 328 U.S. at 259.

59. *Id.* at 260.

60. *Id.*

61. *Id.* at 267.

62. *Id.* at 260–61.

recognized as privately owned property, was held paramount. The court also looked to use and enjoyment to determine whether a taking had occurred.[63] Assuming the elements of trespass, nuisance, or a taking are present, flights that interfere with use and enjoyment would constitute an invasion of a property right.

As a result of *Causby*, property rights above a land estate are no longer infinite today. Airspace becomes public at a point where the needs of modern air travel begin and where private use and enjoyment is no longer jeopardized.

b. Does *Causby* Apply to Deep Saline Aquifers?

Deep saline aquifers, the rock formations in which much of the CO_2 would be stored, are not perfectly analogous to public airspace. However, elements of *Causby*'s *ad coelum* analysis arguably could apply at these extreme depths. The argument that in a modern air-travel age, the outer reaches of airspace can be reserved for public use is equivalent to the argument that in the modern age of climate change mitigation, the deepest depths can be reserved for the public good of carbon sequestration. Furthermore, similar to the consideration that public airspace begins where reasonable surface use ends, one can assert that public CO_2 storage rights begin where economically exploitable mineral reserves and non-CO_2 storage opportunities underground end.

There are three essential differences between the *Causby* example and an example of modern CO_2 sequestration in deep saline aquifers. First, there is no fundamental legislation designating pore space for the public, as there was at the time of *Causby* designating airspace. Second, when dealing with underground CO_2 sequestration options, the "public highway" analogy fails. Indeed, the storage space for a particular injection zone will be privately controlled, meaning that CO_2 will be sequestered in a specific geologic location and expected to remain there or migrate only slightly. Storage spots for different actors will presumably not be allowed to overlap significantly. And third, while public airspace utilized for air travel is infinite, saline aquifer space used for CO_2 sequestration is vast but finite and as a result is more likely to be characterized as an insular property right.

However, while sequestration in the deepest strata may not conflict with the doctrine of *ad coelum*, sequestration activity will occur at a

63. *Id.* at 264–65.

number of different strata. Therefore, a discussion of various real property rights conflicts is necessary.

c. Storage Rights in Depleted Oil and Gas Fields?

The second type of space for CO_2 storage is depleted oil and gas formations.[64] These storage spaces are shallower than deep saline formations and can hold valuable resources closer to the surface. Although there is some case law regarding the underground injection and migration of natural gas, hazardous waste, and other materials, there are a variety of open questions surrounding CO_2 injection into these spaces. Tied up in these questions are mineral rights and extraction right implications, the severability of estates, trespass implications, eminent domain, and other legal and policy doctrines.

Modern property grants can be written to explicitly grant or withhold the right to inject and perpetually hold CO_2 in pore space. As a fundamental rule, the language of any property grant is controlling.[65] However, the vast majority of mineral rights grants were authored prior to the development of CO_2 storage techniques and, in many cases, prior even to natural gas storage techniques. Not surprisingly, there are many conflicting decisions on the basic storage question of who owns the rights to the storage space once mineral recovery is complete. Some courts have held that the surface owner retains injection and storage rights, while others have held that the rights are part of the reasonably anticipated mineral grant.[66]

d. Conflicting Case Law on Storage

Ellis v. Arkansas is the most prominent federal case on the question of pore space ownership. In *Ellis*, the U.S. District Court for the Eastern District of Oklahoma reviewed the injection and storage of natural gas by an oil and gas easement holder underneath the property of a surface owner.[67] The court found that "the parties did not intend that the mineral

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64. We use "depleted oil and gas formations" as a general term referencing strata that are closer to the surface than deep saline and, unlike deep saline formations, contain valuable, extractable resources.

65. RESTATEMENT (THIRD) OF PROP.: SERVITUDES § 4.1 (2000).

66. These differing views are referred to as the "American rule" and the "English rule." The American view holds that the surface owner retains ownership of the pore space after minerals are extracted, while the English view holds that the mineral lease holder retains ownership of the depleted pore space. *See* de Figueiredo, *supra* note 54.

67. Ellis v. Arkansas, 450 F. Supp. 412, 414 (D. Okla. 1978).

interest owner should have injection, storage or occupation rights" beyond the right to extract.[68] Thus, *Ellis* stands for the proposition that after oil and gas extraction is complete pursuant to the grant or lease, the remaining "porous spaces" belong to the surface owner.

A Texas case, however, provides a different holding on pore space ownership. In *Mapco v. Carter*, the Ninth District Court of Appeals of Texas decided an appeal from a judgment for a surface property owner against a mineral rights owner whose extraction opportunities had been exhausted. The mineral rights owner converted the mineral estate into a storage estate by storing natural gas, petroleum, and other hydrocarbons within a salt dome formation.[69] Two holdings in *Mapco* directly conflict with the *Ellis* decision. First, the court held that "[an] interest in minerals is an interest in real property."[70] Therefore, according to the *Mapco* court, a mineral interest holder has not only a right to explore, extract, and exhaust, but also a real property interest in the underlying minerals that exist independent of any extraction.[71]

The *Mapco* court also directs attention to the Texas Natural Resources Code as an expression of legislative public policy preference supporting this view. The court understands the code to present a strong public policy endorsement of underground storage of "natural gas and other comparable minerals."[72] The Texas legislature in the Natural Resources Code took up the question of storage and mineral rights explicitly, requiring that a mineral owner acquire sixty-seven percent of the mineral rights before storage could begin.[73]

In *Emeny v. The United States*, the U.S. Court of Claims took a different view.[74] The U.S. government, through various means, had acquired a series of oil and gas leases in a prominent helium and natural gas deposit in Texas and at a later point began using the field for helium storage.[75] The court viewed the question in simple terms, looking directly to the language of the lease and noting that there was a right to extract and use natural gas and other minerals but not a right to import and store. The court also recognized a right to "reasonable use" but no right beyond "mineral

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68. *Id.* at 420–21.
69. Mapco v. Carter, 808 S.W.2d 262 (Tex. App. 1991).
70. *Id.* at 274.
71. *See id*. at 277 ("[Texas has] virtually uniformly followed the rule of law that mineral owners retain and still possess and own an ownership interest after the underground storage facility has been constructed and completed or the stratum depleted.").
72. *Id.* at 278.
73. *Id.*
74. Emeny v. United States, 412 F.2d 1319 (Ct.Cl. 1969).
75. *Id.* at 1322.

exploration and production."[76] The court concluded that the right to use the formation as a storage space rests with the surface owners, not the mineral right holders.[77]

Tate v. United Fuel Gas Company is a West Virginia case that reinforces the conception that pore space storage rights are left to the surface owners after the exhaustion of extraction opportunities.[78] In *Tate*, the Supreme Court of Appeals of West Virginia determined that the defendants' claim to own the space was extinguished after the extraction of minerals, and therefore their right to inject and store gas was inadequate according to the language of the grant.[79] The court made an important distinction regarding the purpose and process of extraction: "[S]o long as there remain recoverable minerals which are mined in good faith, the space may be used by the owner of the minerals."[80]

The various holdings of these cases illustrate the lack of a consistent national view of pore space ownership with respect to mineral rights leaseholders. Various courts, utilizing various factors, have awarded gas storage rights to surface and mineral holders alike.

2. Migrating CO_2: Trespass and Nuisance

Liability for trespass created by migrating CO_2 is another unresolved property issue. Geologically stored CO_2 can migrate laterally, sometimes unpredictably, from its original storage location. The question then arises: how will the potential for trespass and nuisance play a role in CO_2 storage operations? We can get a glimpse of this operation of law from an underground trespass case involving natural gas and other substances.

