Chapter 17

Carbon Capture and Sequestration

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I. Introduction

This chapter examines U.S. laws applicable to carbon capture and sequestration (CCS) [1] and identifies reforms that will be necessary for CCS to operate as a viable greenhouse gas (GHG) emissions control strategy domestically. In the U.S., few, if any, new coal-fired power plants are projected to be built in the next few decades.[2] Some existing plants may be retrofitted with CCS; some have been designed to facilitate economical retrofitting.[3] In September 2013, the U.S. Environmental Protection Agency (EPA) issued a proposed rule to limit GHG emissions from new fossil-fueled electric generating units (i.e., power plants) effectively requiring at least partial use of CCS at some new plants.[4] President Obama has directed EPA to propose a rule by 2014 to limit GHG emissions from existing plants.[5] U.S. policy on CCS is potentially critical to its adoption as an emissions control strategy in other countries, as well. Adoption of CCS by high GHG-emitting countries such as China and India may require effective demonstration of both the capture technology and sequestration at commercial scale in the U.S.[6] China has taken steps towards developing CCS technology,[7] but more widespread adoption of CCS globally may be facilitated or accelerated by its development at commercial scale in the U.S.

A. Overview of Technology

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CCS is a method for reducing emissions of carbon dioxide (CO_2) to the atmosphere from large, stationary emission sources such as coal-, oil- and gas-fired power generation plants and steel, cement, ammonia and fertilizer manufacturing plants. Given the abundance of coal in the U.S.[8] and elsewhere in the world, coal-fired power plants have been the key focus of CCS research and experimentation to date.[9] The International Energy Agency (IEA) estimates that in 2012 coal accounted for approximately 44% of the world's total energy-related emissions of CO_2 and approximately 29% of the world's anthropogenic emissions of CO_2.[10] Thus, CCS has the potential to make a significant contribution to the mitigation of climate change.

At present, there are three types of CO_2 capture processes: post-combustion, oxy-fuel combustion and pre-combustion.[11] Existing power plants can be retrofitted with the first two types of capture technology; pre-combustion capture would be designed into new plants. All three technologies have the potential to capture up to 90% of the CO_2 produced by a typical coal-fired power plant.[12] Once captured, the gas is purified and compressed into a supercritical state (i.e., a quasi fluid).

The IEA has estimated that global emissions of CO_2 reached record levels of 31.6 gigatonnes (Gt) in 2012.[13] Hence, to achieve the major reductions in emissions of CO_2 that are needed, indefinite storage or sequestration of an enormous amount of CO_2 is necessary.

To be sequestered, the CO_2 is piped to the location where it will be stored indefinitely under a geological cap. Targets for geological sequestration include depleted oil and gas reservoirs, salt caverns, certain coal seams, and the pore space and saline formations situated very deep beneath the earth's surface and offshore beneath the seabed.[14] CO_2 may also be sequestered by other means such as uptake by plants (known as terrestrial or biological sequestration) or disposal into the water column of the ocean. This chapter will focus on geological sequestration on shore and off shore.

Already being tested is the permanent storage of captured CO_2 within depleted oil and gas reservoirs.[15] CO_2 has been used in the U.S. and elsewhere for decades to enhance the recovery of oil and gas, a process in which the CO_2 is injected into oil and gas wells to facilitate movement of more of the hydrocarbons into the wells and to the surface.[16] With few exceptions, there has not been much effort to determine how much of the CO_2 remains in the reservoir after injection. In the U.S., the CO_2 used for this process is typically naturally-occurring CO_2 extracted from the earth, rather than CO_2 that has been captured from existing stationary sources of CO_2 emissions.[17] The reason for this is a combination of the cost of capture, unanswered legal questions about sequestration, the absence of national constraints on emissions of CO_2, and the absence of the infrastructure to transport and sequester the captured CO_2.[18]

At present, CCS is only considered for large CO_2 emission sources because the capture equipment is very expensive to install and operate. Moreover, at a typical coal-fired power plant, the process of capturing, purifying and compressing the CO_2 can consume between 15% and 30% of the power generated by the plant.[19] This is referred to as the “energy penalty” associated with CCS. Then, there is additional cost associated with the transport and sequestration of the captured gas. CCS-equipped power plants are also estimated to use 30% to 100% more water than unabated fossil-fuel fired power plants because of the energy penalty and the associated need for large cooling systems.[20]

The Congressional Budget Office has analyzed a variety of studies and calculated the costs of operating a coal-fired power plant over its lifetime with and without CCS as follows: between \$95-\$112 per megawatt hour to operate a coal-fired plant with CCS, and between \$53-

$66 per megawatt hour to operate the same plant without CCS.[21] To help close this gap, the U.S. Department of Energy (DOE) has invested more than $41 million to develop methods and technologies that reduce the cost of installing and operating capture-related equipment while at the same time increasing the amount of CO_2 captured.[22] DOE aims "to produce competitive and effective CO_2 capture technologies" that are not only "capable of reducing CO_2 emissions by 90%" but that also "reduce the overall economic penalty imparted by current carbon capture (CC) technology by 55%" in order to reduce to 35% the increase in cost of producing electricity associated with use of CCS.[23] DOE's analyses conclude that these goals are "aggressive, but feasible."[24]

B. Status of U.S. Demonstration Projects

This is not the U.S. government's first investment in CCS technology. In 2003, the Bush Administration, through DOE, committed $1 billion to a public-private partnership known as FutureGen to build a power plant with near-zero CO_2 emissions to serve as a prototype for CCS.[25] In connection with the FutureGen project, DOE was to oversee a consortium of industry partners to manage the construction of the plant. Although the original project was cancelled in 2008, the Obama Administration resurrected it with new funding in 2010 as FutureGen 2.0.[26]

The sequestration aspect of CCS also poses some expensive challenges involving property acquisition as well as thorny legal liability issues. As discussed below, these challenges arise from the need for vast amounts of storage space and the long-term nature of the storage. In addition, to enable commercial deployment of CCS, significant pipeline infrastructure must be built for the transportation of CO_2.

Between 2007 and 2010, when the U.S. Congress was considering legislation to cap, tax, or otherwise place restrictions on emissions of CO_2—culminating in the American Clean Energy and Security Act (ACES) passed by the House of Representatives in 2009[27]—there was a flurry of activity by energy companies, engineers, investors, and other stakeholders focused on bringing CCS to commercial scale.[28] For example, in 2007, the president of American Electric Power (AEP), which is among the largest CO_2 emitters in the U.S., committed his company to reduce, avoid, or sequester its greenhouse gas emissions to six percent below the average of its 1998 to 2001 emission levels by 2010.[29] Through this commitment, AEP would have reduced or offset approximately 46 million metric tons of GHG emissions.[30] While this figure equated to less than one percent of the U.S.'s total GHG emissions in 2007,[31] the commitment was symbolic because it was significantly more than other leading energy providers were willing to pledge to at the time.

CCS was one of AEP's strategies for achieving these reductions.[32] In 2009, AEP declared that a CCS demonstration project at its Mountaineer power plant in West Virginia had "exceeded expectations,"[33] and predicted it could "retire 25% of its coal-burning power plants and install advanced carbon-capture equipment on the remaining 75%."[34] To this end, between September 2009 and May 2011, AEP retrofitted an existing coal-fired unit at its Mountaineer plant with capture equipment and successfully demonstrated the CCS process.[35]

In mid-2010, President Obama declared his commitment to having between five and ten CCS demonstration projects operational by 2016, and convened an interagency task force to identify ways to achieve the goal.[36] The Task Force issued its report in August 2010, finding, *inter alia*, that one of the primary obstacles to widespread cost-effective deployment of CCS technology was the lack of a federal policy to reduce GHG emissions.[37] While the Task Force made a number of recommendations to address this concern,[38] by the end of 2010, legislative attention had shifted away from climate change. All of the bills that had proposed any price on carbon stalled or failed (most notably ACES), climate change skepticism resurfaced,[39] and most of the proposed demonstration projects—including FutureGen—had been cancelled or put on hold, despite ongoing commitments of significant federal funds and/or tax relief.[40]

In December 2010, Basin Electric Power Cooperative placed its Antelope Valley CCS Project in North Dakota on hold indefinitely due to cost and the absence of any price on carbon.[41] Another casualty was AEP's Mountaineer project, which was shelved in July 2011.[42]

As of mid-2013, only a handful of CCS projects in the U.S. show any signs of life.[43] There is as yet no commercial-scale, coal-fired, integrated CCS project up and running in the U.S.[44] The five projects that are in planning or development in the U.S. are all characterized as "demonstration" projects. Of these, only two involve the retrofit of an existing power plant unit: FutureGen, which was resurrected with DOE funding in September 2010 as "FutureGen 2.0"[45] and the W.A. Parish plant in Texas.[46]

Although the momentum for developing commercial-scale CCS stalled, EPA's September 2013 proposed New Source Performance Standards will breathe new life into CCS both because the rule will require new power plants to meet a standard that assures some use of CCS to reduce CO_2 emissions and because it is the predicate step to proposal of a performance standard applicable to existing sources. Indeed, the President has directed EPA to propose a standard for existing sources in 2014.[47] CCS may yet emerge as an important mitigation strategy should the U.S. and other countries ultimately reach a political consensus to address global warming. According to the IEA, to achieve deep cuts in worldwide CO_2 emissions, "nearly all new-build fossil-fuel power plants need to be equipped with CCS in the coming decades. In addition, CCS equipment would need to be added to the already installed global fleet of fossil-fuel power plants."[48]

CCS has the attraction of allowing continued fossil fuel consumption.[49] Yet given the significant costs associated with CCS, it seems unlikely to move forward without a meaningful carbon price or regulatory controls to drive investment.[50] Although a few private utility companies have contemplated constructing and operating new coal plants with CCS technology, their petitions to recover the cost from their customers have been denied. For example, in 2012 the Mississippi Supreme Court unanimously denied a request by Mississippi Power to pass on a portion of the costs of constructing its new CCS-equipped plant at Kemper County to its customers.[51] Mississippi Power had already received substantial financial support for the plant[52] and so announced plans to complete construction notwithstanding this result.[53] Similar decisions regarding cost recovery could, however, inhibit other projects. The Public Service Commissions in Virginia and West Virginia denied AEP's requests for full reimbursement of its costs of installing and operating CCS at its Mountaineer plant.[54] These judgments were a key factor influencing AEP's decision not to proceed.[55] There are numerous other potential legal impediments to developing and deploying CCS technology at commercial scale. The aim of this chapter is to describe the variety of legal requirements relevant to CCS and to identify reforms—and in some cases new legal regimes—that would facilitate its progress.

II. Laws Applicable to the Capture Technology

While Chapter 4 addresses regulatory requirements applicable to CO_2 emissions generally, this chapter will highlight key requirements in federal pollution control statutes—and potential exemptions from such requirements—that may apply to the installation and operation of CO_2 capture equipment. From a legal perspective, it is appropriate to treat capture technology separately from sequestration. This is because different laws and legal considerations apply to these different stages of the process and because the emitting source and the sequestration equipment or site may have different owners and operators.

As mentioned earlier, capture technologies are available for use in both new and existing plants.[56] Under existing federal and state law, a proposal to build a new plant triggers myriad statutory, regulatory, and permitting requirements. Whereas existing plants typically escape much of the regulation that applies to new plants, the owner/operator of an existing plant considering a retrofit to capture CO_2 emissions will also need to analyze whether the retrofit triggers a variety of legal requirements.

A. Federal Laws, Regulations and Cases

A CCS project would require numerous permits pursuant to federal law. When a proposed activity (construction or operation of a new facility or modification of an existing facility) will result in the emission of threshold levels of regulated air pollutants, a host of permitting programs under the Clean Air Act (CAA) will be triggered.[57] These include review and permitting of new or modified sources of emissions under either the Prevention of Significant Deterioration (PSD) or New Source Review (NSR) provisions of the CAA.[58] The former applies to facilities in areas that have attained CAA requirements; the latter applies to areas that are in non-attainment.[59] To obtain a PSD or NSR permit, an applicant must demonstrate that the new or modified facility will satisfy New Source Performance Standards (NSPS),[60] Lowest Achievable Emissions Rates (LAER),[61] and/or Best Available Control Technology (BACT).[62] Again, whether these apply will turn on the specific pollutant being emitted, whether the facility is located in an area that is in attainment for that pollutant, and the type of technology in use. These requirements are of concern in the context of CCS because the capture technology (as currently designed and operated) is expected to consume enough energy that the emissions of a variety of air pollutants (including particulate matter, nitrogen oxides, and carbon monoxide) could increase at levels that may trip the requirements for permitting and/or reporting, if the energy penalty is manifested in additional fuel being burned to maintain the plant's output.[63]

Temporary demonstration projects (five years or less) at coal-fueled power plants may qualify, however, for the "clean coal technology" exemption in Section 7651n of the CAA. Specifically, such projects may qualify for exemptions from PSD, NSR and NSPS.[64] This exemption is of limited utility, however, because a company that invests hundreds of millions of dollars in construction of a project is not likely to shut it down within five years.[65]

When proposing a new fossil-fuel burning facility or a significant modification of an existing facility that does not fall within Section 7651n of the CAA, the proponent will need to consider the applicability of the existing and emerging NSPS, which are minimum performance standards (based on "best demonstrated" technology) set by EPA that apply uniformly to all new or modified sources in a particular industrial category.[66] In its 2013 Proposed NSPS Rule for New Power Plants,[67] EPA has determined that CCS is the "best system of emission reduction" (BSER) for new coal-fired plants. As to BACT, a performance standard typically determined by state regulators using "guidance" provided by EPA, and applicable on a case-by-case basis to new or significantly-modified facilities located in areas designated as "in attainment" with air quality standards, the proponent will first need to consider whether BACT applies to the project and then, as to the projected CO_2 emissions, whether CCS is required to satisfy BACT.[68] What constitutes BACT for CO_2 emissions is not yet settled by EPA or the courts. EPA's 2011 guidance document suggests that CCS must be considered in the BACT analysis but also acknowledges that CCS is not yet operating at a commercial scale.[69] Typically, the NSPS establishes a "floor" for BACT below which the states may not go in approving a PSD permit; until EPA's 2013 Proposed NSPS Rule is finalized, EPA's determination that CCS is the best demonstrated technology will not serve as the BACT floor.[70] EPA and the states that have been delegated authority to implement the CAA's PSD provisions for greenhouse gases have considered approximately 20 permit applications that include CCS in the BACT analysis.[71] CCS has not been required as BACT in any of these. The explanation offered by the agencies is cost, the energy penalty, the lack of nearby sequestration facilities, and/or the lack of a pipeline or other readily-available methods of transporting captured gas to a sequestration facility.[72]

However, it is still possible that CCS will be required to meet the BACT standard in the future. In 2012, EPA Region V advised the Illinois Environmental Protection Agency that the state agency could issue a permit that requires CCS as BACT and allows the implementation of CCS at the facility to be phased in over time as piping and sequestration facilities become available.[73] The Illinois Environmental Protection Agency subsequently withdrew its permit approval to "allow for further consideration of the permitting decision, including, but not limited to, elements of the Best Available Control Technology (BACT) analysis.[74] Meanwhile, the Indiana Department of Environmental Management (DEM) issued an air quality permit requiring a three-step phased-in reduction of CO_2 emissions. For a stationary natural gas and liquefied CO_2 production plant owned by Indiana Gasification, LLC, the Indiana agency set a specific, numeric CO_2 BACT emission limit that will be phased in over time and that is premised on the plant's capture and sale of CO_2 to third parties for use in EOR.[75]

Any industrial operation or facility at which there is a potential for storm water to contact pollutants or that disposes of water containing heat or other pollutants from a discernible, confined and discrete conveyance (i.e., a "point source") may trigger effluent discharge standards and permitting requirements under the Clean Water Act (CWA).[76]

In addition to considering the applicability of the CAA and CWA, the owner/operator of the capture equipment at an existing or new plant will also need to consider whether substances removed from the CO_2 stream before its compression or other materials resulting from the capture and treatment process require handling as hazardous wastes under the Resource Conservation and Recovery Act (RCRA), which governs the generation, storage, transportation, and disposal of hazardous waste, or its state analog.[77] Although the CO_2 should be purified and hence not "hazardous" at the time it leaves the site of capture, it is possible that during piping or sequestration it may mix with other substances to become "hazardous"[78] and potentially trigger liability under either RCRA or the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as the Superfund statute, which assigns liability for the cost of addressing risks posed by hazardous substances. [79] Although CERCLA includes an exemption for "federally-permitted releases" of hazardous substances,[80] it is a very narrow exemption precluding cost recovery only under CERCLA without precluding liability under other laws or legal theories.[81] Hence, the capturing entity may, despite holding a permit authorizing sequestration and despite, in some narrow cases, qualifying for the exemption from Superfund liability, find itself subject to claims of liability based on other theories. Because the CCS industry is still in a nascent stage of development, the availability of the exemption to capturing entities has yet to be determined, and there is, as yet, no administrative or court ruling on this issue.