Chance v. BP Chemicals provides an analysis that is useful in conceptualizing a trespass action in the CO_2 injection and storage context.[81] The issue in *Chance* was that "deepwell injection" of hazardous materials had allegedly migrated under the plaintiff's property. The plaintiff brought actions in trespass, strict liability tort, nuisance, negligence, and fraudulent concealment.[82] In most ways, the court resolved the case in the manner typical of nuisance and trespass actions by enumerating and analyzing the specific elements of the claims. However, no trespass was established, largely because of evidentiary issues:

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76. *Id.* at 1323.
77. *Id.* at 1325.
78. Tate v. United Fuel Gas Co., 71 S.E.2d 65 (W.Va. 1952).
79. *Id.* at 71–72.
80. *Id.* at 71.
81. Chance v. BP Chemicals, Inc., 670 N.E.2d 985 (Ohio 1996).
82. *Id.* at 992.

> Our ultimate conclusion that appellants did not prove an actionable trespass is dictated by considering the sum total of the circumstances of this case, as we have done in our foregoing discussion. Appellee operates the wells pursuant to required permits; appellants' subsurface property rights are not absolute and in these circumstances are contingent upon interference with the reasonable and foreseeable use of the properties; the trespass alleged is an indirect one and, due to the type of invasion alleged, physical damage or actual interference with the reasonable and foreseeable use of the properties must be demonstrated; appellants' trespass claim is a novel one, of a type previously unrecognized by any court. When all of the circumstances of this case are considered, appellants' evidence of trespass was simply too speculative.[83]

Chance recognizes, as this article suggests, that the American revisions to the *ad coelum* doctrine place limits on the extent to which a surface owner can claim absolute rights in the depths below his or her property. The court emphasizes the importance of land use in its analysis: "The owner of land owns as much of the space above him as he uses, but only so long as he uses it."[84]

In *Chance*, the court made its *ad coelum* analysis in this context by conceptualizing the native brine not as the outermost reaches of "useable" space for the purposes of the *ad coelum* doctrine, but instead as "waters of the state," a statutory term that connotes a substantial degree of public sovereignty.[85]

The findings in *Chance* have several implications for CCS analysis. First, absent the explicit satisfaction of the traditional trespass elements, trespass actions will be unavailable to surface owners alleging trespass and harm by adjacent owners injecting and sequestering CO_2. Second, and more importantly for our discussion, deep saline aquifer injection may have a partial common law *ad coelum* exemption without attendant legislation because deep saline aquifers and native brine can be considered "waters of the state," or waters over which the public has ultimate sovereignty.

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83. *Id.* at 993.

84. *Id.* at 992 (quoting Hinman v. Pac. Air Transp., 84 F.2d 755, 758 (9th Cir. 1936)).

85. *Id.* ("Our analysis above concerning the native brine illustrates that appellants do not enjoy absolute ownership of waters of the state below their properties, and therefore underscores that their subsurface ownership rights are limited.").

B. Post-injection Liability for Non-performance: What Are the Risks?

There are many potential sources of liability that storage operators may face after CO_2 is injected underground.[86] Unlike the direct legal obstacles to storage outlined in our discussion of property rights above, unresolved liability issues can be characterized as indirect disincentives to CCS development. Potential operators of carbon storage projects have identified liability as a primary barrier to CCS.[87]

For the purposes of this paper, post-injection liability for non-performing sequestration operations applies solely to the party who must make economic restitution should there be a failure to retain the CO_2 as originally sequestered. A non-performing CCS operation is one that has not properly sequestered CO_2,either by allowing the gas to seep out and return to the atmosphere, migrate onto the property of another, or contaminate groundwater resources. Each of these scenarios has the potential to cost the operator money through legal damage awards or contract-type damages for non-compliance with a sequestration agreement.[88]

Considering a projected charge of less than thirty dollar per ton of CO_2, the incentives established by carbon regulation alone may be insufficient to foster private-sector investment in CCS.[89] Industry will want clear guidance on liability issues, either as they relate to the injection phase or to the long-term sequestration stage. Our discussion of liability with regard to CCS operations is limited to on-site, post-injection liability due to non-performance, which includes CO_2 leaks that contaminate water supplies, contribute to seismic activity, or result in other adverse effects on human health or the environment.[90] This section discusses potential contract, tort, and statutory liability for CCS, including contract liability for non-

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86. Liability could encompass pre-injection or "operational" liability as well. Operational liability generally refers to liability that could arise during the capture, transport, and injection phases. Because liability during these phases is often related to legal issues such as trespass, nuisance, and pore space ownership, we address these issues in our discussion of property rights. *See supra* Part II.A.

87. JENNIFER JOHNSON, GREAT PLAINS INST., PROJECT DEVELOPER INTERVIEWS 2–3 (2008), *prepared for* The Midwestern Governors Association Renewable Electricity and Advanced Coal with Carbon Capture Advisory Group.

88. Liability for non-compliance with a sequestration agreement, which would arise from the regulation of carbon emissions, will be discussed later. *See infra* Part II.B.2.

89. Legal uncertainty could also prevent the immediate utilization of CCS after carbon markets are established. A cost of thirty dollars per emitted ton of CO_2 has been identified as a possible probable price point, beyond which CCS becomes profitable. MIT REPORT, *supra* note 8.

90. *See supra* Part II.A (examining property rights issues, pre-injection liability issues, and issues that could arise during the capture and transport phases).

attainment, and tort and statutory liability for adverse impacts on human health, property, and ecology.

1. Contract Liability for Non-Attainment

Potential contract liability for non-attainment could prove to be a significant barrier to the utilization of capture technology. Non-attainment refers to non-performance resulting in contractual, but not necessarily tort, liability. A sequestration site that allows CO_2 to seep out from underground, ultimately returning to the atmosphere as a GHG, could be classified as both a non-performing site and a non-attainment site.

More specifically, non-attainment would occur in the context of national regulation of carbon emissions. Under such a national regulatory scheme, energy companies would likely receive a financial credit expressly conditioned upon their effective sequestration of CO_2. This kind of regulation, which could make it more cost effective to put CO_2 in the ground than in the air, could incentivize CCS. However, regulated sources will also need to ensure that CO_2 will not escape, resulting in money loss for non-sequestered CO_2. For example, a federal regulation which puts a national cap on CO_2 emissions will likely require emitters to pay a charge for CO_2 emissions emitted in excess of their allowances. Any emissions credit or financial incentive for industry to sequester carbon will be dependant on its complete, safe storage.[91]

2. Tort Liability for Health and Environmental Hazards

There is legal uncertainty regarding liability for the environmental and human health hazards associated with CO_2 injection and storage, such as groundwater contamination and induced seismic events. The inherent risks surrounding CCS will probably be similar to those related to existing EOR and natural gas storage operations. While EOR and natural gas storage operations have been safely used for decades, risk management for CCS is a somewhat novel question due to the unprecedented quantities of gas that would be sequestered and the requirement of near infinite storage.[92]

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91. It is also important to note how critical it is that commercial CCS achieve near-perfect rates of sequestration. Even if commercial CCS reaches a seemingly high industry-wide sequestration rate of 99 percent, over half of the sequestered CO_2 would reach the atmosphere within 100 years. Sumit Som, *Creating Safe and Effective Carbon Sequestration*, 17 N.Y.U. ENVTL. L.J. 961, 970 (2008) (internal citations omitted).

92. A moderately sized power plant, at a 500-megawatt generation capacity, would produce two to three million tons of CO_2 byproduct each year. MIT REPORT, *supra* note 8, at ix.

There are several potential sources of liability in tort, using negligence, trespass, or strict liability theories. Although some of the issues we address are unlikely to occur or cause substantial harm, they are nonetheless factors that must be considered and insured against before a CCS plan is undertaken by industry.

a. Risk of Catastrophic Carbon Escape

Because CO_2 is toxic at high concentrations, some fear that escaping CO_2 from a non-performing sequestration site could poison surrounding air supplies, potentially harming humans and animals.[93] The threat of catastrophic escape is often cited as an argument against CCS demonstration projects. The Lake Nyos disaster of 1986, in which volcanic activity led to a massive release of naturally occurring CO_2 from beneath an African lake, is often mentioned.[94]

The Lake Nyos incident was an earth science anomaly and not analogous to commercial CCS storage. At Lake Nyos, volcanic activity beneath the lake led to a buildup of pure CO_2, which was sequestered in the deepest waters of the lake and eventually escaped in a large poisonous cloud.[95] By contrast, any atmospheric releases of CO_2 at a non-performing CCS site would be small and incremental, not likely to result in harm like that at Lake Nyos. Captured CO_2 is injected while in a supercritical state (with both gaseous and liquid characteristics) and is stored as it permeates porous rock.[96] Thus, the stored CO_2 is not sequestered in vast underground reservoirs, and it is unlikely that a massive cloud of CO_2 could escape.

Despite the low probability of such events, the perceived risk of catastrophic release must be addressed as a liability issue. It is the type of occurrence that operators and potential insurers will have to consider before undertaking a CCS operation.

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93. Air becomes toxic when the CO_2 content of it approaches ten percent by volume. A typical unit of air is composed of approximately 21% oxygen and .038% CO_2. IPPC SPECIAL REPORT ON CARBON DIOXIDE CAPTURE AND STORAGE 391 (Bert Metz et. al. eds., 2005), *available at* http://www.ipcc.ch/pdf/special-reports/srccs/srccs_annex1.pdf.

94. "A cloudy toxic mixture of carbon dioxide and water droplets rose violently from Lake Nyos, Cameroon, on Thursday evening, August 21, 1986, killing over 1,700 people and an unknown number of livestock and other animals, mostly while they slept." *Killer Lakes of Cameroon*, SECURITAS MAGAZINE, Nov./Dec. 2005, *available at* http://www.semp.us/publications/securitas_reader.php?SecuritasID=24 (last visited Oct. 23, 2009).

95. *Id.*

96. In some cases, after the CO_2 permeates the porous rock, it will actually solidify, becoming a carbonate component of the rock formation itself.

b. Groundwater Contamination

A more plausible risk associated with CCS is groundwater contamination at non-performing sites. If injected CO_2 "migrates" from its injection point and comes into contact with an underground aquifer, it can effectively poison the water supply by causing acidification or by displacing brine.[97] Moreover, the CO_2 stream that is injected underground may contain impurities and toxins that can affect groundwater quality.[98] Any injection activity that has the potential to impact drinking water supplies would also be regulated by the Safe Drinking Water Act, and operators could be held liable under the statute for any impacts to aquifers.[99] Thus, CO_2 injection operators could be liable *ad infinitum* in tort and pursuant to federal statutes for any leakage that contaminates groundwater supplies.[100]

c. Induced Seismicity

Injecting large quantities of foreign substances deep underground, especially in earthquake-prone regions, could potentially trigger seismic activity.[101] Some fear that massive quantities of CO_2 could expand within porous rock, increase pressure, and possibly lead to earthquakes.[102] Most geologists, however, have concluded that this type of harm is an improbable result of CCS injections. The risk of "induced seismicity" will not likely deter serious operators or investors, but is more likely to be used as a rallying cry by environmental groups and citizen activists who are opposed to CCS.

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97. This risk occurs when the storage space is below or adjacent to drinking water supplies. "[T]he potential exists for injection to force native brines (naturally occurring salty water) into [drinking water supplies]." 73 Fed. Reg. 43,491, 43,497 (proposed July 25, 2008) (to be codified at 40 C.F.R. pts. 144 & 146).

98. *Id.*

99. 42 U.S.C. § 300h (2006).

100. *See id.*; Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. §§ 9601–9675 (2006); Resource Conservation and Recovery Act of 1976, 42 U.S.C. §§ 6901–6992k (2006).

101. In 1962, two minor earthquakes were triggered in Colorado as a result of deep well injections. However, seismic triggers can largely be prevented by proper geologic surveys prior to injection. Joel Sminchak et al., *Issues Related to Seismic Activity Induced by the Injection of CO_2 in Deep Saline Aquifers* (2001), *available at* http://www.netl.doe.gov/publications/proceedings/01/carbon_seq/p37.pdf.

102. *Id.* at 2.

d. Subsurface Trespass

The inconsistent precedent with regard to pore space ownership described above leaves open a possibility for subsurface trespass liability. Trespass is an unprivileged entrance upon the land of another, either by one's own person or by some other object. Generally, a landowner's property includes not only surface area, but also the usable airspace above and the usable subsurface below.[103] This means that a surface owner could maintain a trespass claim for the extraction of minerals underneath his land that have not been severed and for any migration of artificial substances within the usable subsurface. Harm to the owner is not required to maintain such a claim, but such harm could increase the amount of compensable damages for trespass.

Because CO_2 has the potential to migrate beyond the intended storage location of the pore space, it is possible that injected CO_2 could "trespass" into the pore space owned by a neighbor. At least one court has stated that CO_2 migration could support a trespass claim, although the claim asserted was outside the court's scope of review.[104] CO_2 migration, moreover, could lead to significant economic damages, especially if the migrating CO_2 impacts aquifers or if the rights to use pore space becomes a valuable, tradable resource in the future.[105]

3. Insuring for Infinite CO_2 Storage

It is worth emphasizing the fundamental liability posed by *long-term* CO_2 storage. Because of the purpose of CCS—near infinite storage of CO_2—each of the potential sources of liability will extend in perpetuity. To be effective as a climate mitigation strategy, CO_2 storage must be near infinite, and thus contract, tort, and statutory liability will extend long after the injection ends. In fact, all sources of liability will probably outlive the original operators of the CCS operation, making the prospect of insuring against liability even more daunting for private insurers. In Part III, we propose solutions to this problem whereby state or federal agencies assume liability for CO_2 storage in limited circumstances.

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103. Common law trespass is based on the historic *ad coelum* maxim. BLACK'S LAW DICTIONARY 378 (6th ed. 1990) (defining "Cujus est solum ejus est usque ad coelum et ad inferos" to mean that ownership of land includes not only the land's surface, but the sky above and the land below the property). *See also supra* Part II.A.1.a.

104. LeBlanc v. EPA, No. 08–3049, 2009 WL 331557, at *4–5 (6th Cir. Feb. 12, 2009).

105. In a carbon-constrained economy, for example, the property right to use pore space that is suitable for sequestration may become valuable. Thus, any interference with another's pore space could lead to liability and economic damages.

III. RECOMMENDATIONS FOR A NEW REGULATORY FRAMEWORK

The uncertain risks associated with CCS activity, both contractual and tortious, compounded by the necessity of infinite storage, clearly show the need for a uniform regulatory framework to govern CCS. We begin Part III with a survey of the existing law and regulation that currently govern CCS projects, and proposed state laws. While none of the statutes described provide a complete framework to govern CCS, the current patchwork of regulations contains some valuable ideas.