In 2011, EPA proposed a rule to create a "conditional" exemption from RCRA for sequestered CO_2.[82] The final rule is yet to be published, despite EPA's projection that it would be published by August 2013.[83] In the meantime, at least one state (Montana) has enacted legislation that exempts CO_2 contamination of water in a storage reservoir from the definition of "pollution."[84] Of course, such exemptions apply for purposes of state law only and do not change the application of federal law. Entities in states without similar exemptions may be able to reduce their exposure through private indemnification agreements, but some statutes, such as CERCLA, are written to allow the government to assert claims regardless of the existence of private agreements.[85]

B. State Laws

At the state level, there may be analogous requirements under state clean air, clean water, and hazardous materials management laws. In addition, some states regulate the quantity of water that can be withdrawn for industrial purposes,[86] regulate reporting of the handling, storage, and emissions of certain chemicals,[87] or have more stringent standards for air emissions or water discharges than exist under federal law.[88] These requirements are cumulative rather than mutually exclusive unless federal law preempts state law. Thus, owner/operators of carbon capture facilities may face a variety of federal and state requirements of varying stringency.

C. Liability Concerns

Many of the liability concerns related to installation and operation of CO_2 capture equipment are not unique to CCS. For example, if the owner/operator of the plant enters into a contract to supply a specific amount of CO_2 to an enhanced oil recovery facility or to a sequestration owner/operator, the principles that ordinarily apply to contracts will continue to apply. However, if the plant owner/operator commits in a contract or a permit to reduce its emissions of CO_2 and then experiences a leak or release or otherwise breaches the contract or violates the permit, the consequences may go beyond contract law and trigger liability or penalties under laws that limit CO_2 emissions (federal and state statutes regulating CO_2 emissions are at various stages of development, as described in Chapters 4 and 10).

Similarly, breach of a representation about the purity of the CO_2 stream may result in consequences beyond contract liability. If the CO_2 stream contains a concentration or quantity of a hazardous substance that contradicts a representation made by the capturing entity, then the sequestering entity could be exposed to potential liability under a variety of common law theories or statutes for sequestering a "hazardous" substance. For example, such sequestration could be considered disposal of a hazardous substance or hazardous waste triggering regulation under RCRA[89] and/or liability under CERCLA,[90] for the consequences of a "release or threatened release" of hazardous substances. There is as yet no precedent about how these statutes or their state analogs might be applied to CO_2 and whether liability will attach to the company that generated, produced or captured the CO_2 despite a contract with the sequestration facility providing otherwise.

D. Financing Incentives

To enable the development of CCS projects, a range of financial incentives has been introduced by the federal government and the states. These include tax credits, loan guarantees, grants, and perhaps of most value at the moment, public-private partnerships.

Federal tax credits take the form of investment tax credits for clean coal power generation facilities[91] and sequestration tax credits which are available for each ton of carbon dioxide captured from an industrial source and disposed of in secure geological storage.[92] Commentators have suggested that investment tax credits will serve as the primary long-term incentive for CCS projects, with an estimated cost to the federal government of $900 million for the period 2009-2013.[93] A number of states have also adopted tax incentives to encourage CCS projects.[94]

Federal loan guarantees are available for CCS projects under section 1703 of Title XVII of the Energy Policy Act of 2005.[95] Although the statute includes CCS in the list of clean technologies that it aims to support,[96] the program had not sponsored a CCS project and no funding has been provided for loan guarantees in the 2012 fiscal year.[97]

By contrast, the federal government has allocated substantial funding for CCS projects through two other mechanisms: the Clean Coal Power Initiative (CCPI), which is authorized to distribute $200 million for each fiscal year between 2006 and 2014;[98] and the American Reinvestment and Recovery Act (ARRA), which appropriated $3.4 billion for fossil energy, including $800 million for the CCPI.[99] The CCPI is currently funding CCS projects in Mississippi, California, Texas and West Virginia.[100] At least one of those projects has also received funding pursuant to the ARRA.[101] Another $534 million has been appropriated for fossil energy in 2012.[102] A number of states have also introduced grants to encourage research associated with CCS and building of CCS facilities.[103]

Finally, one of the key regional drivers of CCS projects has been the creation of a public-private network known as Regional Carbon Sequestration Partnerships, which operate across seven regions in the U.S. and Canada.[104] These partnerships, which were initiated by DOE and are being implemented in three phases, aim to develop the infrastructure, technology and regulatory framework necessary to establish CCS on a commercial scale.[105] They bring together more than 400 stakeholders including representatives of federal and state agencies, private companies, non-profit organizations and other industrial partners.

The partnerships are responsible for numerous small sequestration projects and eight large-scale projects each sequestering more than one million metric tons of CO_2.[106] They include geological sequestration projects involving captured CO_2 emissions in Southwest

Alabama (a project of the Southeast Regional Carbon Sequestration Partnership)[107] and naturally occurring CO_2 in Northern Montana (a project of the Big Sky Carbon Sequestration Partnership).[108] Some estimates suggest that the federal government's commitment to the regional partnerships may exceed $550 million by 2017.[109] The initiative is intended to demonstrate that CO_2 can be safely and securely stored over long periods and across major geographic regions of the U.S.

III. Laws Applicable to Sequestration

The sequestration aspect of CCS poses some challenging and novel legal issues. In order to mitigate climate change, large quantities of captured CO_2 would need to be securely stored or sequestered indefinitely, if not permanently. Because the CO_2 will take up an enormous amount of underground space,[110] there are both practical and legal problems entailed in acquiring the necessary property rights. In addition, the movement of the gas underground may not be completely predictable, a situation which also presents logistical and legal challenges. Moreover, sequestration of large volumes of CO_2 in deep aquifers may displace groundwater (i.e., push groundwater out of its way) or induce seismic activity.[111] Streams of CO_2 may be contaminated by a hazardous substance or cause contamination through interaction with water and minerals. These problems are not insurmountable, at least in theory. Sophisticated predictive models already exist to guide the siting and engineering decisions necessary to help control the movement of the CO_2.[112] Models are not perfect, however, and the movement of the gas cannot be perfectly predicted.[113]

Seismic events, gas leaks and water displacement or contamination may result in liability for personal injuries, property damage and natural resource damage based on common law legal theories such as trespass, negligence, nuisance and breach of contract, or statutory remedies for the same. In addition, there is a potential for claims for impaired value of neighboring parcels because their future use will be restricted as a result of the need to maintain a secure geological cap over the sequestered CO_2. If the stream of CO_2 is contaminated by a hazardous substance or creates contamination by its interaction with water and minerals, there is potential liability under RCRA, CERCLA and/or their state analogs.[114] This legal exposure may be tempered by the existing exemption for federally-permitted releases in Section 107 of CERCLA[115] and the proposed "conditional" exemption for sequestered CO_2 from RCRA[116] or managed by indemnification agreements.

Industry has expressed concerns about (1) the unknown cost of this potential liability and (2) carrying the long-term risk of such liability on its books,[117] where such risks are perceived to be material. The term of exposure to potential liability is so long it will exceed the typical lifespan of a corporation. Although corporate liability under federal law for hazardous wastes and hazardous substances is likewise indefinite, and there is the possibility that the hazardous material could escape its containment, the concerns about liability for CO_2 sequestration are perceived as being different and have dominated the conversation about CCS. [118] As yet, because CCS has not been widely deployed, the available insurance policies are very limited in number.[119] Zurich Financial Services Group is one of the early movers in the market and has developed two products specifically aimed at CCS project operators: CCS Liability Insurance and Geological Sequestration Financial Assurance.[120]

Because uncertainty about the cost and duration of potential liability poses real and serious barriers to the commercial development of CCS in the U.S., the states that competed for the FutureGen project, Texas and Illinois, each proposed to assume the ultimate liability for the sequestered CO_2 .[121] Most of the model liability regimes that have been proposed to date provide for a government entity to take ownership of and responsibility for the sequestered CO_2 at between 10 and 50 years after the corporate entity has properly and securely closed the sequestration site.[122] Were these regimes to be adopted, they would obviate some of industry's concerns about liability.

Following the discussion below of the existing laws applicable to sequestration of CO_2, Section III will discuss in more detail the types of liability that may occur and options for managing the long-term liability problem.

A. Federal Laws and Regulations

At present, there are three categories of federal laws that explicitly apply to geological CO_2 sequestration: (1) water protection; (2) monitoring and emissions reporting; and (3) use of federal lands. Additional laws apply to sequestration beneath the ocean floor, known as off-shore sequestration. Each will be addressed below.

1. Water Protection

a. Drinking Water

Pursuant to the Safe Drinking Water Act (SDWA) and its Underground Injection Control (UIC) Program,[123] longstanding EPA regulations govern the use of wells for the injection of CO_2 to enhance the recovery of oil or gas.[124] These are referred to under the UIC Program as Class II injection wells. In 2010, EPA finalized a rule creating a new class of wells to be constructed and used for long-term geologic sequestration of CO_2, known as Class VI wells.[125] EPA subsequently issued technical guidance for implementation of the Class VI well regulations.[126]

The regulations applicable to Class VI wells are more stringent than those for Class II wells in order to protect against an assumed increased risk to underground sources of drinking water from sequestration of CO_2 as compared to traditional Class II wells into which far less CO_2 is injected and which are not designed for indefinite storage of the injected CO_2.[127] EPA made a determination of increased risk to drinking water on the basis of specific factors such as an increase in reservoir pressure and proximity between the injection zone and the underground water supply.[128] Among other requirements, owners/operators of Class VI wells must: demonstrate that the wells are appropriately sited, with injection zones that are large and porous enough to receive the CO_2 and with confining zones (geological caps) that are free of faults and fractures and that will not be vulnerable to fracture;[129] delineate the area at risk of drinking water contamination through modeling of the migration of the CO_2 plume; comply with specific construction protocols; post financial assurance;[130] install and operate continuous monitoring devices along with alarms and automatic shutoff systems;[131] perform corrective action as needed;[132] and properly close out the well by means of injection well plugging,[133] post-injection monitoring and site care,[134] and emergency and remedial response.[135]

Despite its seeming comprehensiveness, the UIC program is in fact limited in focus and scope because it is adopted pursuant to—and therefore constrained by the scope of—the SDWA.[136] For example, it applies to "public" but not private drinking water supplies.[137] Private water supplies such as wells and aquifers which could equally be affected by CO_2 migration are not protected. Briny water (which contains at least 10,000 mg/l total dissolved solids) is not protected because it is not currently considered suitable for drinking.[138] In a world altered by climate change, however, where alternative water supplies become increasingly valuable, and with continuing improvements in desalination technology, briny water may become a viable source of drinking water or valuable for other purposes (e.g., agricultural, industrial).[139] Additionally, because the SDWA applies only to "States",[140] the UIC regulations extend only to onshore injection and offshore injection within state territorial waters, but not to projects on the outer continental shelf.[141]

b. Navigable Water

Depending on the nature and location of the sequestration activities, it is possible that a permit under the CWA could be necessary if the activity will result in the discharge of a "pollutant" from a "point source" to "navigable waters" within the meaning of that Act.[142] Discharges to underground aquifers would not ordinarily be considered discharges to "navigable" waters within the meaning of the CWA. So long as the aquifer has no hydrologic connection to navigable surface waters, no NPDES permit would be needed. The case law is divided, however, as to whether discharges to groundwater that may result in pollutants reaching navigable surface waters require NPDES permits.[143] Also murky is the application of the Clean Water Act to offshore sequestration activities, which is discussed below.

Under current law, materials used for enhanced oil and gas recovery are excluded from the definition of "pollutant."[144] It is not clear, however, that the injection of CO_2 into a *depleted* oil and gas reservoir (or any other type of sequestration site) would qualify for this exception.

2. Reporting

In December 2010, EPA finalized a rule requiring owners and operators of sequestration facilities to monitor and report emissions of CO_2 from their facilities.[145] The purpose of this regulation is to verify the amount of CO_2 sequestered and quantify emissions in the event of leakage.[146] To this end, owners and operators must develop and implement site-specific monitoring, reporting and verification plans that, among other things, delineate the monitoring area, identify potential surface leakage pathways for CO_2, include strategies for determining actual surface leakage and establishing expected baselines for such leakage, and summarize considerations used for calculations.[147] Quantities required to be calculated and reported include: CO_2 produced,[148] CO_2 received,[149] CO_2 injected, CO_2 sequestered, CO_2 leaked at the surface or emitted by surface equipment, and cumulative CO_2 sequestered over all reporting years.[150] By comparison, facilities injecting CO_2 into the subsurface for enhanced recovery of oil or gas have a much less onerous reporting requirement: although they are subject to general annual GHG reporting requirements, they are required only to report the amount of CO_2 received. [151]

EPA has authority to exempt research and development projects from some of the reporting requirements.[152]

3. BLM Permitting

The Bureau of Land Management (BLM) is not yet ready to accept applications for long-term storage projects for CO_2 on lands under its control, even on a case-by-case basis.[153] BLM predicts it will take until about 2025 before it has a legal framework in place to allow for sequestration of CO_2 on BLM-controlled property.[154] Although the legal framework has yet to be designed, there is currently no legal prohibition against the use of federal lands for CO_2 sequestration. BLM interprets both the Federal Land and Policy Management Act (FLPMA)[155] and the Mineral Leasing Act[156] as authorizing the lease of public land for CO_2 sequestration.[157] BLM has opined that the existing FLPMA regulations are "sufficiently broad to allow for a variety of authorizations related to geologic sequestration and related activities while sufficiently flexible in form and terms to accommodate many different actions and activities, including surface and subsurface rights-of-way and leases for subsurface storage." [158] In June 2013, BLM released its "first-ever comprehensive" national assessment of geologic carbon dioxide storage potential. [159]

Although BLM is not yet issuing permits for sequestration facilities, it is accepting applications for permits to explore and conduct site characterization activities. To that end, in December 2011, BLM released "Interim Guidance on Exploration and Site Characterization for Potential Carbon Dioxide Geologic Sequestration."[160] Prior to filing a proposal to conduct site characterization activities, prospective land users must meet with the agency to discuss, among other things, the geologic suitability of the proposed site, applicable state and federal requirements, land use plan conformance and time frames for application processing and environmental analysis.[161] The applicant must then submit a proposal to BLM and the agency must publish the required notices, including a Notice of Realty Action in the vicinity of the public lands proposed to be used, informing the public of the proposed geological sequestration and characterization.[162] For an application to be processed, it must be submitted after the Notice of Realty Action.[163] BLM is in the process of selecting contractors to test approximately six sites on federal oil and gas leases to determine the feasibility of short-term CO_2 storage.[164]

B. State Laws and Regulations

In 2007, the Interstate Oil and Gas Compact Commission (IOGCC), a multi-state organization that promotes the conservation and efficient recovery of domestic oil and natural gas resources, issued guidance and a model statute for state regulation of CCS.[165] The guidance is designed to maximize the authority of individual states (rather than the federal government) over CCS from the inception of site activities through the site's end of life, even after post-closure activities cease, and to facilitate state legislative efforts to develop a regulatory framework for sequestration.[166] By 2012, 23 states had enacted laws regulating CCS, a number of which relate specifically to sequestration.[167] Some of the laws regulate injection wells; some regulate property ownership; and some regulate long-term liability. For example, in 2007

Illinois enacted S.B. 1704 by which the State assumed the liability for and took title to CO_2 sequestered by the FutureGen Project.[168] In 2009, Oklahoma enacted S.B. 610, assigning CO_2 ownership to the sequestration operator unless otherwise provided in a contract.[169]

In Texas, H.B. 1796 allows the Texas General Land Office and the Bureau of Economic Geology to build and operate an offshore CO_2 sequestration site.[170] H.B. 469 establishes incentives such as a tax exemption for CCS equipment, a franchise tax credit for in-state projects, and a tax rate reduction for enhanced oil recovery projects that use CO_2 captured from an industrial source.[171] S.B. 1387 provides the Texas Railroad Commission with authority over sequestration site permitting and creates a CO_2 storage trust fund.[172]

North Dakota passed S.B. 2095 in 2009 to address CO_2 ownership and pore space, as well as sequestration site permitting.[173] In West Virginia, H.B. 2860 authorizes the Department of Environmental Protection to regulate geologic sequestration.[174] Wyoming enacted H.B. 17 in 2010 to address long-term liability and carbon sequestration permitting.[175] In Montana, S.B. 285 addresses the timeframe for monitoring closed CO_2 injection wells and assigns title to and responsibility for the stored CO_2 to the sequestration operator (unless title is transferred to the state).[176] H.B. 259 in Kentucky creates a process whereby ownership of, and liability for, stored CO_2 would pass to the federal or state government following a period of monitoring of the storage facility.[177] Mississippi S.B. 2723 assigns liability for sequestered CO_2 to the sequestration operator.[178]

If there is a common theme among the state statutes, it is to encourage and facilitate CCS. What the laws do not yet do is reconcile potentially conflicting uses of the subsurface. For example, secure sequestration of CO_2 will not be possible where hydraulic fracturing for gas extraction is occurring in close proximity in a way that could either impact the movement of the

CO_2 plume or impair/breach the imperviousness of the geological cap holding the CO_2 in place. A 2012 study suggests that close to eighty percent (80%) of the basins suitable for carbon storage overlap with gas fields.[179] This may limit sequestration unless a national or regional framework is developed for subsurface resource allocation.

C. International Laws

Those states or entities contemplating injection of CO_2 beneath the floor of the ocean (i.e., off-shore sequestration) will need to consider the potential applicability of at least three international legal regimes: (1) the United Nations Convention of the Law of the Sea (UNCLOS); (2) the London Convention; and (3) the London Protocol.[180]

As described in Chapter 22, UNCLOS is a framework convention establishing rules for ocean governance, including protection of the marine environment.[181] UNCLOS does not expressly address CO_2 sequestration or CCS but it does establish the rights of nation states to use and exploit the resources of the seabed and its subsoil. Specifically, it provides that coastal nation states have the right to authorize and regulate drilling within their own territorial seas, their exclusive economic zones and on the continental shelf, and to exploit the subsoil of the continental shelf by means of tunneling.[182] The treaty imposes strict duties on nation states to prevent pollution and protect the marine environment.[183]

The Convention on the Prevention of Marine Pollution Dumping of Wastes and Other Matter, popularly known as the London Convention, entered into force in 1975. The U.S. is a party along with 86 other countries.[184] This Convention aims “to promote the effective control of all sources of pollution of the marine environment” and “to take all practicable steps to prevent pollution of the sea by dumping wastes and other matter.”[185] Key terms are “dumping” and “sea.” Injection of CO_2 into the seabed arguably should not constitute “dumping” into the "sea" because the term "sea" refers to the water column ("marine waters") and not the seabed.[186] The Convention excludes from its coverage the "disposal of wastes or other matter directly arising from, or related to, the exploration, exploitation and associated off-shore processing of sea-bed mineral resources."[187] This exclusion has been interpreted to apply to CO_2 injection from ships or platforms for purposes of enhanced oil recovery, but is not necessarily applicable to long-term CO_2 sequestration.[188]

By contrast, the London Protocol—an agreement reached by the parties to the London Convention in 1996—expressly addresses offshore CO_2 sequestration by a 2006 amendment. The U.S., however, has yet not ratified the Protocol.[189] Of central importance in the Protocol's regulatory structure is its definition of "dumping."[190] In relevant part, "dumping" refers to "any storage of wastes or other matter in the seabed and subsoil thereof from vessels, aircraft, platforms or other man-made structures at sea."[191] Excluded from this definition is the "placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Protocol."[192] This exclusion for non-disposal-motivated "placement" is potentially applicable to offshore CO_2 sequestration conducted for purposes of enhanced oil and gas recovery or scientific research.[193] Also excluded is "[t]he disposal or storage of wastes or other material directly arising from, or related to, the exploration, exploitation and associated off-shore processing of seabed mineral resources."[194] The U.S. has interpreted this exclusion as clarifying that "the Protocol does not regulate disposal or storage, for example, of wastes or other matter directly arising from, or related to, offshore oil and gas operations."[195]

The Protocol defines "sea" to include: "all marine waters other than the internal waters of States, as well as the seabed and the subsoil thereof; it does not include sub-seabed repositories accessed only from land."[196] Hence, the Protocol does not apply to sequestration projects that utilize land-based pipelines to deliver CO_2 to the offshore seabed. The Protocol provides that CO_2 may be sequestered beneath the seabed pursuant to a permit, provided: (1) "disposal is into a sub-seabed geological formation;" (2) the CO_2 streams "consist overwhelmingly of carbon dioxide," although "[t]hey may contain incidental associated substances derived from the source material and the capture and sequestration processes used;" and (3) "no wastes or other matter are added for the purpose of disposing of those wastes or other matter."[197]

The Protocol mandates that parties to the Convention adopt administrative or legislative measures to ensure that their permitting processes comply with Annex II of the Protocol.[198] Annex II calls for implementation of the following permitting measures: (1) evaluation of waste reduction and prevention techniques; (2) consideration of alternatives to dumping; (3) characterization of wastes based on their potential impacts on human health and the environment; (4) application of an Action List establishing dumping thresholds based on wastes' potential impacts on human health and the environment; (5) site analysis; (6) assessment and articulation of the expected consequences of proposed disposal options (i.e., an "impact hypothesis"); and (7) compliance monitoring.

If issued, permits must ensure, "as far as practicable, that environmental disturbance and detriment are minimized and the benefits maximized."[199] Permits must (1) specify the types and sources of materials to be "dumped;" (2) identify the location of the dumpsite(s); (3) describe the method of dumping; (4) include monitoring and reporting requirements; and (5) undergo regulatory review at regular intervals.[200] In November 2007, the parties to the Protocol adopted "Specific Guidelines for Assessment of Carbon Dioxide Streams for Disposal into Sub-seabed Geological Formations" ("Specific Guidelines").[201] These provide guidance on the process of risk assessment and management of CO_2 streams proposed for offshore sequestration projects. They identify the goal of these projects as permanent sequestration of the CO_2 and aim to address the environmental risks associated with potential seepage.[202]

III. Additional Legal Issues: Managing Liability and Acquiring Property Rights

Apart from the absence of any meaningful incentive (e.g., a price on carbon or a regulatory requirement) to spur commercialization of CCS, and even if the financial challenges to CCS were overcome in the near term, there still remain at least three major legal obstacles to widespread commercial deployment of CCS. These are: (1) management of the long-term, unquantifiable, potential legal liabilities; (2) ownership and management of the pore space deep beneath the earth's surface in which large quantities of captured CO_2 would be sequestered; and (3) ownership and management of the deep aquifers which will either be used for sequestration or which may be displaced and/or contaminated by the movement of the CO_2 during injection and sequestration. All three of these obstacles are attributable, in part, to the fact that for CCS to be successful, it must capture and permanently sequester enormous volumes of CO_2. Sequestration of 90% of the CO_2 stream from a typical 800 megawatt coal-fired power plant is projected to require access to between 300 and 11,000 km^2 (116 – 4,247 square miles) of subsurface space to store 30 years of CO_2 emissions, depending on the depth and quality of the geological formation.[203] By way of comparison, New York City is about 305 square miles.[204] Even more space may be needed because not all of the CO_2 can be expected to move or settle underground precisely as the models predict.[205] Hence, there is a quandary about potential liability and a need to sort out property access and ownership issues on an enormous scale.

A. Absence of a Federal Liability Framework for CCS

One major obstacle to commercial deployment of CCS is the absence of an appropriate federal liability framework. Although scientific experts (e.g., geologists) maintain that the risk of CO_2 leaks, water contamination, water displacement and the like are highest during the years of active CO_2 injection activities, corporate representatives consistently express concern about the exposure to lingering, potential future liability that is unbounded by time, cost and character.[206] Businesses and investors crave certainty and resist carrying potential liabilities on their books for indefinite time periods. Hence, for CCS to move from demonstration to commercial deployment, several legal interventions will be necessary.

Imposing a price on carbon through a carbon tax, cap and trade, or another method would trigger greater private investment in CCS. In addition, Congress will likely need to provide some certainty or boundaries on corporate exposure to liability. Many legal commentators, including the author of this chapter, have suggested that as to commercial[207] sequestration operations, the sequestration owner/operator should retain full liability and responsibility during siting, construction, operation, closure and for some period of time after closure of the site. The reasoning for this position is that the site owner/operator has the ability to control the risk by means of careful and comprehensive pre-sequestration site characterization, careful site operation and prompt corrective action.[208] While views differ on the precise time horizon, there is considerable support for the proposal that liability should remain with the owner/operator until it has been demonstrated through a decade or more of post-closure monitoring that the sequestered CO_2 has stopped migrating and that the site is stable and acting as predicted by the models.[209]

Under such a regime, the owner/operator would be required from the outset to post and maintain some form of reliable financial security to ensure the availability of funds to take corrective action or pay for liability as appropriate, both pre- and post-closure.[210] In addition, the federal government could assess and collect a small fee on each unit of CO_2 captured and sequestered for establishment of a national fund to pay for costs that arise after an owner/operator's liability ends or in the event of a bankruptcy or insufficiency of the owner/operator's posted financial security.[211] (A state could also establish a state fund in a similar manner.)

Such legislation would provide an opportunity for Congress to address other open legal questions. For example, Congress could clarify: (1) how leaks of sequestered CO_2 will affect tax credits utilized and emission allowances spent (if any of the latter are ever set at the federal level); (2) whether leaks will result in loss of permits and/or the right to bid on federal contracts or obtain leases to federal lands; (3) how federal land use priorities will be set (as between, for example, hydraulic fracturing to extract natural gas or maintaining reserves of briny water for future use in a climate-changed world versus maintaining a secure geological cap for sequestration); (4) whether and under what circumstances owners/operators of sequestration facilities and of capture equipment will be liable under CERCLA and RCRA; and (5) whether permits should be required under the Clean Water Act.

In order to launch the experimental FutureGen demonstration project, Texas and Illinois both enacted laws by which the state would assume the ultimate liability for the sequestered CO_2.[212] Other states have also enacted laws limiting the future liability of the corporate owners/operators of sequestration sites.[213] While this is certainly helpful for projects that will be confined to private or state-owned land within the state's borders, it may not be enough to facilitate very large projects or those situated near a state border where the CO_2 cannot be guaranteed to remain within the state's boundaries. Of course, in other contexts, corporations function despite having to contend with a multitude of inconsistent state liability laws. CCS is unique, however, because currently there is no short-term profit to be made in sequestration and no legal mandate to do it at all. In the absence of a business incentive to undertake CCS, a comprehensive federal liability regime may help to promote investment.

B. Ownership of Pore Space and Deep Aquifers

As large as is the obstacle to CCS posed by indefinite and unbounded exposure to liability, that issue may, as a practical matter, be dwarfed by the logistics, cost and uncertainties posed by gaining lawful access to the vast swaths of underground space needed to sequester CO_2. While some CO_2 will be stored in depleted oil and gas reservoirs, salt caverns and coal seams, the overwhelming majority of it will need to be injected deep beneath the earth's surface in pore space or deep aquifers, or potentially offshore.[214] This poses the fundamental question of who owns and controls the target pore space and aquifers.[215] The answer is murky. Pore space and aquifers are examined separately below because the laws that apply to ownership of subsurface estates, minerals and water have developed differently.

1. Pore Space

Pore space, as its name implies, is comprised of the pockets of space within geological formations.[216] Historically, not much legal attention has been paid to ownership of pore space because unless and until one has a need to store something in it, it has no intrinsic value. CCS is one of the few activities at present that requires vast amounts of pore space and which, therefore, may create value in it.[217] The pressure to find ways to mitigate climate change combined with the lack of historic legal attention to ownership of pore space have created an opportunity for new legal scholarship[218] and legislation.[219] Some commentators find ample historical and legal support for the proposition that the federal government already owns much if not all of the deep pore space.[220] Others disagree.[221]

Some state legislatures have been so anxious to maintain control over ownership and use of property within their borders and promote CCS that they have already enacted statutes addressing the issue. For example, Montana, North Dakota and Wyoming have each passed laws in the last few years declaring that the subsurface pore space belongs to the owner of the surface estate.[222] Although seemingly straightforward, this approach does not fully resolve the question of who owns and controls the subsurface. Rather, it raises additional questions, including (1) how to resolve conflicts between owners of the mineral estate and owners of the surface/pore space when mineral extraction is not complete; (2) how to deal with holdouts and manage transaction costs when rights are vested in hundreds or thousands of surface and subsurface owners; and (3) how to manage access to pore space that crosses state or national boundaries.

If the mineral estate has been severed from the surface estate, it will be no simple logistical matter to determine when precisely the pore space within the mineral estate has been fully mined and has reverted to the surface owner. This problem has led some commentators to recommend that the owner/operator of a proposed sequestration site should first check the title and acquire permission from every owner of the surface and mineral estates in the potential path of the sequestered CO_2.[223]

This leads to a second difficulty: how to identify each owner and obtain permission from resistant surface and mineral rights owners. This is a potentially expensive, time-consuming and massive undertaking. The stream of CO_2 captured from a single power plant operating for 30 years could require hundreds, if not thousands, of square miles of pore space.[224] This would entail research and negotiation with hundreds if not thousands of property owners.

In states that have a long history of oil and gas exploration, such as Texas and Louisiana, laws have developed to help overcome the problem of assembling access rights.[225] These laws are often referred to as “unitization” or “pooling” laws. To oversimplify, they provide that if the majority of owners in the area agree to lease their property for oil and gas extraction, the activity may proceed despite the objections of the minority. Usually, but not always, the minority or holdouts will still be paid.[226] One basis for resistance may be fear of potential future liability under RCRA or CERCLA for the pore space owner. Some commentators have suggested that unitization or pooling may work in the CCS context.[227] Yet at present we lack the tools to predict with precision the movement of the CO_2 after injection and thus even unitization or pooling may not suffice to solve the property access and liability problems because it will still be difficult to assemble exactly the right parcels of property.[228]

Delays and transaction costs will quickly mount as title searches and analyses are conducted to determine the ownership of each parcel. In some states it will not be enough to check the current title for the surface estate; it will also be necessary to trace and confirm historic ownership of the subsurface. There will be many instances where it is doubtful that either the state or a private entity ever acquired full rights to the subsurface.[229] For example, to encourage settlement of the western U.S., the federal government enacted the Stock-Raising Homestead Act (SRHA), allowing it to grant rights to the surface to private parties for agricultural development and animal grazing, while retaining for the nation the underlying mineral rights.[230] At least one commentator has suggested that the SRHA forms the basis for a solid argument that the federal government retains the rights to the pore space within the minerals underlying these lands.[231]

Other commentators, using different analytical approaches, also conclude that there is ample authority for federal dominion over the deep subsurface.[232] They find support for their conclusions in the historic disposition of property rights from the federal government to the states and draw on analogies to outer continental shelf and radio frequencies.[233] Their analyses apply equally to ownership of the pore space and the deep aquifers, but do not, of course, resolve the third problem — acquiring access to pore space (or deep aquifers) that cross international borders.

2. Deep Aquifers

Sorting out rights of access to deep aquifers is also very sticky and has spawned a variety of law review articles and legal theories re-examining the doctrine extending property ownership to the center of the earth and its rejection by the U.S. Supreme Court in *United States v. Causby*.[234] As with deep pore space, various theories have been advanced to support the notion that deep aquifers are not privately owned.[235] And, as with pore space, some states have passed laws assigning ownership of deep groundwater to private parties.[236] For a variety of reasons, Congress could assert its dominion over these aquifers. For example, interests in these aquifers are nonvested rights, which leaves Congress free to reserve public ownership with possibility of allocating for private ownership in the future. Another option would be for the federal government to use eminent domain to establish vast depositories in strategically selected areas throughout the country.[237] For just as many reasons, it is unlikely to do so soon enough to facilitate the commercialization of CCS or protect the federal government from takings claims. "Prospectors" have already bought up vast tracts of land with a view to leasing or selling access rights for CO_2 sequestration.[238]

There are a number of national benefits to federal ownership of the subsurface property (lands and waters) that were neither granted to the states as they came into statehood nor otherwise granted to private entities through laws such as the SRHA.[239] For one, federal ownership would reduce or eliminate the need to negotiate with dozens—if not hundreds or thousands—of property owners. For another, federal ownership would preserve national access to potentially vital resources (e.g., minerals, pore space, aquifers and more). Because no one yet knows the full potential value of the deep aquifers or the potential national need to use them for drinking water, mineral content, heat, agriculture, storage or other purposes, it may be sensible for the federal government to assert its dominion now, proactively. Thinking ahead, again, to a climate-challenged and-changed world, it may prove necessary for the federal government to manage future national water needs and prevent water conflicts between dry and wet states in the U.S. Moreover, there may be minerals such as lithium or other substances present in the deep aquifers on which we are not yet focused as a nation and which may turn out to be of great value.[240] In the absence of federal action, such value could be claimed by pre-existing rights holders. Congress did not contemplate geothermal energy at the time it passed the SRHA and yet the Ninth Circuit held in *United States v. Union Oil* that the mineral reservation under the SRHA includes geothermal resources and "[a]ll of the elements of a geothermal system magma, porous rock strata, even water itself may be classified as 'minerals.'"[241]

Federal ownership may be better than alternative regimes at avoiding conflicting uses of the subsurface. For example, currently when CCS projects are conducted close to state borders, the potential arises for injected CO_2 to travel into jurisdictions that do not regulate pore space, thereby enabling the state with pore space ownership rights to benefit at the expense of the 'host' state.[242] Furthermore, in circumstances where sequestration rights have been granted to an owner/operator, those rights may conflict with the rights of owners of mineral estates who seek to utilize the same subsurface area for mineral extraction.[243]

That said, any assertion of federal dominion would likely meet with tremendous resistance from states, corporate actors and individuals, for a variety of reasons, many of which are reasonable and legitimate. Many Americans prefer less, not more, federal intervention in their lives. Many western states and their residents prefer to manage resources they have long perceived to belong to them whether or not history bears out their claims. As noted previously, at least 23 states have already passed laws addressing ownership of the pore space or other aspects of CCS. Those laws would be disrupted by a federal assertion of ownership. Businesses and individuals that have been buying tracts of land or investing in leases with a view to using the subsurface for CCS or other purposes would likely pursue takings claims.

In contrast to pore space, there is already a large body of law governing ownership of groundwater, although the subject groundwater tends to be relatively close to the surface. A number of legal doctrines have been developed over the years governing allocation of water rights.[244]

The injection of CO_2 will inevitably displace water in its path.[245] What, if any, liability would result? The owner/operator of a sequestration project must not only sort out ownership of deep groundwater but also contend with potential liability for its displacement. As with pore space, assembling the rights to these aquifers is also likely to be challenging and expensive. The task will be particularly complicated if the sequestration site is located near a state or national border, thus implicating multiple property ownership regimes.