After reviewing existing and proposed regulation, we provide a model regulatory framework consisting of the essential elements that will allow CCS to develop into a viable industry. Most importantly, we suggest a system of government assumption of liability and clear definitions of property rights. Our recommendations are by no means exhaustive, but they represent the most fundamental components that we believe will be necessary to support meaningful investment in, and deployment of, this burgeoning technology. Finally, we recommend the creation of a CCS utility that can quickly and effectively facilitate CCS and assure its ultimate success.

A. Examples of Existing and Proposed Federal and State Regulations

1. Federal Underground Injection Control Program

EPA's Underground Injection Control (UIC) program,[106] which was promulgated in 1974 under the Safe Drinking Water Act (SDWA), currently provides the only federal regulations for injections pursuant to CCS activity.[107] The UIC regulates all underground injections that could affect the quality of drinking water resources in the United States. The UIC regulates five categories of wells.[108] Current CO_2 storage operations are regulated as Class V "experimental" wells, as CO_2 injections do not qualify under the existing well classifications.[109]

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106. 42 U.S.C. §§ 300h–300j (2006).

107. 40 C.F.R. § 144.3 (2008).

108. *Id.* § 146.5.

109. Wells for EOR, meanwhile, are regulated under Class II. Class V is used as a catch-all classification for the injection of non-hazardous wastes, such as CO_2, that are not regulated in Classes I – IV. Under the regulations, CCS injections are "[i]njection wells used in experimental technologies." *Id.* at § 146.5(e)(15).

Although EPA has proposed new rules that would create a new classification to cover CO_2 injections,[110] the UIC rules are ill-suited for CCS. The UIC provides only a partial regulatory framework and neglects to address many of the attendant issues that would be involved in CCS activity. The UIC program is limited in scope by its enabling statute, the SDWA, which gives EPA broad authority to regulate activities that may contaminate drinking water supplies, but does not give EPA enough authority to regulate other aspects of CCS. For example, injection for CO_2 storage would likely occur in rock formations that are much deeper than the drinking water resources that are the object of the SDWA.

Because the UIC program and EPA's proposed rules are focused solely on preventing harm to drinking water supplies, these rules alone are an inadequate regulatory framework to govern CCS.[111] The proposed rules do not address many important issues, such as long-term liability, post-injection monitoring, and property rights questions.[112]

2. American Clean Energy and Security Act

On June 26, 2009, the U.S. House of Representatives passed the Waxman-Markey American Clean Energy and Security Act, a comprehensive climate bill without historical precedent.[113] The 1,400-page bill devotes an entire subtitle to CCS regulation.[114] The climate bill amends the Clean Air Act to require the Administrator to establish a coordinated approach to certify and permit sites where geologic sequestration of carbon dioxide will occur.[115]

To address the issue of liability, the bill amends the SDWA standards in section 1421(e)(2) to require a demonstration of financial responsibility for CO_2 sequestration wells. Specifically, the bill requires an operator to maintain evidence of financial responsibility for "emergency and remedial response, well plugging, site closure and post-injection site care."[116] The

110. 73 Fed. Reg. 43,491 (2008).

111. *Id.* ("The Agency proposes to tailor existing UIC program components so that they are appropriate for the unique nature of injecting large volumes of CO_2 into a variety of geological formations to ensure that USDWs are not endangered.").

112. *Id.* at 43,492 ("The SDWA does not provide authority to develop regulations for all areas related to [CCS, such as the following:] capture and transport of CO_2; determining property rights (i.e., to permit its use for ground storage and for possible storage credits); transfer of liability from one entity to another; and accounting or certification for greenhouse gas (GHG) reductions." *Id.* at 43,492.

113. H.R. 2454, 111th Cong. (2009). At the time of article submission, the House of Representatives had just recently passed the bill, and the bill had yet to be heard in the Senate.

114. *See id.* at Title 1, Subtitle B.

115. *See id.* § 112(a).

116. *Id.* § 112(b).

operator may establish financial responsibility "in accordance with regulations promulgated by the [EPA] Administrator [in a combination of any method]: insurance, guarantee, trust, standby trust, surety bond, letter of credit, qualification as a self-insurer, or any other method satisfactory to Administrator."[117]

While passage of the bill would further the ultimate goal of mitigating America's impact on the climate through its detailed carbon cap-and-trade regime and move America toward a clean energy future, its proposed CCS regulation is not by itself a complete regulatory framework. The bill does not attempt to address, either explicitly or through a federal framework for the states, the important issue of property rights in storage space. As explained below, addressing this issue is essential for proper deployment of CCS. Generally, the bill defers many of the regulatory details to a later date. It requires the Administrator to assemble a task force within six months of enactment to review existing statutory language for use in regulating CO_2 sequestration.[118] Further, the Administrator must consult with the heads of other relevant federal agencies and submit a report to Congress. The report must set forth a unified and comprehensive strategy to address the key legal and regulatory barriers to the commercial-scale deployment of carbon capture and sequestration.[119]

3. Interstate Oil and Gas Compact Commission

In 2007, the Interstate Oil and Gas Compact Commission (IOGCC), a multi-state government agency that promotes recovery of domestic oil and natural gas resources, proposed the most comprehensive regulatory model for CO_2 storage to date.[120] Under the IOGCC model, the states, acting as long-term "caretaker[s]," administer a "cradle to grave" regulatory system.[121] The model addresses the three major phases of a CCS project: pre-injection licensing; the storage phase; and long-term monitoring and liability.

In the pre-injection phase, the IOGCC model statute proposes to extend the right of eminent domain to operators so that they would be able to "acquire all surface and subsurface rights and interests necessary or useful

117. *Id.*

118. *See id.* § 113(a)(1).

119. *See id.* § 111.

120. *See generally* Interstate Oil and Gas Compact Commission (IOGCC), Storage of Carbon Dioxide in Geologic Structures: A Legal and Regulatory Guide for States and Provinces (2007), http://iogcc.publishpath.com/Websites/iogcc/PDFS/2008-CO2-Storage-Legal-and-Regulatory-Guide-for-States-Full-Report.pdf [hereinafter IOGCC Guide].

121. *Id.* at 12.

for the purpose of operating the storage facility."[122] Thus, the IOGCC statute would afford CO_2 storage the high status of public use, sufficient to support the taking of private property.[123]

In the storage phase, the IOGCC model specifies procedures for permitting and operating CO_2 storage project wells to "safeguard life, health, property and the environment."[124] Further, the model specifies design standards that prevent CO_2 migration from injection wells.

For long-term monitoring and liability, the model creates a two-stage approach: closure and post-closure periods. The IOGCC statute proposes a ten-year closure period from the time the well is plugged. During the closure period, the operator would be responsible for both operational and well-specific bonds. After ten years, the liability would transfer from the storage operators to the state government for the post-closure period. The goal of the state-held liability in the post-closure period is meant to "allow for regulatory certainty by the industry and help to promote the development of [future] carbon dioxide storage."[125] The IOGCC also suggests a storage tax to be levied on a per-ton basis on all injected CO_2. The storage tax, which individual states would determine, would support the state regulatory agency's long-term modeling.[126]

While the IOGCC model is the most comprehensive to date, it is useful only as a model and not as a sole basis for regulation. Because the IOGCC is a compact made up of state agencies, it not surprising that the model suggests that states are best equipped to administer all phases of the program, even the long-term liability. And, the model fails to specify the role of the federal government.