As yet, there have been relatively few if any claims to deep aquifers because at present they are not considered useful for drinking or agricultural purposes due to their typically high saline content. For that reason, EPA in the UIC regulations discussed earlier takes the position that those waters are not potential drinking water supplies. However, that position could prove to be mistaken in a climate-changed world, where droughts may eventually require us to tap into those supplies and desalinate them. Even if they are never to be used for drinking water purposes, it may turn out that that this water is suitable and valuable for agricultural, industrial or other purposes. Although expensive, the technology certainly exists to withdraw and treat this water source.[246]

IV. Conclusion

While not a panacea, CCS holds promise as an interim measure for mitigating CO_2 emissions from coal-, oil- and gas-fired power plants and from other large stationary sources of CO_2. Many existing federal and state statutes, which govern air pollution, water pollution and hazardous waste, may apply to carbon capture and sequestration. Both new “CCS-ready” facilities and existing facilities contemplating CCS retrofit would need to comply with these requirements. Yet the prospect that in the near-term there will be many such facilities in the U.S. remains low. Private investment to bring CCS to commercial scale is not likely without the imposition of a price on carbon or regulatory requirements that make fossil fuels more costly, thus driving demand for CCS. Commercial deployment of CCS will require not only greater clarity in the applicability of existing regulatory requirements to CCS, but the development of new legal rules governing long-term liability for sequestered carbon dioxide. Among other things, CCS deployment at scale would require: (1) a thoughtful, long-term, national (or at least regional) strategy for balancing competing uses of the subsurface; (2) a legal framework for managing sequestration sites for many decades (at least) after they are closed; and (3) a clear policy about who owns the subsurface that will facilitate acquisition of property rights.

Notes

[1] One CCS bill was pending at the time of writing: H.R. 2127, a bill introduced by Rep. David McKinley of West Virginia to prevent the EPA from regulating greenhouse gas (GHG) emissions from the utility sector until CCS is "technologically and economically feasible." *See* H.R. 2127, 113th Cong. (2013). Senator Jay Rockefeller of West Virginia was developing legislation to promote clean coal technologies, including CCS. *See* Press Release, Rockefeller Renews Efforts at Clean Coal Technology Deployment in West Virginia: Senator Seeks Broad Input about CCS Challenges, Opportunities (Aug. 8, 2012), *available at* http://www.rockefeller.senate.gov/public/index.cfm/press-releases?ID=21261a9c-d41a-4897-8e54-e3a0a32d1c25. Also proposed to address climate change and promote "clean coal" technologies such as CCS was the Managed Carbon Price Act of 2012, H.R. 6338, 112th Cong. (2012), introduced by Rep. Jim McDermott (Wash.) in July 2012 to establish a carbon tax on coal, oil and natural gas producers and other large emitters. The bill would have required permits to be purchased for every quarter ton of CO_2 emitted, but it died in committee. The bill sought to account for volatility in the marketplace by creating a flexible pricing system.

Two bills were proposed in 2011 to help to finance CCS projects. These were S. 757: Carbon Dioxide Capture Technology Prize Act of 2011 amending the Energy Policy Act of 2005 to direct DOE "to provide incentives to encourage the development and implementation of technology to capture carbon dioxide from dilute sources on a significant scale using direct air capture technologies." *See* Carbon Dioxide Capture Technology Prize Act, S. 757, 112th Cong. (2011), *available at* https://www.govtrack.us/congress/bills/112/s757/text.

Also, S. 699: Department of Energy Carbon Capture and Sequestration Program Amendments Act of 2011 was proposed to amend the Energy Policy Act of 2005 to direct DOE "to carry out a demonstration program for the commercial application of integrated systems for the capture, injection, monitoring, and long-term geological storage of carbon dioxide from industrial sources." *See* Govtrack.us, Department of Energy Carbon Capture and Sequestration Program Amendments Act of 2011, S. 699, 112th Cong., *available at* http://www.govtrack.us/congress/bills/112/s699.

[2] Gov't Accountability Office (GAO), GAO-13-72, *Electricity: Significant Changes Are Expected in Coal-Fueled Generation, but Coal is Likely to Remain a Key Fuel Source* 5 (2012); Today in Energy – 27 gigawatts of coal-fired capacity to retire over next five years, U.S. Energy Information Administration (July 27, 2012), *available at* http://www.eia.gov/todayinenergy/detail.cfm?id=7290 ("Plant owners and operators…expect to retire almost 27 gigawatts of capacity from 175 generators between 2012 and 2016.").

[3] A 2012 IEA report states that "it is critical for governments to incentivize the construction of new installations in a way that would allow for economic retrofit of CCS at a later stage." Matthias Finkenrath, Julian Smith & Denis Volk, *CCS Retrofit: An Analysis of the Globally Installed Coal-Fired Power Plant Fleet* at 7, 22-23, 38 (2012) [hereinafter "IEA Retrofit Report"]. A 2013 IEA report confirmed that "[i]t is possible to take actions at the time of design and construction that will reduce the cost of a retrofit, thus making the facility "CCS-ready." Technology Roadmap: Carbon Capture and Storage 29 box 8 (2013).

[4] EPA, Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units (Sep. 20, 2013) (to be codifed at 40 C.F.R. pt. 60), http://www2.epa.gov/sites/production/files/2013-09/documents/20130920proposal.pdf [hereinafter "2013 Proposed NSPS for New Power Plants"] (replaces the proposed rule at 77 Fed.Reg. 22,392 (April 13, 2012)) (as of the date this chapter was written, the proposed rules have not yet appeared in the Federal Register).

[5] Memorandum for the Administrator of the Environmental Protection Agency Regarding Power Sector Carbon Pollution Standards (June 25, 2013), *available at* http://www.whitehouse.gov/the-press-office/2013/06/25/presidential-memorandum-power-sector-carbon-pollution-standards.

[6] Because China and India have large and rapidly growing coal-fired power plant fleets, their decision to embrace CCS is crucial to reducing global CO_2 emissions. Worldwide, new coal-fired electricity is expected to continue to grow significantly and CCS retrofitting could play an important part in controlling CO_2 emissions. IEA Retrofit Report, *supra* note 3, at 7, 21-24.

[7] China's key CCS project is "GreenGen," a power plant and carbon research center in Tianjin, which is being developed by a consortium of Chinese companies, including China Huaneng Group, and a US company, Peabody Energy. *See Peabody in China,* Peabody Energy 2012, *available at* http://www.peabodyenergy.com/content/145/Peabody-in-China; *GreenGen Fact Sheet,* Carbon Capture and Sequestration Technologies @ MIT (Aug. 6, 2013), *available at* http://sequestration.mit.edu/tools/projects/greengen.html.

[8] Given its abundance and relative ease of access to it, for decades coal was considered the cheapest of the fossil fuels. However, the boom in horizontal drilling and hydraulic fracturing to release natural gas from shale has resulted in a glut of natural gas and a dramatic drop in the price of natural gas in the United States. Chapter 14 discusses the shifting focus from coal to natural gas.

[9] A 2012 report prepared for the International Energy Agency (IEA) concludes that coal-fired power generation is "expanding faster than ever" around the globe and predict its continued rapid growth outside of the United States for at least several more decades. IEA Retrofit Report, *supra* note 3, at 7. It is this phenomenon that has fueled much of the intense focus on the application of CCS to coal-fired power plants. Approximately one ton of CO_2 is produced along with each megawatt hour of electricity generated using coal (this number varies based on the age of the power plant, its capacity and other factors). *See* U.S. Energy Information Administration, *Frequently Asked Questions: How much carbon dioxide (CO_2) is produced per kilowatt-hour when generating electricity with fossil fuels?* (Feb. 22, 2012), *available at* http://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11; U.S. Department of Energy, *Fact Sheet: Clean Coal Technology Ushers In New Era in Energy* at 3, *available at* http://energy.gov/sites/prod/files/edg/media/CleanCoalTaxCreditFactSheet.pdf. There are, however, several large-scale CCS facilities that serve as an exception to the focus on coal-fired power plants. These include facilities powered by natural gas at the Sleipner and Snøhvit Gas Fields in Norway and the In Salah gas field in the Algerian Sahara, which are presently capturing and storing 1 million, 0.7 million, and 1.2 million tons of CO_2 per year respectively. *See Sleipner West*, Statoil (Nov. 15, 2011), *available at* http://www.statoil.com/en/TechnologyInnovation/NewEnergy/Co2Management/Pages/SleipnerVest.aspx; *Snøhvit- Unlocking Resources in the Frozen North*, Statoil (Nov. 23, 2009), *available at* http://www.statoil.com/en/OurOperations/ExplorationProd/ncs/Pages/SnohvitNewEnergyHistoryInTheNorth.aspx; *In Salah*, Statoil (Sept. 23, 2009), *available at* http://www.statoil.com/en/technologyinnovation/newenergy/co2management/pages/insalah.aspx.

[10] IEA, *IEA World Energy Outlook Special Report* (2013) at 9, 26, *available at* http://www.worldenergyoutlook.org/media/weowebsite/2013/energyclimatemap/RedrawingEnergyClimateMap.pdf. Within the U.S., until 2012, coal was the primary source of domestic energy, generating ~42% of total electricity production in 2011. U.S. Energy Information Administration, *Electric Power Annual 2011,* 36 tbl.3.1.A, Net Generation by Energy Source: Total (All Sectors), 2001 – 2011 (Jan. 2013), *available at* http://www.eia.gov/electricity/annual/pdf/epa.pdf. In 2012, for the first time, natural gas generation equaled coal generation. U.S. Energy Information Administration, *Today in Energy: Monthly Coal- and Natural Gas-Fired Generation Equal for First Time in April 2012* (July 6, 2012), *available at* http://www.eia.gov/todayinenergy/detail.cfm?id=6990.

[11] Post-Combustion: This process involves the separation of CO_2 from flue gas after the combustion of a fossil fuel. Coal is combusted in air creating a mixture of gases, compounds and heavy metals. Heat is then generated, which drives a steam turbine connected to generators that produce electricity. When the CO_2 is removed from the gas stream and compressed into a relatively pure stream, it is transported for storage. Global CCS Institute, *CO_2 Capture Technologies: Post-Combustion Capture*

3 (2012), *available at* http://www.globalccsinstitute.com/publications/co2-capture-technologies-post-combustion-capture-pcc.

Oxyfuel-Combustion: This method differs from other capture technologies because it uses 95-97% usually pure oxygen during the combustion process. When oxygen is used in the combustion process it produces flue gas with low nitrogen content. The flue gas that is produced is made up of water vapor and CO_2. Cooling and compressing the gas stream can easily separate the water vapor, and the CO_2 can be transported for storage. Global CCS Institute, *CO_2 Capture Technologies: Oxy-Combustion with CO_2 Capture* 3-4, 6 (2012), *available at* http://www.globalccsinstitute.com/publications/co2-capture-technologies-oxy-combustion-co2-capture.

Pre-Combustion: This method requires that a fossil fuel be reacted at high temperature and pressure for the formation of a gas. The resulting gas is then reacted to form two basic components: hydrogen (H_2) and CO_2. The H_2 portion can be used to form electricity while the CO_2 must be absorbed directly through means of a physical or chemical absorbent. The CO_2 is removed independently of the H_2 used for combustion. This method is used primarily in new power plants or integrated gasification combined cycle (IGCC) power plants since it requires significant incorporation into the existing system to function optimally. The heat produced from the gas turbine can be used to drive a steam turbine and produce additional electricity. Global CCS Institute, *CO_2 Capture Technologies: Pre-Combustion Capture* 3 (2012), *available at* http://www.globalccsinstitute.com/publications/co2-capture-technologies-pre-combustion-capture.

See also Deer Park Energy Center (Texas), LLC, Greenhouse Gas Prevention of Significant Deterioration Preconstruction Permit for the Calpine Corporation, Permit No. PSD-TX-979-GHG, Aug. 2012, at 7-17 [hereinafter "Deer Park Permit"].

[12] Peter Folger, Cong. Research Serv., R41325, *Carbon Capture: A Technology Assessment* 3 (2010) *available at* http://www.cmu.edu/epp/iecm/rubin/PDF%20files/2010/CRS_Carbon%20Capture%20Tech%20Assessment_R41325_July%2019,%202010.pdf.

[13] International Energy Agency, *Redrawing the Energy-Climate Map: World Energy Outlook Special Report* at 26 (June 10, 2013), *available at* http://www.worldenergyoutlook.org/media/weowebsite/2013/energyclimatemap/RedrawingEnergyClimateMap.pdf.

[14] Suitable geological formations for CCS should generally be at least one-half mile or 800 meters beneath the earth's surface. Sally M. Benson & David R. Cole, *CO_2 Sequestration in Deep Sedimentary Formations*, 4 ELEMENTS 325, 325 (2008). For a summary of estimated CO_2 capacity sources across the U.S, see U.S. National Energy Technology Laboratory (NETL), THE 2010 CARBON SEQUESTRATION ATLAS OF THE UNITED STATES AND CANADA – THIRD EDITION (Atlas III), [hereinafter "NETL Sequestration Atlas"], *available at* http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIII/index.html. Texas, Louisiana, Montana, Wyoming, and Mississippi, are the five states with the largest estimated CO_2 storage resources. *See id.* at 155.

[15] *See* U.S. Department of Energy, *Enhanced Oil Recovery / CO_2 Injection* (Dec. 12, 2011) [hereinafter "DOE Report"], *available at* http://fossil.energy.gov/programs/oilgas/eor/; Organization of the Petroleum Exporting Countries, *Press Room - Speeches, Carbon Capture and Storage, CO_2 for Enhanced Oil Recovery, and Gas Flaring Reduction* (Jun. 9, 2004), *available at* http://www.opec.org/opec_web/en/press_room/905.htm.

[16] DOE Report, *supra* note 15.

[17] DOE Report, *supra* note 15 (explaining that CO_2 used for EOR has traditionally been sourced from reservoirs in which it naturally occurred). For example, the West Texas Permian Basin Project, an enhanced oil recovery project, relies upon naturally occurring CO_2. *Id.* CO_2 has also been used to

varying degrees in enhanced oil recovery projects in eastern New Mexico, Kansas, Mississippi, Wyoming, Oklahoma, Colorado, Utah, Montana, Alaska, and Pennsylvania. *Id.*

[18] DOE, *Carbon Dioxide Enhanced Oil Recovery; Untapped Domestic Energy Supply and Long Term Carbon Storage Solution* 10-11 (2010) (discussing the low cost of naturally occurring CO_2); Wendy B. Jacobs, Expert Workshop Addressing CCS Liability, *Oversight and Trust Fund Issues: Summary Report*, Emmett Environmental Law & Policy Clinic, Harvard Law School 1 (Oct. 2010) (discussing uncertainty about liability and the absence of "any national price on or restriction of CO_2 emissions in the United States" as key barriers to the expansion of CCS).

[19] U.S. Congressional Budget Office, *Federal Efforts to Reduce the Cost of Capturing and Storing Carbon Dioxide* 2 (2012), *available at* http://www.cbo.gov/publication/43357 (noting that "the capture and compression of CO_2 reduce the net amount of energy that the power plant yields for customers by between 15 percent and 30 percent"). *See* IEA Retrofit Report, *supra* note 3, at 36. *Cf.* Robert Pang & Anupam Sanyal, *Lower Energy Penalty CO_2 Capture System*, Carbon Capture J. (Mar. 4, 2012), *available at* http://www.carboncapturejournal.com/displaynews.php?NewsID=904 (energy penalty typically ranges from 20 percent to 30 percent).

[20] DOE / National Energy Technology Laboratory, *Coal-Fired Power Plants in the United States: Examination of the Costs of Retrofitting with CO_2 Capture Technology* 7 (2011); World Coal Association, *Challenging the Water-Energy Relationship*, Vol. 76. (Nov. 2011), *available at* http://www.worldcoal.org/resources/ecoal/ecoal-current-issue/challenging-the-water-energy-relationship/. The need for significant amounts of water could prove problematic in states that restrict water withdrawals.

[21] U.S. Congressional Budget Office, *supra* note 19, at 7-8, 19-20 (explaining the calculations). DOE has estimated the cost to retrofit an existing coal-fired plant to be approximately $103/ton, as compared with $114/ton for a new natural gas plant, $95/ton for a new post-combustion plant, and $60/ton for a new IGCC plant. DOE / National Energy Technology Laboratory, *Carbon Dioxide Capture and Storage RD&D Roadmap* 24-25 (2010).

[22] A DOE list of funded projects can be found at http://energy.gov/energy-department-investments-innovative-carbon-capture-projects. *See* Press Release, DOE, *DOE Announces $41 Million Investment for Carbon Capture Development* (Aug. 25, 2011), *available at* http://energy.gov/articles/department-energy-announces-41-million-investment-carbon-capture-development.

[23] DOE/NETL, *Research & Development Goals for Capture and CO_2 Technology*, DOE/NETL-2009/1366 (2011) at v [hereinafter "DOE/NETL R&D Report"]. Others are also studying ways to lower the energy penalty. *See, e.g.*, Kurt House, Charles Harvey, Michael Aziz & Daniel Schrag, *The Energy Penalty of Post-Combustion CO_2 Capture & Storage and Its Implications for Retrofitting the U.S. Installed Base*, 2 Energy & Envtl. Sci., 193-205 (2009); Trent Harkin, Andrew Hoadley, & Barry Hooper, *Reducing the Energy Penalty of CO_2 Capture and Compression Using Pinch Analysis*, 18(9) J. Cleaner Prod., 857-66 (2010).

[24] DOE/NETL R&D Report, *supra* note 23.