4. Wyoming

In 2008, Wyoming became one of the first states to enact legislation for the specific purpose of regulating CCS operations, as opposed to EOR injections. Wyoming addresses the pore space ownership issue by vesting ownership in depleted oil and gas fields in the surface owners and by stating that the conveyance of mineral rights alone does not sever the

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122. *Id.* at 33 n.3 ("[T]he [IOGCC] Task Force has concluded that the amalgamation of property rights is absolutely necessary . . . to operate a carbon dioxide storage project.").

123. *Id.* at 34.

124. *Id.*

125. *Id.* at 35.

126. *Id.* at 34.

surface owners' rights to the pore space.[127] Wyoming law also clearly defines pore space as a property right that "can be used as storage space for carbon dioxide or other substances."[128]

As for liability, the Wyoming statute provides for the development of a bonding system to "assure adequate financial resources are provided to pay for any mitigation or reclamation costs that the state may incur as a result of default by the permit holder."[129] In the statute's detailed permit application requirements, the applicant must show proof of bonding or financial assurance for construction, operation, and closing.[130]

Furthermore, the Wyoming statute requires an element of transparency. For an industry and an activity like CCS, where procedures are new to most communities and risks are unmeasured, public and landowner notice is crucial. The Act requires proof of notice to landowners, mineral claimants and owners, and the community through newspaper publication.[131]

5. Kansas

The Kansas House of Representatives recently proposed an alternative route to promote and regulate CCS. Kansas House Bill 2419, introduced in 2008, sought to provide direct incentives for CCS development. For example, the bill would have exempted from property taxation "any carbon capture, sequestration or utilization property," as well as "any electric generation unit which captures and sequesters all of its carbon dioxide and other emissions." The bill would further incentivize CCS and establish an income tax deduction on the amortizable costs of carbon dioxide capture, sequestration, and utilized machinery for a total of ten years.[132]

As for the regulatory aspects of CCS, the bill would fully empower the State Corporation Commission (the state's oil and gas industry regulator) to promulgate all applicable rules, including rules for site selection criteria, design requirements, safety, closure, and long-term monitoring.[133] However, unlike legislation in Wyoming or the IOGCC, the bill did not provide for full or partial release of liability. The bill only covers the

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127. Thus, Wyoming has codified the American rule of surface ownership in depleted pore space. *See* WYO. STAT. ANN. § 34-1-152(a)–(b) (2009) (defining "pore space" as "subsurface space which can be used as storage space for carbon dioxide or other substances").

128. *Id.*

129. *Id.* § 35-11-313(g)–(k).

130. *See* § 35-11-313(g) (directing the state oil and gas supervisor and the director of public health to promulgate rules prior to September 30, 2009 for a financial assurance program for CCS operations).

131. *Id*. § 35-11-313(f).

132. *See* Kansas H.B. 2419, at 3, New Sec. 7(a).

133. *See id.* at 1, New Sec. 2(b).

liability issue by requiring that the permittee provide proof of financial assurance to cover closure of the permitted facility.[134]

B. Fundamental Attributes of an Effective Regulatory System

The existing and proposed laws and regulations discussed above contain valuable components, but none represents a complete framework for CCS. Ultimately, government involvement will be necessary if CCS is to become a viable technology capable of mitigating the effects of climate change. To effectively deploy CCS, federal and state agencies should not only fund and incentivize CCS projects, but should also take a role in ensuring long-term liability and defining property rights. This government enterprise needs to be a flexible and cooperative arrangement between the federal government and the states.

While the law of property rights, contracts, and tort liability is historically within the domain of the states, the impact of carbon dioxide emissions is national, and for that matter, global. The transport, storage, and attendant contracts will undoubtedly have an interstate character. For these reasons, we believe that a federal CCS framework would pass constitutional muster as a necessary and proper means of carrying out Congress's power to regulate interstate and foreign commerce and fulfill responsibilities under treaties with other nations. Nonetheless, states could implement most of these recommendations in the absence of federal action.

1. Delineation of Property Rights and Eminent Domain

The ownership of the two different categories of pore space—oil and gas fields and deep saline aquifers—is the most critical property rights question for CCS deployment. To provide certainty for industry and landowners, a legislative package should unequivocally resolve basic property rights issues. Such legislation must begin with a clear expression that: 1) the deepest geologic reaches are reserved as public space for the widespread sequestration of CO_2; and 2) surface owners retain ownership of depleted oil and gas storage space.

a. Deep Saline Aquifers as Public Space

As we noted in our earlier discussion of the *ad coelum* doctrine and its modern revisions, property rights to the air and subsurface cannot extend

134. *See id.* at 1, New Sec. 2(e).

infinitely in the face of modern necessity.[135] Where the reasonable use of marketable underground assets ends, the public space designated for deep saline aquifer sequestration should begin. Therefore, legislation should define deep saline injection sites as public space for the purposes of prolonged carbon storage. This conclusion is based on modern conceptions of the *ad coelum* doctrine and legal recognition that the current body of common law can consider deep saline aquifers to be waters over which the public already enjoys a degree of sovereignty. Further, legislation can follow the fundamental logic of the federal statutes that appropriated American airspace for the public good of regional and continental air travel for all citizens. The Air Commerce Act of 1926,[136] and the Civil Aeronautics Act of 1938,[137] today known as the Federal Aviation Regulations, led directly to the *U.S. v. Causby* challenge discussed earlier in this article. Those statutes purported to give the United States "complete and exclusive national sovereignty in the air space" over all of the nation's real property.[138] The statutes granted any citizen of the United States "a public right of freedom of transit [in air commerce] through the navigable air space [of the United States]."[139] The statute goes on to define "navigable air space" as "airspace above the minimum safe altitudes of flight prescribed by the Civil Aeronautics Authority."[140]

The Acts declared that "such navigable airspace shall be subject to a public right of freedom of interstate and foreign air navigation."[141] They did not declare that the public appropriation of air space that the legislation represented did not constitute a taking under the strictures of the Fifth Amendment to the Constitution. As discussed above, the court in *Causby* upheld this legislation as a necessary and appropriate exercise of federal regulatory authority in a modern age, finding that the *ad coelum* doctrine needed to be reexamined in the age of air travel.

We recommend similar legislation, a "public space" statute that would utilize two legal and prudential rationales to make deep saline aquifer space available for the purpose of carbon sequestration and storage: the modern *ad coelum* doctrine, and the "waters of the state" analysis. First, this

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135. *See supra* Part II.A. (noting that modern air travel has required a reconsideration of the common law *ad coelum* doctrine, which held that a surface owner held an absolute right to the airspace above his/her property).

136. Air Commerce Act, 44 Stat. 568 (1926) (repealed 1938).

137. Civil Aeronautics Act, 52 Stat. 973 (1938) (current version at 49 U.S.C. § 40103 (2006)).

138. 49 U.S.C. § 176(a) (2000) (superseded by 49 U.S.C. 40103(a) (2006)) ("The United States Government has exclusive sovereignty of airspace of the United States.").

139. 49 U.S.C. § 40103(a)(2) (2006).

140. *Id.* § 180 (repealed 1958).

141. *Id.*

legislation would declare all American deep saline aquifer space beyond a professionally determined "economic viability zone" available for CO2 storage, assuming proper permitting and that state authority had granted an entity such a right. It would be essential to determine accurately the proper limits of the "economic viability zone" to avoid creating a compensable Fifth Amendment taking. If, for example, the designated public space overlapped with available and economically exploitable oil and gas reserves, a takings claim could arise.

Regarding space beyond the "economic viability zone," Congress could make several declarations. The first is that at a particular depth the federal government, individual state governments, or a regional governmental entity would have complete sovereignty over deep saline aquifers for the narrow purpose of CCS. The statute should specify the purpose and extent of the CCS activity as well. Specifically, the statute should declare sovereignty for express and narrow public good purposes. Sequestration for the sake of climate change prevention or mitigation should be the only permissible purpose.[142]

Our discussion of the Air Commerce Act of 1926 and the Civil Aeronautics Act of 1938 is generally instructive in the carbon sequestration and storage context. However, one major difference between those statutes and the "public space" statute we propose is the public right concept. The Air Commerce Act of 1926 and the Civil Aeronautics Act of 1938 grant the right to use to the public at large, subject to the litany of aviation regulations that make air travel and aviation generally safe in America.

Although it contemplates a public good that is as significant as the commerce associated with air travel, this CCS "public space" statute will not confer a general public right because CCS projects will most likely be large, centralized, and regional—not distributed and accessible to the public. So, although we anticipate the creation of a public good, there will not be a public right to use. Accordingly, the "public space" legislation must contain carefully devised structures and procedures to allocate sequestration rights. These procedures must not confer the right to sequester in a manner that puts individual private gain over the public good.

An additional legal justification to reclassify deep saline sequestration resources for public use exists in common law approaches to water rights. The alternative legal rationale for this legislation centers on deep saline

142. Though the purpose must be express and limited, in our view no limitations need to be placed on the motivation and operation of the entity fundamentally responsible for the sequestration activity with regard to profit making. We advocate for the creation of a non-profit "regional sequestration authority," but in our view a profit motivation does not obviate the public necessity and good of sequestration activity for the purposes of climate change prevention and mitigation.

aquifers and the public right of sovereignty associated with water in longstanding common law. In Ohio, for example, case law has recognized public sovereignty over "waters of the state,"[143] including deep saline aquifers. In the water rights context, the "public space" legislation must balance the states' traditional sovereignty over water resources with the needs and expectations of surface owners.

Because local, state, and national governments have traditionally retained varying degrees of sovereignty over water resources, there is some justification for the claim that common law doctrines already grant a degree of public sovereignty over the deep saline aquifer sequestration resource. Therefore, a CCS "public space" statute would, in many instances, simply clarify what is already law.

Such a statutory declaration would alleviate the threat of trespass claims for sequestered CO_2 that migrates within a deep saline aquifer. If private ownership were to extend to these deep and otherwise unusable formations, any excursions through these formations that cross property lines thousands of feet above could create innumerable trespass cases. Further, vesting rights in deep saline formations in the public would prevent holdout landowners from obstructing storage activity.

b. Depleted Oil and Gas Fields

Legislation should further establish that the surface owner will retain ownership of all pore space not appropriated to the public. This conclusion is consistent with a majority of state cases that follow the American Rule,[144] as well as consistent with the Wyoming CCS statute.[145] An explicit legislative declaration would resolve a host of jurisdictional conflicts and bring much needed uniformity to modern mineral right property questions. As a direct property question, this is clearly legislation that individual state legislatures can develop and promulgate.

As a recognized "stick" in the bundle of property rights, pore space in depleted oil and gas fields can be transferred separately from mineral reserves and the rest of the surface estates. Nevertheless, CCS statutes cannot infringe on the freedom of contract between two private parties or explicitly supersede common law property rights. Therefore, a caveat to the rule needs to state that the surface owner holds pore ownership unless

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143. *See* Chance v. BP Chemicals, Inc., 670 N.E.2d 985, 992–93 (Ohio 1996) (citing O.R.C. § 6111.01(h)) ("[W]aters of the state include all waters regardless of the depth of the strata in which underground water is located.").

144. *See supra* Part II.

145. *See supra* Part III.A.3.

explicitly reserved otherwise in a grant, lease, or other instrument. In those particular situations, however, the CCS legislation should also require that instruments effective as of the date of the legislation describe the transfer in detail, and that the appropriate local office record these instruments.

To promote CCS, it is important that the surface owner retains an interest in order to keep transaction time and cost at a minimum. Surface ownership of pore space allows the CCS operator or utility to only purchase the rights from the surface owner, as well as enter into a contract with the owner for the lease of the surface footprint. This rule will streamline transactions by eliminating the need for the CCS operator to negotiate agreements with both the surface and mineral rights holder.

c. Takings and the Use of Eminent Domain

To promote orderly development and maximize the usefulness of pore spaces, legislation should also establish eminent domain as a viable option for the gathering of subsurface sequestration and storage rights under a public use theory. Carbon sequestration and storage is the legal and technical cousin of geologic natural gas storage in several important ways. Currently, eminent domain powers are available to entities looking to store and transport natural gas. The public benefits associated with geologic carbon sequestration and storage should qualify the activity for similar regulatory treatment. Current law may not allow regulators or storage utilities to exercise this control. However, once legislation develops eminent domain authority, the legal issues and concepts associated with this appropriation will resemble those associated with natural gas storage leases.

Accordingly, it is essential to review the legal ramifications of seizure of storage sites through eminent domain and the takings arguments that may accompany government appropriation of deep well sites for CO_2 storage through the guise of the Natural Gas Act.

The Natural Gas Act (NGA) of 1938 was the first instance of direct federal regulation of the natural gas industry.[146] Concern about the exercise of market power by interstate pipeline companies prompted the NGA, which gave the Federal Power Commission (FPC)[147] the authority to set "just and reasonable rates" for the transmission or sale of natural gas in interstate commerce.[148] The NGA also gave FPC the authority to grant certificates allowing construction and operation of facilities used in

146. *See* Energy Information Administration, http://www.eia.doe.gov/oil_gas/natural_gas/analysis_publications/ngmajorleg/ngact1938.html.

147. Subsequently the Federal Energy Regulatory Commission (FERC).

148. Energy Information Administration, *supra* note 146.

interstate gas transmission and to authorize the provision of services.[149] The FPC may issue a "certificate of public convenience and necessity" under Section 7 of the NGA, allowing pipeline companies to charge customers for some of the expenses incurred in pipeline construction and operation.[150] Certificate holders must have control of the area prescribed in the certificate. If the holder cannot acquire control by contract, or is unable to agree with the property owner about compensation for the necessary land or other property and the necessary right-of-way to construct, operate, and maintain a pipeline or pipelines for the transportation of natural gas, the holder may acquire the property through exercise of the right of eminent domain.[151] In order to use the power of eminent domain that the Natural Gas Act grants, the company seeking to condemn property must meet several requirements: (1) that it is a natural gas company regulated by FERC pursuant to the Natural Gas Act; (2) that it holds a valid certificate of public convenience and necessity from FERC for the storage field where condemnation is sought; (3) that the easement sought is in the certificated geologic formation; and (4) that the affected real property is within the "map area" of the storage field defined by the certificate of public convenience and necessity.[152]

Early courts interpreting the Natural Gas Act's eminent domain power held that the granting of such power to federal district courts did not constitute a taking of private property for private use, nor was it an invasion of rights reserved to states.[153] Similarly, these courts held that Congress can constitutionally bestow a right of condemnation upon private licensees that develop national policy regarding the interstate movement of natural gas.[154] The Supreme Court addressed the constitutionality of eminent domain in dicta, citing with approval the Sixth Circuit's holding that the language of the Natural Gas Act included the power to condemn property for underground natural gas storage and not merely interstate transportation.[155]

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149. *Id*.