[25] DOE, *Abraham and Dobriansky announce "FutureGen"*(Feb. 27, 2003), *available at* http://energy.gov/management/february-27-2003-abraham-and-dobriansky-announce-futuregen. In December 2005, a coalition of energy companies agreed to contribute $250 million towards that cost. However President Bush's request for $237 million to fund FutureGen in the fiscal year 2005 was rejected by Congress, and the project was eventually cancelled in 2008 due to allegations that project costs had doubled. *See* H.R. Rep. No. 108-542 (2005) at 112, *available at* http://www.gpo.gov/fdsys/pkg/CRPT-108hrpt542/pdf/CRPT-108hrpt542.pdf; *see generally* Press Release, *FutureGen Alliance, FutureGen Industrial Alliance to Pioneer Development of First Near-Zero Emissions Electricity and Hydrogen Production Facility* (Sept. 13, 2005), *available at* http://www.prnewswire.com/news-releases/news-releases-list/; FutureGen and the Department of Energy's Advanced Coal Programs: Hearing Before the Subcomm. on Energy and Environment, 111th Cong. (2009) *available at* http://www.gpo.gov/fdsys/pkg/CHRG-111hhrg47719/html/CHRG-111hhrg47719.htm; Andrew C. Revkin, *Pact Signed for Prototype of Coal Plant*, N.Y. TIMES, Dec. 7, 2005, *available at* http://www.nytimes.com/2005/12/07/national/07climate.html; Matthew Wald, *Energy Department Said to Err on Coal Project*, N.Y. TIMES, Mar. 10, 2009, *available at* http://www.nytimes.com/2009/03/11/science/earth/11coal.html.

[26] *See* note 45, *infra*, and accompanying text.

[27] H.R. 2454, 111th Cong. (2009). Although ACES passed the House in 2009, it failed in the Senate in 2010. For one interpretation of the bill's travails, *see* Ryan Lizza, *As the World Burns: How the Senate and the White House Missed Their Best Chance to Deal with Climate Change*, NEW YORKER, Oct. 11, 2010.

[28] For example, James Rogers, CEO of Duke Energy Corp., the fourth-largest coal burner in the U.S., announced "plans to invest $50 million a year in clean-coal technology and other environmental-friendly energy sources." *Davos: Duke Energy CEO: US Needs Clear Path to Clean Energy*, DOW JONES INT. NEWS, Jan. 25, 2007. Wayne Leonard, the Chief Executive of Entergy Corp., which is based in New Orleans, indicated that the company would "stabilize its carbon emissions at 20 percent below its 2000 level, [and] supports a federal mandate to cut greenhouse gas and is studying expansion of its nuclear fleet and projects to sequester carbon." *Entergy CEO Argues Utility's Carbon-Cutting Agenda*, REUTERS NEWS, May 4, 2007. Steven F. Leer, Chief Executive Officer of Arch Coal Inc., which has coal operations in West Virginia, Virginia, Wyoming, Utah and Colorado announced that "Coal is going to be the answer…and carbon capture and sequestration is the answer to climate change." Bob Moen, *Sequestered Carbon Key for Coal, Exec Says*, CHARLESTON GAZETTE, AP, Nov. 18, 2007.

[29] Press Release, AEP, *AEP Endorses "Path To Sustainability" Statement of the Global Roundtable on Climate Change* (Feb. 20, 2007) [hereinafter "AEP Press Release"], *available at* http://www.aep.com/investors/newsreleasesandemailalerts/allNewsReleases.aspx?id=1347; Press Release, Center for Global Development, *CGD Ranks CO_2 from Power Plants Worldwide* (Nov. 11 2007), *available at* http://www.cgdev.org/content/article/detail/14846/ (reporting that according to a new research database, AEP was the second largest emitter of CO_2 in 2007 in the United States).

[30] AEP Press Release, *supra* note 29.

[31] The one percent figure is based on AEP reducing its contribution to the U.S.'s total estimated GHG emissions of 6.144 million metric tons by 46 million tons. U.S. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010* (2012), *available at* http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Main-Text.pdf. By way of comparison, the government-backed Energy Star program (an appliance rating program), which seeks to reduce GHG emissions by increasing the energy efficiency of appliances and which involves more than 12,000 organizations, collectively reduced GHGs by approximately 40 million tons in 2007. *See* Energy Star, *Energy Star Overview of 2007 Achievements*, *available at* http://www.epa.gov/appdstar/pdf/2007overview.pdf.

[32] AEP Press Release, *supra* note 29.

[33] Rebecca Smith, *U.S. News: Big Utility Turns Bullish on Carbon Capture*, WALL S. J., Dec. 9, 2009, at A6, *available at* http://online.wsj.com/article/SB126032092489782773.html.

[34] *Id*. AEP's actual performance fell far short of the 2009 predictions. Due to a lack of financial support, it announced in July 2011 that the Mountaineer project would be discontinued and plans to install CCS technology to its coal-fired power plants are now on hold. *See* AEP, 2012 Corporate Accountability Report at 31, *available at* http://www.aepsustainability.com/reporting/docs/AEP-CAReport12.pdf.

[35] In total, the Mountaineer project operated for more than 6,500 hours, captured more than 50,000 metric tons of CO_2, and stored more than 37,000 metric tons of CO_2. *See* AEP, *Corporate Citizenship: Carbon Capture and Storage*, *available at* http://www.aep.com/environment/climatechange/carboncapture.aspx.

[36] Press Release, *Presidential Memorandum, A Comprehensive Federal Strategy on Carbon Capture and Storage* (Feb. 3, 2010) [hereinafter "Presidential Memorandum"], *available at* http://www.whitehouse.gov/the-press-office/presidential-memorandum-a-comprehensive-federal-strategy-carbon-capture-and-storage.

[37] Report of the Interagency Task Force on Carbon Capture and Storage 14 (2010) [hereinafter "Interagency Task Force Report"], *available at* fossil.energy.gov/programs/sequestration/CCS_task_force.html.

[38] *Id.* at 123-27.

[39] *See, e.g.*, Fred Upton & Tim Phillips, *How Congress Can Stop the EPA's Power Grab*, WALL S. J., Dec. 28, 2010, *available at* http://online.wsj.com/article/SB10001424052748703929404576022070069905318.html; Elisabeth Rosenthal, *Climate Fears Turn to Doubts Among Britons*, N. Y. TIMES, May 24, 2010, *available at* http://www.nytimes.com/2010/05/25/science/earth/25climate.html.

[40] Wald, *supra* note 25 (discussing the cancellation of FutureGen).

[41] According to then-General Manager Ronald Harper, it was "imperative that a revenue stream, such as enhanced oil recovery, be available in order to make a project like this viable." Lauren Donovan, *Basin shelves lignite's first carbon capture project*, BISMARCK TRIBUNE, Jul. 31, 2012, *available at* http://bismarcktribune.com/news/local/article_a5fb7ed8-0a1b-11e0-b0ea-001cc4c03286.html?mode=story.

[42] According to then-AEP President Michael Morris, the project was not to resume "until economic and policy conditions create a viable path forward." Matthew L. Wald & John M. Broder, *Utility Shelves Ambitious Plan to Limit Carbon*, N. Y. TIMES, Jul. 13, 2011, *available at* http://www.nytimes.com/2011/07/14/business/energy-environment/utility-shelves-plan-to-capture-carbon-dioxide.html.

[43] Large-scale projects scheduled to start up between 2014 -2017 include: FutureGen 2.0 (Illinois), Texas Clean Energy Project (Texas), Kemper County (Mississippi), Hydrogen Electric California Project (California) and W.A. Parish (Texas). *See Carbon Capture & Sequestration Technologies at MIT, Power Plant Carbon Dioxide Capture and Storage Projects*, Massachusetts Institute of Technology (MIT) Energy Initiative (Nov. 22, 2013), *available at* http://sequestration.mit.edu/tools/projects/index_capture.html. Work has also commenced on a number of large-scale projects pursuant to Regional Carbon Sequestration Partnerships established by DOE. *See* Section I (d) at page 13.

[44] There are a handful of plants that capture fewer than 300,000 tons of CO_2 annually for use in carbonation. AES operates two such plants, one in Maryland and one in Oklahoma. A commercial-scale operation would capture more than one million tons of CO_2 annually. *See* Interagency Task Force Report, *supra* note 37, at 31. A 2012 Congressional Budget Office Report suggests that the $6.9 billion spent by the federal government to date is insufficient to promote the commercial adoption of CCS technology in the absence of an effective, national climate change policy. U.S. Congressional Budget Office, *supra* note 19, Summary.

Outside the U.S., there are a number of commercial-scale CCS operations. However, several may be distinguished on the basis that they do not involve coal-fired power plants. *See, e.g.*, Sleipner and Snøhvit (in Norway) and In Salah (in Algeria), *supra* note 9. The U.S. also has several commercial-scale plants that fall into this category, including the Great Plains Synfuels Plant in North Dakota which is owned by the Basin Electric Cooperative. It burns coal to make synthetic natural gas, captures and pressurizes the resulting CO_2, and pipes it to a facility in Weyburn, Saskatchewan, Canada where it is used for enhanced oil recovery, but not permanently sequestered. It handles approximately one million megatons of CO_2 per year. *See* Arnold W. Reitze Jr. & Mary Bradshaw Durrant, *State and Regional Control of Geological Carbon Sequestration (Part I),* 41 ELR 10348, 10351-52 *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1850776. The world's largest CO_2 capture plant, which is powered by natural gas, is located at LaBarge in Wyoming. It captures close to 6 million megatons of CO_2 per year; however, in 2012, the captured CO_2 was not being sequestered. *See Carbon Capture & Sequestration Technologies at MIT, LaBarge Fact Sheet, Carbon Dioxide Capture and Storage Project*, MIT (Nov. 23, 2011), *available at* http://sequestration.mit.edu/tools/projects/la_barge.html; Exxon Mobil, *2011 Corporate Citizenship Report* at 21 (2012).

[45] FutureGen 2.0 entails the conversion of an existing oil-fired electricity generation unit from oil to coal, and then advanced oxy-combustion technology will be installed to capture 90% of the CO_2 stream. The expectation is that 1.3 million metric tons of CO_2 will be captured annually and sequestered. *See FutureGen 2.0 Project*, FutureGen Alliance, *available at* http://www.futuregenalliance.org/futuregen-2-0-project/; *see also Carbon Capture and Sequestration Technologies Program at MIT, FutureGen Fact Sheet: Carbon Dioxide Capture and Storage Project*, MIT (Oct. 30, 2013), http://sequestration.mit.edu/tools/projects/futuregen.html. The FutureGen Alliance selected Morgan County, Illinois as the preferred location for the FutureGen 2.0 CO2 storage site. Press Release, FutureGen Alliance, *FutureGen Alliance selects Morgan County, Ill. As the site for the FutureGen 2.0 carbon storage facility* (Feb. 28, 2011), *available at* www.futuregenalliance.org/pdf/pr_02_28_11.pdf.

DOE released the FEIS for Morgan County on October 2013, indicating that FutureGen 2.0 should "go ahead with support from $1 billion in federal funding." Chris Dettro, *DOE environmental review favors carbon storage plan*, The State Journal-Register (Oct. 30, 2013 at 10:06 pm); *see also* Press Release, DOE, *Department of Energy Formally Commits $1 Billion in Recovery Act Funding to FutureGen 2.0* (Sept. 28, 2010), *available at* http://energy.gov/articles/department-energy-formally-commits-1-billion-recovery-act-funding-futuregen-20 (discussing a DOE award to the FutureGen Alliance of $1 billion in funding under ARRA).

In February 2013, DOE approved the start of Phase 2 of FutureGen 2.0. Phase 2 includes the final permitting and design activities required prior to rendering a decision on commencing construction. *FutureGen 2.0 Community Corner Archive*, FutureGen Alliance (Mar. 2013), *available at* www.futuregenalliance.org/community-corner/2013/03/.

In December 2012, the Illinois Commerce Commission approved a power purchase agreement that requires the state's electric utilities and alternative retail electric suppliers to purchase electricity generated at the FutureGen 2.0 facility for 20 years. *FutureGen 2.0 Community Corner Archive*, FutureGen Alliance (Mar. 2013), *available at* www.futuregenalliance.org/community-corner/2013/03/. This effort by the ICC both protects Illinois rate-payers and provides cost recovery for FutureGen's electricity. *Id.*; *see also Carbon Capture and Sequestration Technologies Program at MIT, FutureGen Fact Sheet: Carbon Dioxide Capture and Storage Project*, MIT (Oct. 30, 2013), http://sequestration.mit.edu/tools/projects/futuregen.html.

[46] The W.A. Parish Plant, in Houston, Texas, is projected to produce 60 megawatts of electricity using post-combustion technology to capture 90% of the CO_2. The project has been delayed and is now slated to begin construction in 2015. DOE has contributed $167 million towards the project, which is half

the cost associated with the construction. *See Carbon Capture and Sequestration Technologies Program at MIT, W.A. Parish Fact Sheet: Carbon Dioxide Capture and Storage Project*, MIT (Aug. 12, 2013), *available at* http://sequestration.mit.edu/tools/projects/wa_parish.html.

[47] *See supra* notes 4 and 5.

[48] IEA Retrofit Report, *supra* note 3, at 7.

[49] IPCC, *IPCC Special Report on Carbon Dioxide Capture and Storage* 64 (2005), *available at* http://www.ipcc-wg3.de/publications/special-reports/.files-images/SRCCS-WholeReport.pdf ("CCS would provide a way of limiting the environmental impact of the continued use of fossil fuels.").

[50] For example, if the 2013 Proposed NSPS Rule for New Power Plants is finalized or other regulations are enacted declaring CCS to be the Best Available Control Technology for purposes of complying with the federal Clean Air Act, this would help stimulate investment.

[51] *See* Sierra Club v. Miss. Pub. Serv. Comm'n, 82 So.3d 618 (Miss. 2012). The plant has been developed using integrated gasification combined cycle technology, which produces fewer CO_2 emissions than conventional coal-fired power plants. *See* Southern Company, *Kemper County IGCC Project* (2011), *available at* http://www.mississippipower.com/kemper/home.asp. Press Release, Southern Company, *Mississippi Power files appeal with Mississippi Supreme Court* (Jul. 9, 2012), *available at* http://southerncompany.mediaroom.com/index.php?s=43&item=2596; Press Release, Southern Company, *Mississippi Power Provides Kemper Project Update* (Jun. 8, 2012), *available at* http://southerncompany.mediaroom.com/index.php?s=43&item=2580. The project has been the subject of considerable controversy concerning, among other things, the cost of the project to ratepayers. *See* Sierra Club, *Mississippi Power Rate Increase for Kemper County Coal Plant Denied, Case Updates* (Jan. 28, 2013), *available at* http://www.sierraclub.org/environmentallaw/lawsuits/0485.aspx. The continued controversy has led to a credit rating downgrade from "stable" to "negative" for Southern Company by S&P. Tamar Hallerman, *S&P Downgrades Southern Company's Outlook due to Kemper Woes*, GHG Reduction Technologies Monitor (May 31, 2013). Costs continue to increase. Jeff Amy, *Mississippi Power says more overruns likely at Kemper*, Bloomberg Businessweek (Jul. 1, 2013), *available at* http://www.businessweek.com/ap/2013-07-01/miss-dot-power-says-more-overruns-likely-at-kemper.

[52] These amounts include a $270 million grant from DOE, $133 million in investment tax credits and $279 million in tax credits from the Internal Revenue Service and loan guarantees from the federal government. S*ee* Southern Company, *Kemper County IGCC Project, Facts and FAQs* (2011), *available at* http://www.mississippipower.com/kemper/facts-and-faqs.asp; *see also Carbon Capture and Sequestration Technologies Program at MIT, Kemper County IGCC Fact Sheet: Carbon Dioxide Capture and Storage Project*, MIT (Oct. 30, 2013)*available at* http://sequestration.mit.edu/tools/projects/kemper.html. Note, however, that Southern Company has decided not to request a federal loan guarantee of up to $1.5 billion for the power plant. Press Release, Associated Press, *Southern decided against federal loan for Kemper coal plant* (Apr. 3, 2013).

[53] Press Release, Southern Company, *Mississippi Power files appeal with Mississippi Supreme Court* (Jul. 9, 2012), *available at* http://southerncompany.mediaroom.com/index.php?s=43&item=2596; Press Release, Southern Company, *Mississippi Power Provides Kemper Project Update* (Jun. 8, 2012), *available at* http://southerncompany.mediaroom.com/index.php?s=43&item=2580; Sierra Club, *Mississippi Power Rate Increase for Kemper County Coal Plant Denied, Case Updates* (Jun. 22, 2012), *available at* http://www.sierraclub.org/environmentallaw/lawsuits/0485.aspx.

[54] *In re* Appalachian Power Co., PUE-2009-00030, (Va. S.C.C. July 15, 2010); *In re* Appalachian Power Co., 10-0699-E-42T, (W. Va. P.S.C. March 30, 2011).

[55] Wald & Broder, *supra* note 42**.**

[56] Global CCS Institute, *supra* note 11.

[57] Clean Air Act of 1970, 42 U.S.C. §§ 7401-7671q (2012). *See generally* Sections 111 (New Source Performance Standards), Section 173 (permit requirements), Section 502 (operating permit program), 42 U.S.C. § 7411, 7503 (2012); Titles I, IV and V of the Clean Air Act.

[58] Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 31514 (June 3, 2010) (codified in 40 C.F.R. pt. 51, 52, 70, et al.). *See generally* Title I, parts C and D of the Clean Air Act (addressing PSD and NSR permitting); EPA, *Clean Air Act Permitting for Greenhouse Gases* (Feb. 20, 2013), *available at* http://www.epa.gov/nsr/ghgpermitting.html; EPA, *New Source Review* (Jun. 11, 2013), *available at* http://www.epa.gov/nsr/.