150. 15 U.S.C. § 717f(c)–(d) (2006).

151. *Id.* § 717f(d).

152. David D. Noble, *Ten Years of Federal Underground Gas Storage Condemnations*, ENERGY & MIN. L. INST. Ch. 26. § 26.06 (1993).

153. Thatcher v. Tenn. Gas Transmission Co., 180 F.2d 644, 648 (5th Cir. 1950).

154. *See* Williams v. Transcon. Gas Pipe Line Corp., 89 F. Supp 485, 487 (W.D. S.C. 1950) (noting *Thatcher* and other decisions affirming Congress's authority to grant eminent domain powers to private licensees); *see also* Gas Transmission Co. v. Thatcher, 84 F. Supp. 344, 345 (W.D. La. 1949) (ruling that the Natural Gas Act gave the Federal Power Commission authority to condemn a fifty-foot right-of-way to construct a pipeline).

155. *See* Schneidewind v. ANR Pipeline Co., 485 U.S. 293, 295 n.1 (1988) ("Petitioners argued that Storage was not a natural gas company within the meaning of the NGA, contending that the storage of gas constitutes neither the transportation nor the sale of gas in interstate commerce."). Both courts

Therefore, an analogous federal statute authorizing eminent domain for CCS is workable and constitutionally sound.

Similarly, CCS legislation should specify that a properly permitted operator or utility must acquire all surface and subsurface rights necessary for operating the storage facility, including easements and rights-of-way across lands. IOGCC developed similar language and policy in its model CCS regulation. Furthermore, as was necessary in the context of delineating property rights, eminent domain for CCS must be codified with language qualifying that it does not infringe on any other common law property rights.

2. Financial Assurance and Limitations of Liability

The other important aspect of any CCS legislation is a mechanism that shifts liability from private actors to public ones. Government-based assurance and insurance are important catalysts for effective deployment of CCS. Further, the statute should arrange a two-tiered financial assurance and liability regime, similar to the IOGCC model. The structure we propose has precedent in federal laws related to coal reclamation and nuclear power and will guarantee that CCS operators have liability coverage for both short and long-term contract and tort liability.

a. CCS Bonding: A Federally Structured and State Implemented Scheme

Since a major contributor to CO_2 emissions is the coal-fueled energy sector, it is appropriate that a financial assurance structure should reflect the very structure that assures proper reclamation of coal mining sites. While states could develop a CCS bonding program, a federal bonding program that is standardized yet flexible for the needs of state law is preferable. The Surface Mining Control and Reclamation Act (SMCRA) provides a useful model.

The SMCRA grants states "exclusive jurisdiction over the regulation of surface . . . mining,"[156] but provides that if a state fails to submit a program for approval, the program is not approved, or the Secretary of the Interior withdraws the approval because of the inadequacy of the program,

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rejected this argument. *See* ANR Pipeline Co. v. Schneidewind, 627 F. Supp. 923, 925–26 (W.D. Mich. 1985); *see also* ANR Pipeline Co. v. Schneidewind, 801 F. 2d 228, 230 n.3 (6th Cir. 1986) (The court reasoned that "transportation" includes the storage of natural gas by stating: "Underground gas storage facilities are a necessary and integral part of the operation of piping gas from the area of production to the area of consumption.").

156. Surface Mining Control and Reclaimation Act of 1977 § 503(a), 30 U.S.C. § 1253(a) (2006).

exclusive jurisdiction resides in the federal government.[157] Similarly, in the context of CCS liability and insurance, a primacy state could exclusively administer a federal standard.

Using actual language from the SMCRA, federal CCS bonding legislation would require a permitted CCS operator or utility to file a bond for performance, payable to the United States or to the state, conditioned upon faithful performance of all the requirements in the injection permit.[158] The bond would cover both the land where the operator would initiate injection operations and the subsurface storage location within the permit's initial term.[159] As the operator conducts succeeding injection and storage operations within the permit area, the permittee would file additional bonds with the regulatory authority to cover such increments. The amount of the bond required for each bonded area would depend upon the amount of CO_2 being injected.[160]

An important issue with any bonding system is the duration of the bond requirement. The IOGCC's model provides an exemplary solution to this problem. The model offers a closure period of liability under the bond for the duration of the injection operation and closure of the well, followed by a period of ten years.[161] The ten-year period would obligate best practices and monitoring by the operator who will bear the liability for that period, but would also give the operator certainty that its obligations have ceased.

The federal CCS bonding program would allow the same flexibility for individual states as under the SMCRA, where the Secretary of the Interior may approve as part of a state or federal program an alternative system that will achieve the objectives and purposes of the coal reclamation bonding program. While the alternative bonding system has arguably failed to assure proper reclamation in many instances and has been the subject of years of litigation[162] and state inaction,[163] such flexibility is necessary in the context of the burgeoning CCS industry to quickly address the country's contribution to global climate change.

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157. *See id.* § 1254(a).

158. *Id.* § 1259(a).

159. *Id.*

160. *Id.*

161. IOGCC Guide at 120.

162. *See* Pa. Fed'n of Sportsmen's Clubs v. Hess, 297 F.3d 310 (3d Cir. 2002) (discussing an Eleventh Amendment challenge to Pennsylvania's SMCRA alternative bonding program).

163. Ohio's alternative bonding program has been in violation of SMCRA's minimum standards since it gained primacy in 1983, and despite threats by the Federal Office of Surface Mining to take over and federalize the program, Ohio has yet to fully comply.

b. Federal Indemnity: The Price-Anderson Analogy

After a bond is released, however, there must still be safeguards for the indefinite life of the CO_2 storage area covered. The goal is to contain CO_2 well beyond the lifespan of even the most well-managed and sustainable corporate entity. If the federal government wants to deploy CCS quickly and successfully, it should look to its nuclear power policy for guidance. The risks associated with CO_2 storage are by no means analogous to nuclear power generation. Nevertheless, since large-scale CCS is undoubtedly new and its long-term liability implications are uncertain, the federal government should consider implementing an indemnity scheme similar to one it implemented to ensure the operation of nuclear power facilities.

First passed in 1957, the Price-Anderson Nuclear Industries Indemnity Act governs liability-related issues for all non-military nuclear facilities constructed in the United States.[164] The Price-Anderson Act was enacted with two primary goals: 1) to encourage private industry to invest in and produce nuclear energy; and 2) to provide a procedure for compensating the public for personal injury and property damage in the event of a nuclear incident causing personal or economic harm.[165] Prior to the Price-Anderson Act, the unavailability of private insurance had exposed licensees to potentially crippling liability and thus created a "roadblock" to the development of nuclear power.[166] Secondly, because an operator's resources might well be exhausted at an early stage, claimants had little assurance that they would in fact be compensated.[167] The Price-Anderson Act addressed those problems by requiring financial protection, providing for government indemnity, and limiting liability.

A governmental assumption of perpetual liability for CO_2 storage would withstand a constitutional challenge before the United States Supreme Court. The Price-Anderson Act faced a similar challenge in 1978 in *Duke Power v. Carolina Environmental Study Group*. In this case, a nuclear power company with permits to construct two plants in the Carolinas appealed a district court opinion allowing certain environmental groups standing to argue permitting and procedural violations. Specifically, the groups argued that the government failed to take into account the severity of a possible nuclear incident and its cost to the public, violating

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164. The Price-Anderson Act is named for Congressman Charles Melvin Price (D-Ill.) and Senator Clinton Presba Anderson (D-N.M.), both of whom eventually chaired Congress's Joint Committee on Atomic Energy.

165. 42 U.S.C. § 2012 (2006).

166. S. REP. NO. 85-296, 85th Cong., 1st Sess. 1 (1957).

167. Duke Power Co. v. Carolina Envtl. Study Group, Inc., 438 U.S 59, 69–70 (1978).

the public's constitutional rights of Due Process and equal protection under the Fifth Amendment.[168] The Supreme Court reversed, concluding that the legislative record supported a policy of encouraging nuclear development in the private sector and that indemnifying insured nuclear operators in the manner specified in the Act was a reasonable and rational alternative to compensating injured plaintiffs under the common law.[169] Specifically, the Court found that congressional assurance of a $560 million fund in the event of an incident was reasonable in the face of an unpredictable recovery cost, and was not arbitrary considering Congress's commitment to "take whatever action is deemed necessary and appropriate to protect the public from the consequences of a nuclear incident."[170]

The provisions of the Price-Anderson Act were tested less than a year later when an incident occurred at the Three Mile Island nuclear facility near Harrisburg, Pennsylvania. A partial core meltdown caused the release of what later was found to be a minimal amount of radiation that had "a negligible effect on the physical health of individuals," and "the major health effect of the accident was found to be mental stress."[171] Nevertheless, the Price-Anderson Act authorized more than $70 million in settlements and direct distributions from primary insurance sources between the first day of the incident and 1997. These payments covered immediate and delayed economic and physical harm, funded evacuations, and established an area health fund.[172]

The impetus for the Act was that investors were unwilling to accept the then-unmeasured risks of nuclear energy without some limitation on their liability. The direct correlation with CCS and its relatively lower, yet still unmeasured, risks should be evident.

While the Price-Anderson Act has faced stark opposition from both environmental organizations and independent think tanks,[173] a federal indemnification program for CCS tailored after Price-Anderson is ideal for deploying CCS technology. Unlike nuclear power generation and waste

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168. *Id.* at 91.

169. *Id.* at 83.

170. *Id.* at 91.

171. JOHN KEMENY, REPORT ON THE PRESIDENT'S COMMISSION ON THE ACCIDENT AT THREE MILE ISLAND, 12 (1979).

172. AM. NUCLEAR SOC'Y, THE PRICE-ANDERSON ACT, at 3 (2005), http://www.ans.org/pi/ps/docs/ps54.pdf.

173. For example, the Cato Institute and other conservative research organizations oppose Price-Anderson, arguing that providing a safety net for nuclear facility owners and operators encourages negligence, and that some provisions in the legislation act to indemnify the Department of Energy and private contractors even in the face of gross negligence and willful misconduct.

storage, sequestering carbon is a low-risk venture. Creating a federal indemnity scheme will ensure that its transaction costs are low.

3. Creating a Sequestration and Storage Utility

Federal or regional authorities should establish a geologic sequestration utility (GSU) program to facilitate and manage the rapid expansion of geologic sequestration, particularly in saline formations. The utility concept, originally developed by the Midwest Governors' Association (MGA),[174] would create a new public utility for the purpose of coordinating, regulating, and perhaps insuring an expanding CO_2 storage industry. A CO_2 storage utility would provide additional certainty to potential CCS operators, and a system of government regulation could assure skeptical citizens of the safety and feasibility of underground storage. A GSU would allow one regional body to coordinate and deploy most of the duties and responsibilities of the CCS industry. The new utility would create certainty by offering a known CO_2 storage option.

There are several options for a storage utility. The MGA model envisions the creation of a new agency solely devoted to CO_2 storage regulation. The MGA's proposed GSU would have expansive powers and obligations. For example, the MGA model would assume full liability for CCS projects and responsibility for site monitoring, develop and maintain a system of pipelines to transport CO_2 for injection, and purchase and lease all property rights necessary for CCS development.[175] A GSU such as the one proposed by the MGA could be used to implement and enforce many of our recommendations for government assumption of liability, but it would also presuppose significant government involvement as a market participant in CCS.

Another option would be to create a similar administrative body with advisory, not regulatory, authority. An advisory body could still provide important assistance and counseling to operators regarding the most daunting aspects of CCS, including licensing, permitting, acquiring sufficient surface and subsurface property rights, securing storage credits pursuant to national CO_2 regulation, and managing long-term liability. Establishing an advisory body, however, would not require the federal

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174. The Midwest Governor's Association has developed a draft proposal for a geologic storage utility. MGA Geologic Carbon Storage Utility Design Recommendations (Draft), (Mar. 17, 2009), http://www.midwesterngovernors.org/MGA%20Energy%20Initative/Renewable%20Electricity,%20Advanced%20Coal%20with%20Carbon%20Capture/mtg6/GCS%20utility%20design%20recommendations_3-17-09.pdf.

175. *Id.*

government to become an active market participant as a buyer and seller of storage rights. Therefore, the federal government could implement this type of body as a temporary compromise to facilitate private development of CCS until Congress determines the full federal role in areas such as liability management. Moreover, an advisory-type utility could be housed within one of several existing administrative agencies such as the FERC, the Department of the Interior, or the EPA.

In sum, the fundamental goals of the utility concept could be achieved through either the creation of a new agency with broad powers to acquire and lease property and assume liability for CO_2 injections, or through a less powerful advisory council—or by an amalgam of the two. Most importantly, the utility concept frees existing utilities and industries from the task of becoming experts in a completely new activity outside their core business. CCS is a complex undertaking, and the utility's role would be to reduce its complexity and to establish transparent oversight of multiple projects in a region.

CONCLUSION

In the United States and around the world, coal-generated electricity is the single largest source of GHG emissions. There is now a general agreement within the industry and across the political spectrum that stopping or slowing the effects of climate change will require vast reductions in the amount of CO_2 that coal-powered generation emits. Yet there remains significant debate over how to achieve these reductions.

Some advocates suggest abandoning the ugly legacy of coal altogether, instead focusing solely on the development of renewable power generation. They argue that promoting advanced coal technology only deepens the world's dependence on a harmful commodity. There is no doubt that coal mining is a destructive process. Mining for power generation eviscerates mountaintops and poisons whole streams, while coal combustion fouls the air and warms the planet. The environmental and economic scars that coal mining has inflicted upon Appalachia alone will take generations to heal.

But, as we argued Part I, it is unlikely that we can replace the full amount of power generated by coal in the short term. Coal will almost certainly provide a significant percentage of the world's electricity for years to come. Global climate change, therefore, requires a new pragmatism. We do not have the luxury to hope that the world will abandon coal as an energy source in the near term; instead, we must promote the immediate, widespread deployment of the technologies that allow for cleaner, carbon-neutral coal combustion.

Carbon capture technology represents the potential to reduce CO_2 emissions and mitigate the harmful effects of the greatest contributors to climate change. Scientists and geologists are confident that deep geologic formations can safely and permanently store colossal quantities of CO_2. What is needed now is an appropriate legal framework to govern CCS. Our recommendations focus on what we view as the most important components of such a framework: clear, consistent definitions of property rights and a liability-limiting system whereby private operators can undertake storage operations with confidence.

Cleaner, carbon-neutral coal-fired generation will be an important first step in solving the global climate crisis. By addressing the regulatory void surrounding CCS through legislation and rulemaking, we can allow this promising technology to flourish in the United States and ultimately enable CCS to reduce GHG emissions worldwide.