[59] *Id.*

[60] Standards of Performance for Fossil-Fuel-Fired Steam Generators for Which Construction Commenced After August 17, 1971, 40 C.F.R. §§ 60.40-60.48 (2013); Standards of Performance for Electric Utility Steam Generating Units for Which Construction is Commenced After September 18, 1978, 40 C.F.R. §§ 60.40Da-60.62Da (2013). In September 2013, EPA proposed new NSPS for all new fossil-fueled electricity generating units. *See* 2013 Proposed NSPS for New Power Plants, *supra* note 4. The proposal effectively requires at least partial use of CCS to meet the standard for power plants that burn coal, petroleum coke and fossil fuels other than natural gas. *Id.* EPA recognizes that new coal-fired plants are not likely to be built in the near term (before 2020 or 2030) due to the glut of natural gas and its predicted low price for the next decade or two.

[61] 42 U.S.C. § 7501 (2012).

[62] 42 U.S.C. § 7475 (2012). For an analysis of the application of BACT to CCS, see EPA, PSD and Title V Permitting Guidance for Greenhouse Gases 32-36 (2011).

[63] 42 U.S.C. §§ 7411, 7503, 7651g (2012).

[64] *See* 40 C.F.R. § 60.14(k) (2013) (exempting clean coal technology demonstration projects from the requirements applicable to modified facilities under the Clean Air Act).

[65] Notably, FutureGen 2.0, the demonstration project heavily subsidized by the DOE, did not request the clean coal technology exemption in its application for a permit under the CAA. *See* Illinois EPA, Construction Permit Application for a Proposed Project at a CAAPP Source, Filed by Meredosia Energy Center for the FutureGen 2.0 Repowering Project (Feb. 8, 2012) (on file with author).

[66] *See* 2013 Proposed NSPS for New Power Plants, *supra* note 4

[67] *See* 2013 Proposed NSPS for New Power Plants, *supra* note 4

[68] 42 U.S.C. §§ 7475(a)(4), 7479(3) (2012). *See, e.g.,* Deer Park Permit, *supra* note 11; Indiana Department of Environmental Management, PSD New Source Construction Plant Operating Permit No. T-147-30464-00060, issued to Indiana Gasification, LLC (Jun. 27, 2012) [hereinafter "Indiana Gasification Permit"].

[69] EPA, *supra* note 62, at 17.

[70] *See* 2013 Proposed NSPS for New Power Plants, *supra* note 4 at 308.

[71] The majority of these permits are set out in Vinson & Elkins LLP, *Table 1: GHG BACT Controls at Recently Permitted Facilities* (2012), *available at* http://www.velaw.com/uploadedFiles/VEsite/Resources/TableGHGPSDPermitsBACTAnalysis.pdf. Additional permits include: Illinois EPA, Construction Permit –PSD Approval issued to Christian County LLC, Application No. 05040027, Apr. 30, 2012**;** Indiana Gasification Permit, *supra* note 68.

[72]*Id. See, e.g.,* Deer Park Permit, *supra* note 11.

[73] Letter from U.S. EPA Regional Administrator Region 5 to Illinois EPA, (Jun. 12, 2012) (requesting that the Illinois EPA reconsider its decision not to require CCS as BACT at Christian County Generation's Taylorville facility).

[74] Exhibit A to Notification of Permit Withdrawal, In re Christian County Generation LLC, PSD Appeal No. 12-01 (EAB, July 9, 2012) (Letter from Illinois EPA to Christian County Generation LLC re: Notice of Withdrawal of PSD Approval (July 6, 2012)), *available at* http://yosemite.epa.gov/oa/EAB_Web_Docket.nsf/Filings%20By%20Appeal%20Number/9E9EAB0C7355E28285257A36005DF415?OpenDocument.

[75] Indiana Gasification Permit, *supra* note 68, condition D.4.9.

[76] Clean Water Act of 1972, 33 U.S.C. §§ 1251-1387 (2012). *See generally* Sections 301-302 (effluent discharges), 306-307 (standards), 402 (NPDES permits), 404 (dredge and fill permits), and 502 (definition of a point source), 33 U.S.C. §§ 1311-1312, 1316-1317, 1342, 1344, 1362(14) (2012).

[77] Resource Conservation and Recovery Act of 1976, 42 U.S.C. § 6901-6992k (2012). *See* Sections 3006 (state programs), 3002-3004 (standards), and 3005 (permits), 42 U.S.C. §§ 6922-6926 (2012).

[78] Carbonic acid, which is formed when CO_2 chemically reacts with water, can "alter rock and well-bore properties and composition" creating the possibility of leakage from geological formations used as sequestration sites. *See* S. Julio Friedmann, *Energy: A Geoscience Perspective: Geological Carbon Dioxide Sequestration,* 3 ELEMENTS 179, 180 (Jun. 2007). *See also* Kevin Knauss, James W. Johnson & Carl Steefel, *Evaluation Of The Impact Of CO_2, Co-Contaminant Gas, Aqueous Fluid And Reservoir Rock Interactions On The Geologic Sequestration Of CO_2*, 217 Chem. J. 339, 340 (2005).

[79] Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. § 9601-9675 (2012). *See* Section 107 (liability), 42 U.S.C. § 9607.

[80] 42 U.S.C. § 9601(10) (2012) (defining federally permitted discharge).

[81] 42 U.S.C. § 9607(j) (2012) (detailing obligations and liability pursuant to a federally permitted release). For a case involving the application of this provision, *see, e.g.,* Carson Harbor Village, Ltd. v. Unocal Corp., 287 F. Supp. 2d 1118, 1183-86 (C.D. Cal. 2003), *affirmed*, 433 F.3d 1260 (9th Cir. 2006).

[82] *Hazardous Waste Management System: Identification and Listing of Hazardous Waste: Carbon Dioxide (CO^2) Streams in Geologic Sequestration Activities*, 76 Fed. Reg. 48,073 (Aug. 8, 2011) (to be codified at 40 C.F.R. pt. 260, 261). EPA, *Hazardous Waste Management System: Conditional Exclusion for Carbon Dioxide (CO_2) Streams in Geologic Sequestration Activities*, (22 Nov. 2013), *available at* http://yosemite.epa.gov/opei/RuleGate.nsf/085231c713c0717385257873007ade5e/8525791000607c8985257a8600029b42!OpenDocument#1.

[83] *Id.*

[84] S. 498, 61st Leg. (Mt. 2010).

[85] 42 U.S.C. § 9607(e)(1) (2012).

[86] *E.g.*, Massachusetts Water Management Act, Mass. Gen. Laws Ann. ch. 21G § 1-20 (West 2013).

[87] Massachusetts Toxics Use Reduction Act, Mass. Gen. Laws Ann. ch. 21I § 1-23 (West 2013).

[88] For example, Colorado law allows for more stringent water pollution requirements than those required by federal law provided that a public hearing is held and the stricter standards are proven necessary to "protect the public health, beneficial use of water, or the environment of the state." *See* Colo. Rev. Stat. Ann. § 25-8-202 (West 2013). Rhode Island also allows for state air emissions standards to be stricter than federal law if it can be shown that a variation is required "based on considerations of population density, meteorological conditions, contaminant emissions, air quality, land development plans, and any other factors that may be relevant to the protection of the air resources of the state." *See* R.I. Gen. Laws Ann. § 23-23-5 (West 2013). Additionally, both California and New Jersey have introduced legislation regulating GHG emissions. *See* AB32: Global Warming Solutions Act (enacted as Cal. Health & Safety Code § 38500 (West 2013)), SB 1368, Greenhouse Gas Emissions Performance Standard for Major Power Plant Investments (enacted as Cal. Pub. Util. Code § 8340 (West 2013)); Global Warming Response Act (New Jersey) (enacted as N.J. Stat. Ann. § 26:2C-37 (West 2013)).

[89] 42 U.S.C. §§ 6921-6924 (2012) (explaining the identification and listing of hazardous waste; standards applicable to owners/operators and generators).

[90] 42 U.S.C. § 9607 (2012).

[91] 26 U.S.C. § 48A (2012) (for integrated gasification combined cycle projects and other projects using advanced coal-based generation technologies); 26 U.S.C. § 48B (2012) (for gasification projects). *See also* Anthony Andrews & Molly F. Sherlock, Cong. Research Serv., R40662, *Clean Coal Authorizations, Appropriations, and Incentives* 6-7 (2010), *available at*

http://nepinstitute.org/get/CRS_Reports/CRS_Energy/Electric_Power_Generation/Clean_Coal_Authorizations_Nov_2010.pdf, (describing additional process requirements). For an example of a CCS project that has successfully claimed investment tax credits, see Southern Company, Kemper County IGCC Project, *supra* note 51.

[92] 26 U.S.C. § 45Q (2012) (as enacted by the Energy Improvements and Extension Act of 2008, Pub.L. 110-343, § 115(a), 122 Stat. 3829 (2008), and *amended by* the American Recovery and Reinvestment Tax Act of 2009, Pub.L. 111-5, § 1131(a)-(b), 123 Stat. 325 (2009)).

[93] When compared with investment tax credits, sequestration tax credits are unlikely to be considered a reliable source of long-term financing because they are only available on a limited basis (until the end of the year in which 75 million tons of CO_2 has been captured and stored). This may meet the needs of demonstration projects but would be of limited assistance for large-scale CCS projects. Wendy B. Jacobs, *Proposed Roadmap for Overcoming Legal and Financial Obstacles to Carbon Capture and Sequestration*, Emmett Environmental Law & Policy Clinic, Harvard Law School (Mar. 2009); Tenaska Trailblazer Partners, *Bridging the Commercial Gap for Carbon Capture and Storage* 43 (Jul. 2011); Andrews & Sherlock, *supra* note 91, at 6. Additionally, attempts are already underway to repeal sequestration tax credits. *See* H.R. 4301, 112th Cong., 2nd Session (2012).

[94] States that provide tax credits for CCS-related projects include New Mexico, Texas, North Dakota, Illinois, Kansas, Mississippi, Wyoming and Montana. For state laws relating to tax credits, see: N.M. Stat. Ann. § 7-2-18.25 (West 2013); Tex. Gov't Code Ann. § 490.352 (redesignated as Tex. Tax. Code Ann. § 171.652 as amended, eff. Jun. 14, 2013 (West 2013)); N.D. Cent. Code Ann. § 57-60-02.1 (West 2013); 20 Ill Comp. Stat. 655/5.5 (West 2013); Ind. Code Ann. § 6-3.1-29-14 (West 2013); Kan. Stat. Ann. § 79-32,239 (West 2013); for tax deductions/exemptions, see: Kan. Stat. Ann. § 79-32,256 (West 2013); Tex. Tax Code Ann. § 171.108 (West 2013); Miss. Code. Ann. § 27-65-19 (West 2013); Wyo. Stat. Ann. § 39-15-105 (West 2013); Mont. Code Ann. § 15-24-3111 (West 2013); Kan. Stat. Ann. § 79-233 (West 2013).

[95] 42 U.S.C. § 16513(b)(5) (2012).

[96] 42 U.S.C. § 16513(b)(5) (2012).

[97] *See* Consolidated Appropriations Act, 2012, H.R. 2055, 112th Cong. (1st Sess. 2011).

[98] 42 U.S.C. § 15961-65 (2012).

[99] American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, 123 Stat 115 (2009) (discussing allocation for Fossil Energy Research and Development); U.S. Department of Energy, *Financial Assistance Funding Opportunity Announcement* (Jun. 9, 2009), *available at* http://www.fossil.energy.gov/programs/sequestration/publications/arra/DE-FOA-0000042.pdf.

[100] *See* MIT, *supra* note 43.

[101] *See* MIT, *Carbon Capture and Sequestration Technologies at MIT, Texas Clean Energy Project (TCEP) Fact Sheet* (Mar. 2, 2012), *available at* http://sequestration.mit.edu/tools/projects/tcep.html (noting that TCEP received $450 million from CCPI and an additional $100 million from the ARRA).

[102] *See* Consolidated Appropriations Act, 2012, H.R. 2055, 112th Cong. (1st Sess. 2011).

[103] Colo. Rev. Stat. Ann. § 40-2-123 (West 2013); 20 Ill. Comp. Stat. 3855/1-20, 20 Ill. Comp. Stat. 605/605-332 (West 2013); Ky. Rev. Stat. Ann. §154.27-030 (West 2013); Minn. Stat. § 216B.1694 (West 2013); Tex. Gov't Code Ann. § 2305.037 (West 2013).

[104] The seven partnerships are: Big Sky Regional Carbon Sequestration Partnership (Big Sky), *available at* http://www.bigskyco2.org (covers Montana, Wyoming, South Dakota, Idaho, Eastern Washington and Oregon); Plains CO_2 Reduction Partnership (PCOR), *available at* http://www.undeerc.org/pcor (covers nine US states and four Canadian provinces); Midwest Geological Sequestration Consortium (MGSC), *available at* http://www.sequestration.org (covers Illinois, Kentucky and Indiana); Midwest Regional Carbon Sequestration Partnership (MRCSP), *available at* http://216.109.210.162 (covers Indiana, Kentucky, Maryland, Michigan, Ohio, Pennsylvania, West

Virginia, New York and New Jersey); Southeast Regional Carbon Sequestration Partnership (SECARB), *available at* http://www.secarbon.org (covers sixteen states and two U.S. territories (the U.S. Virgin Islands and Puerto Rico)); Southwest Regional Partnership on Carbon Sequestration (SWP), *available at* http://www.southwestcarbonpartnership.org (covers Arizona, Colorado, Oklahoma, New Mexico, Utah, Kansas, Nevada, Texas, and Wyoming); and West Coast Regional Carbon Sequestration Partnership (WESTCARB), *available at* http://www.westcarb.org/ (covers Alaska, Arizona, California, Hawaii, Oregon, Nevada, Washington, and one Canadian province).

[105] DOE, *Carbon Sequestration Regional Partnerships* (Jul. 19, 2012), *available at* http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html

[106] *Id.*; DOE/NETL, *Carbon Storage: Regional Sequestration Partnerships, available at* http://www.netl.doe.gov/technologies/carbon_seq/infrastructure/rcsp.html.

[107] CO_2 storage capacity at this site is expected to exceed 800 years. Southeast Regional Carbon Sequestration Partnership (SECARB), *Phase III Anthropogenic CO_2 Injection Field Test, Fact Sheet* (Jan. 23, 2012), *available at* http://www.secarbon.org/files/anthropogenic-test.pdf.

[108] SECARB, *Projects*, *available at* http://www.secarbon.org/index.php?page_id=8.

[109] Dawn Marie Deel, Regional Carbon Sequestration Partnerships Phase III, *Presentation to West Coast Regional Carbon Sequestration Partnership Annual Business Meeting by NETL/Office of Fossil Energy* (Nov. 9, 2006), *available at* http://www.westcarb.org/Phoenix_pdfs/finalpdfs-11-09-06/12-Deel_Phase3.pdf (estimating that DOE would provide $16 million, $100 million and $450 million to the Partnerships for phases I, II and III respectively). DOE has requested $95 million to fund the Partnerships in FY2013. *See* U.S. DOE Office of Fossil Energy, Budget in Brief FY13, *available at* http://www.fossil.energy.gov/aboutus/budget/13/2013_FE-Budget-in-Brief.pdf.

[110] *See infra* notes 202 to 204 and accompanying text.

[111] It is the quantity of material injected, not the pressure that may cause seismic activity. *See generally* Cliff Frohlich, *Two year study comparing earthquake activity and injection-well locations in the Barnett Shale, Texas*, PNAS 1-5 (2012).

[112] Sally Benson & Terry Surles, *Carbon Dioxide Capture and Storage: An Overview With Emphasis on Capture and Storage in Deep Geological Formations*, 94 Proceedings of the IEEE 1795, 1800 (2006) (noting that “models are available to predict where the CO2 moves when it is pumped underground, although more work is needed to further develop and test these models, particularly over the long time frames and large spatial scales envisioned for CO_2 storage”).

[113] *Id*.

[114] See discussion of RCRA and CERCLA in section I(C).

[115] A permit to use an underground injection control well for CO_2 sequestration should qualify for the exemption. *See supra* note 81 and accompanying text.

[116] 76 Fed. Reg. 48,073 (Aug. 8, 2011) (to be codified at 40 C.F.R. pt. 260, 261); *see supra* note 82 and accompanying text.

[117] The risk is perceived to be long-term because it may take thousands of years for the injected CO_2 to return to its mineralized state. A 2009 study of projects being undertaken by the regional partnerships indicates that long-term liability concerns have presented a significant barrier to progressing CCS in some cases. *See* Craig A. Hart, *Advancing Carbon Sequestration Research In An Uncertain Legal And Regulatory Environment: A Study Of Phase II Of The Doe Regional Carbon Sequestration Partnerships Program* 6 (2009).

[118] Liability concerns were the dominant topic at the June 2010 CCS workshop convened in Washington, D.C. by Wendy Jacobs, Director of Harvard Law School’s Emmett Environmental Law & Policy Clinic. Three of the five proposals discussed at the workshop dealt with 1) limits on liability for CCS projects; 2) mechanisms to limit liability; and 3) the role of states in managing liability. Discussions “highlighted the lack of consensus among experts on this issue” and a summary of the various viewpoints on the liability proposals was compiled. *See* Jacobs, *supra* note 18, at 3-7, 11, and App. B; Wendy B.

Jacobs & Debra L. Stump, *Proposed Liability Framework for Geological Sequestration of Carbon Dioxide*, Emmett Environmental Law & Policy Clinic, Harvard Law School 1-2 (Nov. 2010) (generally discussing uncertainty regarding liability as a barrier to CCS).

[119] Existing insurance policies such as "property, general liability, pollution liability, and surety" cover certain risks associated with CCS; however, insurers have developed specific products designed to capture the risks associated with CCS operations. *See* Eliot Jamison and David Schlosberg, *Insuring Innovation: Reducing the Cost of Performance Risk for Projects Employing Emerging Technology* 14 (2011), *available at* http://calcef.org/2011/10/11/jamison2/; *see also* Patrick MacGuire, *Conquering Insurance Obstacles for Carbon Sequestration Technologies*, COAL POWER (2009), *available at* http://www.coalpowermag.com/environmental/Conquering-Insurance-Obstacles-for-Carbon-Sequestration-Technologies_184.html (discussing the emerging market in CCS insurance); Cyril Tuohy, *Capturing the Carbon Market*, RISK & INSURANCE (2009), *available at* http://www.riskandinsurance.com/story.jsp?storyId=269538953 (discussing the limitations of existing policies regarding the long-term risks of carbon capture).

[120] *Zurich launches CCS Insurance Products*, CARBON CAPTURE J. (Jan. 20, 2009), *available at* http://www.carboncapturejournal.com/displaynews.php?NewsID=325 ("[Zurich's] CCS Liability Insurance Policy covers pollution event liability, business interruption, control of well, transmission liability and geomechanical liability whereas the Geological Sequestration Financial Assurance Policy covers specified closure and post closure activities."); Zurich Insurance Group, *Climate Products, Carbon Capture & Storage* (2012), *available at* http://www.zurich.com/insight/global-issues/climate/climateproducts.htm.

[121] In July 2006, two proposed locations in Illinois and two locations in Texas were selected for further review. Both States agreed to take liability for the carbon dioxide. In May 2006, prior to the announcement of the four finalists, Texas H.B. 149 gave the title of the captured carbon dioxide to the Railroad Commission of Texas. In July 2007, Illinois Public Act 095-0018 gave the State of Illinois the rights, title, and liabilities associated with the sequestered gases. *See* H.B. 149, 79th Leg. 3d Spec. Sess. (Tex. 2006); Clean Coal FutureGen for Illinois Act, Ill. Pub. Act 095-0018 (2007).

[122] Jacobs & Stump, *supra* note 118, at 11-12; International Risk Governance Council, *Regulation of Carbon Capture and Storage* 23 (2008); Interstate Oil and Gas Compact Commission, *Storage of Carbon Dioxide in Geologic Structures, A Legal and Regulatory Guide for States and Provinces, Task Force on Carbon Capture and Geologic Storage* 29 (2007) [hereinafter IOGCC Guide], *available at* http://groundwork.iogcc.org/sites/default/files/2008-CO2-Storage-Legal-and-Regulatory-Guide-for-States-Full-Report.pdf.

[123] Safe Drinking Water Act of 1974, 42 U.S.C. §§ 300f-300j-26 (2012). *See* Part C for provisions on the protection of underground sources of drinking water, 42 U.S.C. §§ 300h-300h-8. For all classes of wells, states may ask to exercise primary enforcement responsibility over the UIC program or may request authority only as to Class VI wells. *See* 40 C.F.R. § 145 (2013); EPA, *UIC Program Primacy* (Aug. 1, 2012), *available at* http://water.epa.gov/type/groundwater/uic/Primacy.cfm.

[124] 40 C.F.R. § 144.22 (2013).

[125] 40 C.F.R. § 144.18 (2013).

[126] EPA, *Geologic Sequestration Guidance Documents* (July 28, 2012), *available at* http://water.epa.gov/type/groundwater/uic/class6/gsguidedoc.cfm (collection of links to EPA guidance documents for the Class VI well program).

[127] 40 C.F.R. § 144.19(a) (2013).

[128] 40 C.F.R. § 144.19(b) (2013).

[129] 40 C.F.R. § 146.83 (2013).

[130] 40 C.F.R. §§ 146.84, 146.85 (2013).

[131] 40 C.F.R. § 146.88 (2013).

[132] 40 C.F.R. § 146.84 (2013).

[133] 40 C.F.R. § 146.92 (2013).

[134] 40 C.F.R. § 146.93 (2013).

[135] 40 C.F.R. § 146.94 (2013).

[136] 42 U.S.C. §§ 300h-300h-5 (2012) (describing provisions related to underground injection control programs).

[137] 42 U.S.C. § 300g (2012). For a discussion of the limitations of the SDWA, see Wendy B. Jacobs, *et al*., *Submission to the E.P.A. on the Proposed Federal Requirements under the Safe Drinking Water Act for Long-Term Sequestration of Carbon Dioxide in Geological Formations*, Emmett Environmental Law & Policy Clinic, Harvard Law School 23 (2008) [hereinafter "SDWA Submission"].

[138] 40 C.F.R. § 144.3 (2013) (defining "underground source of drinking water" as "an aquifer or its portion, which contains a sufficient quantity of ground water to supply a public water system [and] … contains fewer than 10,000 mg/l total dissolved solids").

[139] SDWA Submission, *supra* note 137, at 37-41 (suggesting that the EPA should update the definition of "underground source of drinking water" to ensure that viable future drinking water supplies are protected from geological sequestration).

[140] 42 U.S.C. § 300g (2012) ("National primary drinking water regulations under this part shall apply to each public water system in each State.").

[141] *Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells*, 75 Fed. Reg. 77,230 (Dec. 10, 2010).

[142] National Pollutant Discharge Elimination System (NPDES), 33 U.S.C. § 1342 (2012).

[143] For cases holding that some discharges to groundwater that later end up in navigable surface waters require NPDES permits, see Hernandez v. Esso Standard Oil Co. (Puerto Rico), 599 F. Supp. 2d 175, 181 (D.P.R. 2009); Idaho Rural Council v. Bosma, 143 F. Supp. 2d 1169, 1180 (D. Idaho 2001); Friends of Santa Fe County v. LAC Minerals, Inc., 892 F. Supp. 1333, 1358 (D.N.M. 1995); Sierra Club v. Colo. Refining Co., 838 F. Supp. 1428 (D. Colo. 1993); McClellan Ecological Seepage Situation v. Weinberger, 707 F. Supp. 1182, 1193 (E.D. Cal. 1988); United States v. Phelps Dodge Corp., 391 F. Supp. 1181 (D. Ariz. 1975) (supporting the notion that NPDES permits are required); *but cf.* Rapanos v. United States, 547 U.S. 715 (2006) (plurality opinion). For cases holding that NPDES permits are not required for any discharges to groundwater, *see* Vill. of Oconomowoc Lake v. Dayton Hudson Corp., 24 F.3d 962, 965 (7th Cir. 1994); Umatilla Water Quality Protective Assoc., Inc. v. Smith Frozen Foods, Inc., 962 F. Supp. 1312, 1318 (D. Or. 1997); Kelley v. United States, 618 F. Supp. 1103 (W.D. Mich. 1985).

For cases holding that a NPDES permit is not required when there is no indication of any hydrologic connection between the groundwater and the navigable surface waters, *see* McClellan Ecological Seepage Situation v. Weinberger, 707 F. Supp. 1182, 1193 (E.D. Cal. 1988); Exxon Corp. v. Train, 554 F.2d 1310, 1312 n.1 (5th Cir. 1977); United States v. GAF Corp., 389 F. Supp. 1379, 1383 (S.D. Tex. 1975); *see generally* Casey Schmidt, *Private Wetlands and Public Values: "Navigable Waters" and the Significant Nexus Test Under the Clean Water Act*, 26 Pub. Land & Resources L. Rev. 97, 107-08 (2005); Thomas L. Casey, III, *Reevaluating "Isolated Waters": Is Hydrologically Connected Groundwater "Navigable Water" Under the Clean Water Act?*, 54 Ala. L. Rev. 159 (2002); Philip M. Quatrochi, *Groundwater Jurisdiction Under the Clean Water Act: The Tributary Groundwater Dilemma*, 23 B.C. Envtl. Aff. L. Rev. 603 (1996).

[144] 33 U.S.C. § 1362(6)(B) (2012).

[145] 40 C.F.R. §§ 98.440-98.449 (2013).

[146] *See* Mandatory Reporting of Greenhouse Gases: Injection and Geologic Sequestration of Carbon Dioxide, 75 Fed. Reg. 75,060 (Dec. 1, 2010) (codified at 40 C.F.R. §§ 72, 78, 98 (2013)).

[147] 40 C.F.R. § 98.448 (2013).

[148] "CO_2 produced" means any CO_2 produced with oil or natural gas or other fluids, by an owner or operator of a sequestration facility, and which is required to be calculated and reported in accordance with the regulation. *See* 40 C.F.R. §§ 98.440, 98.443 (2013).

[149] "CO_2 received" is defined as the CO_2 stream received for the first time for injection into a well to which the regulation applies. It includes (but is not limited to) a CO_2 stream from a production process unit inside the owner or operator's facility and a CO_2 stream injected into a well on another facility, removed from a discontinued enhanced oil/gas well, and transferred to the owner or operator's facility. *See* 40 C.F.R. § 98.449 (2013).

[150] 40 C.F.R. § 98.442 (2013) (detailing the greenhouse gases that must be reported by sources subject to Subpart RR).

[151] 40 C.F.R. § 98.440(c) (2013).

[152] 40 C.F.R. § 98.440(d) (2013).

[153] Email from Donnie Shaw, BLM Fluid Minerals Division, to Peter Gallagher, Research Assistant to author, (May 25, 2012 1:43:06 PM EDT) (on file with author) [hereinafter "May 25 Shaw Email"]; *see generally* Tamar Hallerman, *BLM Official: No Plans Yet to Allow Private CO_2 Storage on Agency Land*, GHG REDUCTION TECHNOLOGIES MONITOR (2012), *available at* http://ghgnews.com/index.cfm/blm-official-e28098no-planse28099-yet-to-allow-private-co2-storage-on-agency-land/?mobileFormat=false.

[154] May 25 Shaw Email, *supra* note 153 (discussing the steps that would precede BLM approval of long-term storage projects). This is somewhat inconsistent with President Obama's stated commitment to having up to ten CCS projects up and running by 2016. While BLM is developing a legal framework for potential CO_2 sequestration, the Department of the Interior and DOE continue to explore geologic capacity to store CO_2 by supporting geological storage demonstration projects on public lands. *See* Presidential Memorandum, *supra* note 36.

[155] Federal Land and Policy Management Act of 1976, 43 U.S.C. § 1701-1787 (2012).

[156] Mineral Leasing Act of 1920, 30 U.S.C. § 181-287 (2012).

[157] U.S. Department of the Interior (DOI), Report to Congress: Framework for Geological Carbon Sequestration on Public Land In Compliance with Section 714 of the Energy Independence and Security Act of 2007 7-9 (2011).

[158] *Id*. at 9; *see also* 43 C.F.R. § 2920 (2013).

[159] Press Release, U.S. Dept. of the Interior, *Interior Releases First-Ever Comprehensive National Assessment of Geologic Carbon Dioxide Storage Potential* (June 26, 2013), *available at* http://www.doi.gov/news/pressreleases/interior-releases-first-ever-comprehensive-national-assessment-of-geologic-carbon-dioxide-storage-potential.cfm. In addition, RAND released a report in 2013 assessing the capacity of the industrial base for geologic storage activities. *See* RAND, THE INDUSTRIAL BASE FOR CARBON DIOXIDE STORAGE: STATUS AND PROSPECTS, *available at* http://www.rand.org/pubs/technical_reports/TR1300.html.

[160] DOI Bureau of Land Management, *Interim Guidance on Exploration and Site Characterization for Potential Carbon Dioxide Geologic Sequestration* (Dec. 2011), *available at* http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2012/IM_2012-035.html.

[161] *Id*.

[162] 43 C.F.R § 2920.4 (2013).

[163] *Id.*

[164] Email from Donnie Shaw, BLM Fluid Minerals Division, to Peter Gallagher, Research Assistant to author, (May 23, 2012 13:24 EDT) (on file with author) (discussing BLM's plans to test the feasibility of short-term CO_2 storage sites).

[165] IOGCC Guide, *supra* note 122, App. I (2007).

[166] *Id.* at 9.

[167] A report issued by the Southern Energy States Board (a non-profit interstate organization promoting innovative energy policies in the Southern States) lists Arizona, Minnesota, New York, Pennsylvania, California, Illinois, Kentucky, Minnesota, Oklahoma, Virginia, Colorado, Florida, Indiana, Kansas, Louisiana, Mississippi, Montana, North Dakota, New Mexico, Texas, Washington, West Virginia and Wyoming. *See* Southern Energy States Board, *Carbon Capture and Sequestration Legislation in the United States of America* (Jul. 2011), *available at* http://www.sseb.org/files/ccs-legislation-full-version.pdf.

[168] Enacted as Clean Coal FutureGen for Illinois Act, 2007, 20 Ill. Comp. Stat. 1108 (2007).

[169] Enacted as Oklahoma Carbon Capture and Geologic Sequestration Act, Okla. Stat. tit. 27A, § 3-5-101 (West 2013).

[170] Enacted as Tex. Health & Safety Code Ann. § 382.501 (West 2013) (Offshore Geologic Storage of Carbon Dioxide).

[171] Enacted as Tex. Gov't Code Ann. § 490.352 (redesignated as Tex. Tax. Code Ann. § 171.652 as amended, eff. Jun. 14, 2013 (West 2013)) (Tax Credit for Clean Energy Project).

[172] Enacted pursuant to 16 Tex. Admin. Code § 5.101 (West 2013) (Carbon Dioxide).

[173] Enacted as N.D. Cent. Code § 38-22 (West 2013) (Carbon Dioxide Underground Storage).

[174] Enacted as W. Va. Code § 22-11A-6 (West 2013) (Carbon Dioxide Working Group).

[175] Enacted as Wyo. State. Ann. § 35-11-318 (West 2013) (Geological Sequestration Special Revenue Account).

[176] Enacted as Mont. Code. Ann. § 82-11-180 (West 2013) (Preservation of Property Rights).

[177] Enacted as Ky. Rev. Stat. Ann. §353.810 (West 2013) (Transfer of Ownership and Liability of Storage Facilities).

[178] Enacted as Miss. Code. Ann. § 53-11-1 (West 2013) (Mississippi Geologic Sequestration of Carbon Dioxide Act).

[179] T.R. Eliot & M.A. Celia, *Potential Restrictions for CO_2 Sequestration Sites Due to Shale and Tight Gas Production*, 46 Environ. Sci. Technol., 4223, 4225 (2012); *see also* NETL Sequestration Atlas, *supra* note 14 (including an analysis of organic-rich shale basins as potential future storage opportunities).

[180] *See generally* Chapter 22.

[181] UNCLOS entered into force in 1994, and approximately 160 nations are parties to it. The U.S. has not yet joined but the Obama Administration previously included UNCLOS on its Treaty Priority List. United Nations Convention on the Law of the Sea, opened for signature Dec. 10, 1982, 1833 U.N.T.S. 397 (entered into force Nov. 16, 1994). United Nations, *United Nations Convention on the Law of the Sea - Overview and Full Text*, *available at* http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm; United Nations, *Oceans and Law of the Sea, Chronological lists of ratifications of, accessions and successions to the Convention and the related Agreements as at 03 June 2011* (Sept. 21, 2012), *available at* http://www.un.org/Depts/los/reference_files/chronological_lists_of_ratifications.htm; U.S. Dept. of State, *Treaty Priority List for the 111th Congress* (May 11, 2009), *available at* http://globalsolutions.org/files/general/White_House_Priorities_List.pdf [hereinafter "Treaty Priority List"].

[182] UNCLOS, *supra* note 181, art. 2 (providing that the sovereignty of a coastal state extends to its territorial seabed and subsoil); art. 56 (providing that the sovereignty of a coastal state extends to exploring and exploiting the seabed and subsoil within its exclusive economic zone); art. 81 (providing that a coastal state may authorize and regulate drilling on its continental shelf for all purposes); art. 85 (providing that a coastal state may exploit the subsoil by tunneling, irrespective of the depth of the water above the subsoil).

[183] *Id.* arts. 192, 194.

[184] International Maritime Organization, "London Protocol and Convention." Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 26 U.S.T. 2403, 1046 U.N.T.S.

120, 11 ILM 1294 (1972) [hereinafter "London Convention"] and 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 36 ILM 1 (1997) [hereinafter London Protocol], *available at* http://www.imo.org/OurWork/Environment/SpecialProgrammesAndInitiatives/Pages/London-Convention-and-Protocol.aspx (stating that there are currently 87 parties to the convention); *see also* International Maritime Organization, Report of the Secretary-General on the Status of the London Convention 1972, LC 2/32, 20 July 2010 (listing signatories to the London Convention and Protocol), *available at* http://www.imo.org/OurWork/Environment/SpecialProgrammesAndInitiatives/Pages/London-Convention-and-Protocol.aspx. The U.S implements the provisions of the Convention through the Marine Protection, Research, and Sanctuaries Act (MPRSA) (also known as the Ocean Dumping Act), 33 U.S.C. §1401-1445 (2012).

[185] London Protocol, *supra* note 184, art.1

[186] *Id.* art. III, para. 3.

[187] *Id.* art. III, para. 1(c).

[188] *See, e.g.*, University College London Faculty of Laws, *UCL Carbon Capture Legal Programme*, *available at* http://www.ucl.ac.uk/cclp/ccsconvention.php (stating that "activities in which CO_2 is re-injected into the seabed following the normal operation of an installation, for the purpose of enhanced oil recovery (EOR), enhanced gas recovery (EGR) or for separation, would be permissible under the Convention").

[189] The U.S. has signed but not ratified the Protocol, which entered into force in 1996. The Bush Administration transmitted the Protocol to the Senate for ratification in September 2007, and the Obama Administration included it on its Treaty Priority List in 2009. *See* Treaty Priority List, *supra* note 181; London Protocol, *supra* note 184.

[190] The Protocol was drafted to modernize and eventually replace the London Convention. Annex 1 of the Protocol was amended in 2006 with the intent that CO_2 streams from CCS be included in the list of wastes or other matter that may be considered for "dumping." *See* International Energy Agency, *Carbon Capture and Storage and the London Protocol, Options for Enabling Transboundary CO_2 Transfer* 10 (2011), *available at* http://www.iea.org/publications/freepublications/publication/CCS_London_Protocol.pdf.

[191] London Protocol, *supra* note 184, art. 1, para. 4.1.3.

[192] *Id.* art. 1, para. 4.2.2.

[193] *See, e.g.*, A.B. Weeks, *Sub-Seabed Carbon Dioxide Sequestration as a Climate Mitigation Option for the Eastern U.S.*, 12 Ocean & Coastal L. J. 245, 258 (2007) (arguing that the exclusion for non-disposal-motivated "placement" is sufficiently ambiguous to permit carbon dioxide seabed sequestration if it were not permanent).

[194] London Protocol, *supra* note 184, art. 1, para. 4.3.

[195] S. Treaty Doc. No. 110-5 (2007) at 2, *available at* UNT Digital Library, http://digital.library.unt.edu/ark:/67531/metadc31108/ (attaching Article-by-Article Analysis 1-2 of the London Protocol prepared by the Department of State).

[196] London Protocol, *supra* note 184, art. 1, para. 7.

[197] Amendments to Annex I to the London Protocol 1996, Resolution LP.1(1), Adopted on Nov. 2, 2006, para. 4.3.

[198] London Protocol, *supra* note 184, art. 4, para. 1.2.

[199] *Id*. at Annex II, para. 17.

[200] *Id*. at Annex II, paras. 17.1-17.4 and 18. In the U.S., permits relating to sub-seabed CO_2 sequestration on the outer continental shelf would be issued by the Bureau of Ocean Energy Management under the authority of the Outer Continental Shelf Lands Act, 43 U.S.C. § 1337(p)(1)(C) (2012).

[201] London Protocol: Specific Guidelines For Assessment Of Carbon Dioxide Streams For Disposal Into Sub-Seabed Geological Formations, adopted by the 2nd Meeting of Contracting Parties in November 2007, *available at* http://www.gc.noaa.gov/documents/gcil_imo_co2wag.pdf [hereinafter "London Protocol: Specific Guidelines"]. The Specific Guidelines build on an earlier document, the "Risk Assessment and Management Framework for CO_2 Sequestration in Sub-seabed Geological Structures," which was adopted under the Protocol in 2006.

[202] London Protocol: Specific Guidelines, *supra* note 201, paras. 1.1, 1.2.

[203] R.L. Gresham, S.T. McCoy, J. Apt, & M.G. Morgan, *Implications of Compensating Property Owners for Geologic Sequestration of CO_2,* 44 Environ. Sci. Technol. 2897-2903 (2010) (examining pore space acquisition costs for an 800 megawatt power plant). A commercial scale sequestration site is expected to require tens to hundreds of square miles of pore space for the footprint of the compressed CO_2. Wendy B. Jacobs & Debra Stump, *Commercial-Scale CCS in Pennsylvania: Options for Acquiring Access to Pore Space*, Emmett Environmental Law & Policy Clinic, Harvard Law School 4 (September 2010) (discussing the potential of holdouts, who refuse to sell or lease their subsurface pore space, to obstruct a project).

[204] Sam Roberts, *It's Still a Big City, Just Not Quite So Big*, N. Y. TIMES, May 22, 2008, *available at* http://www.nytimes.com/2008/05/22/nyregion/22shrink.html.

[205] There are inherent difficulties in calculating the storage potential of a given plot of land because CO_2 reservoirs can extend vertically as well as horizontally, and CO_2 may be stored in multiple reservoirs simultaneously at different depths. Energy Policy Institute, *Analysis of Existing and Possible Regimes for Carbon Capture and Sequestration: A Review for Policymakers* 26 (April 2011) (discussing the complexities that may arise in determining majority pore space owners under unitization laws). *See infra* notes 225 and 226 accompanying text (discussing unitization laws).

[206] *See* EPA Technical Support Document, *Vulnerability Evaluation Framework for Geologic Sequestration of Carbon Dioxide* 44 (Jul. 10, 2008), *available at* http://www.epa.gov/climatechange/Downloads/ghgemissions/VEF-Technical_Document_072408.pdf (discussing the environmental risk profile for sequestration at various stages of CO_2 injection); Jacobs, *supra* note 18, at 2 (discussing concerns about potential future liability arising from "lack of experience sequestering CO_2 at large volumes" and "the absence of a national framework delineating liability and financial responsibility for owners and operators of CCS projects, and for landowners who consent to having CO_2 sequestered in the pore space under their land").

[207] Commercial operations should be distinguished from demonstration projects which require a different set of incentives and allocation of legal risks. *See* Jacobs & Stump, *supra* note 118, at 6, 9-10; Wendy B. Jacobs, Leah Cohen, Lara Kostakidis-Lianos & Sara Rundell, *Proposed Roadmap For Overcoming Legal and Financial Obstacles to Carbon Capture and Sequestration*, Discussion Paper 2009-04, Belfer Center for Science and International Affairs 18 (March 2009) [hereinafter "CCS Roadmap"].

[208] *See* Jacobs & Stump, *supra* note 118, at 5, 10-12 (stating that if the owner and operator are separate entities they share joint and several liability); IOGCC Guide, *supra* note 122, at 29; CCS Roadmap, *supra* note 207, at 19; International Risk Governance Council, *Regulation of Carbon Capture and Storage* 23 (2008). *See generally* World Resources Institute, *CCS Guidelines* at 83, 104 (2008) [hereinafter "CCS Guidelines"].

[209] Jacobs & Stump, *supra* note 118, at 5-7, 12-13; IOGCC Guide, *supra* note 122, at 29; CCS Guidelines, *supra* note 208, at 104; Chiara Trabucchi & Lindene Patton, *Storing Carbon: Options for Liability Risk Management, Financial Responsibility*, BUREAU OF NATL AFFAIRS, DAILY ENV'T REPORT, Sept. 3, 2008 (discussing how financial risk declines as CCS projects move from siting to long-term stewardship and how long-term residual risk tends to be managed by third parties).

[210] *See e.g.* Jacobs & Stump, *supra* note 118, at 6-7; IOGCC Guide, *supra* note 122, at 41. Under the UIC program, Class II and Class VI wells require different forms of financial security. For example,

owners/operators of Class VI wells must demonstrate and maintain financial responsibility sufficient to cover the cost of corrective action on wells, injection well plugging, post-injection site care and site closure and the emergency and remedial response phases. *See* 40 C.F.R. § 146.85(a)(2) (2013); EPA, *Geologic Sequestration of Carbon Dioxide: Underground Injection Control (UIC) Program Class VI Well Financial Responsibility Guidance* (July 2011), *available at* http://water.epa.gov/type/groundwater/uic/class6/upload/uicfinancialresponsibilityguidancefinal072011.pdf. In comparison, owners/operators of Class II wells need only maintain financial responsibility sufficient to cover the cost of closing, plugging or abandoning a well. *See* 40 C.F.R. §§ 144.28(d), 144.52(a)(7); EPA, *Federal Financial Responsibility Demonstrations for Owners and Operators of Class II Oil- and Gas-Related Injection Wells*, EPA 570/9-90-003, (1990), *available at* http://www.epa.gov/r5water/uic/forms/ffrdooc2.pdf.

[211] Jacobs & Stump, *supra* note 118, at 18-24 (proposing a CCS Trust Fund); IOGCC Guide, *supra* note 122, at 11, 26, 29-30, 34 (proposing a Carbon Dioxide Storage Facility Trust Fund).

[212] *See* H.R. 149, 79th Leg., 3rd Sess. (Tex. 2006); Clean Coal FutureGen for Illinois Act, Ill. Pub. Act 095-0018 (2007).

[213] *See, e.g.,* Ky. Rev. Stat. Ann. §353.810 (West 2013); La. Rev. Stat. Ann. § 30:1109(A) (1) (West 2013); Wyo. Stat. Ann. § 34-1-153 (West 2013), Mont. Code Ann., § 82-11-183 (West 2013); N.D. Cent. Code § 38-22-17 (West 2013).

[214] *See generally* NETL Sequestration Atlas, *supra* note 14 (discussing ongoing efforts in the U.S. to identify carbon storage potential including in pore spaces, saline aquifers and offshore).

[215] Because property ownership issues related to salt caverns, unmineable coal seams, and depleted oil and gas reservoirs are somewhat more settled by state law, this chapter will focus on the unsettled rights to pore space and briny aquifers.

[216] Geological formations suitable for CO_2 sequestration tend to be comprised of "vast volumes of inter-layered sedimentary rocks of different textures and compositions that provide both the pore volume to sequester the CO_2 and impermeable seals [made of shale or fine-grained mudstone] to trap the CO_2 underground." *See* D.R. Cole, A.A. Chialvo, G. Rother, L. Vlcek & P.T. Cummings, *Supercritical Fluid Behavior at Nanoscale Interfaces: Implications for CO_2 Sequestration in Geologic Formations* 90, Philosophical Magazine, 2339, 2340 (2010).

[217] Natural gas is also stored in pore space, but only temporarily and not in as large a quantity as will be the case for sequestered CO_2 because, as one commentator points out, storage is part of a "continuous cycle of injections and withdrawals of gas, while CO_2 sequestration involves injection for permanent storage." *See* Owen L. Anderson, *Geologic CO_2 Sequestration: Who Owns the Pore Space?*, 9 Wyo. L. Rev. 97, 115 (2009).

[218] *See, e.g.*, John G. Sprankling, *Owning the Center of the Earth*, 55 UCLA L. Rev. 979 (2008); Anderson, *supra* note 217; Victor B. Flatt, *Paving the Legal Path for Carbon Sequestration from Coal*, 19 Duke Envtl. L. & Pol'y F. 211 (2009); Kevin L. Doran & Angela M. Cifor, *Does the Federal Government Own the Pore Space Under Private Lands in the West? Implications of the Stock-Raising Homestead Act of 1916 for Geologic Storage of Carbon Dioxide*, 42 Envtl. L. 527, 541 (2012); Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, U. Ill. L. Rev. 363, 375 (2010); Jacobs & Stump, *supra* note 203; James Robert Zadick, *The Public Pore Space: Enabling Carbon Capture and Sequestration by Reconceptualizing Subsurface Property Rights*, 36 Wm. & Mary Envtl. L. & Pol'y Rev. 257 (2011); A. Bryan Endres, *Geologic Carbon Sequestration: Balancing Efficiency Concerns and Public Interest in Property Rights Allocations*, 2011 U. Ill. L. Rev. 623 (2011); Energy Policy Institute, *supra* note 205.

[219] *See, e.g.*, Mont. Code. Ann. §82-11-180 (West 2013); N.D. Cent. Code 47-31-01 to 47-31-08 (West 2013); Wyo. Stat. Ann. §34-1-152 (West 2013).

[220] Doran & Cifor, *supra* note 218, at 531, 536, 548 (arguing that "the federal government likely holds title to some 70 million acres of subsurface pore space located under private land" in the Western

U.S.); Jacobs & Stump, *supra* note 203, at 15 (analyzing the argument that "deep subsurface property should be considered a national resource under the dominion of the federal government"); Flatt, *supra* note 218, at 216-20 (arguing that "there is precedent for federal preemption of state site restrictions regarding the geologic storage of CO_2").

[221] Flatt, *supra* note 218, at 230; Anderson, *supra* note 217, at 106-07.

[222] Mont. Code. Ann. §82-11-180 (West 2013); N.D. Cent. Code 47-31-01 to 47-31-08 (West 2013); Wyo. Stat. Ann. §34-1-152 (West 2013).

[223] Anderson, *supra* note 217, at 107-08; Klass & Wilson, *supra* note 218, at 423; Endres, *supra* note 218, at 632.

[224] Refer to Section III above. *See also supra* note 203 and accompanying text.

[225] Tex. Nat. Res. Code Ann. § 101.011 (West 2013); La. Rev. Stat. § 30:9 (West 2013). *See generally* 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, 478 (2008) (discussing voluntary unitization in Texas).

[226] The amount that a minority or holdout is entitled to claim (if any) depends on the terms of any private voluntary agreement that is reached or the applicable state compulsory pooling / unitization statute. *See* Bruce M. Kramer, *Compulsory Pooling and Unitization: State Options in Dealing with Uncooperative Owners*, 7 J. Energy L. & Pol'y 255, 260-64 (1986) (discussing potential payment alternatives under private agreements and certain state statutes).

[227] *See, e.g.,* Flatt, *supra* note 218, at 231-32; Doran & Cifor, *supra* note 218, at 545-46 (discussing the use of pooling and unitization schemes for CCS as opposed to "…interact[ing] with a single (or very large) subsurface owner such as the federal government").

[228] *See* Gresham, *et al*., *supra* note 203, at 2898-99 (discussing difficulties predicting the migration of $CO_{2)}$; Energy Policy Institute, *supra* note 205, at 15; Endres, *supra* note 218, at 648.

[229] *See* Jacobs & Stump, *supra* note 203, at 7 (discussing the fact that courts have not yet recognized individual property rights deep beneath the subsurface); Thomas Brugato, *The Property Problem: A Survey of Federal Options for Facilitating Acquisition of Carbon Sequestration Repositories*, 29 Va. Envtl. L.J. 305, 317-18 (2011).

[230] Stock-Raising Homestead Act (SRHA), 43 U.S.C. §§ 299 -302 (2012). *See* Watt v. Western Nuclear, Inc., 462 U.S. 36, 53 (1983) (interpreting relevant provisions of the SRHA).

[231] *See* Doran & Cifor, *supra* note 218, at 541-45; *contra* Anderson, *supra* note 217, at 137.

[232] These analyses tend to emphasize that technological change serves as a catalyst which necessitates the revision of existing legal doctrines. *See* Sprankling, *supra* note 218, at 1000-01; Klass & Wilson, *supra* note 218, at 386-89 (discussing air space rights); *see also* Endres, *supra* note 218, at 628-30, 633-34 (discussing property rights regarding radio frequencies and air space); Brugato, *supra* note 229, at 330-31 (discussing federal rights over the outer continental shelf).

[233] *See, e.g.*, U.S. v. Causby, 328 U.S. 256, 260-61 (1946) (stating that, in relation to airspace rights, "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."); United States v. California, 332 U.S. 19, 32-33 (1947) (noting that the continental shelf was never intended to be blocked off "for private ownership and use in the extraction of its wealth"); National Broadcasting Co. v. United States, 319 U.S. 190, 213 (1943) (noting in relation to radio communications that regulation was essential to ensure the "potentialities of radio were not to be wasted").

[234] 328 U.S. 256 (1946).

[235] *See, e.g.*, Endres, *supra* note 218, at 628 (positing that property rights in pore space and deep saline aquifers "may be another candidate for initial public ownership with subsequent allocation to the private sector"); Jacobs & Stump, *supra* note 203, at 15 (stating that ownership of resource lies with federal government); Flatt, *supra* note 218, at 216-20 (federal preemption).

[236] *See, e.g.*, Wyo. Stat. Ann. §34-1-152 (West 2013); N.D. Cent. Code §47-31-03 (West 2013).

[237] *See, e.g.*, Endres, *supra* note 218, at 628; Jacobs & Stump, *supra* note 203, at 15; Brugato, *supra* note 229, at 337-38.

[238] Confidential communications between landowners and the author (2008 - 2010).

[239] 43 U.S.C. §§ 299 -302 (2012).

[240] Jacobs & Stump, *supra* note 118, at iii.

[241] United States v. Union Oil, 549 F.2d 1271, 1273-74 (1977).

[242] Energy Policy Institute, *supra* note 205, at 32-33 (discussing CCS projects that span state boundaries and noting that the Vermillion Basin which spans the Wyoming-Colorado border provides a potential example of how a state such as Wyoming, which has rules as to pore ownership, may benefit at the expense of a state such as Colorado, which has not yet ruled on the issue).

[243] Anderson, *supra* note 217, at 107.

[244] Flatt identifies these as "(1) absolute dominion (2) reasonable use (3) correlative rights 4) the [R]estatement rule, [and] 5) prior appropriation." Flatt, *supra* note 218, at 235. *See generally* Joseph L. Sax, Berton H. Thompson, Jr., John D. Leshy & Robert H. Abrams, LEGAL CONTROL OF WATER RESOURCES: CASES AND MATERIALS (5th ed. 2012).

[245] Klass & Wilson, *supra* note 218, at 376.

[246] Mark A. Shannon, *et al.*, *Science and Technology for Water Purification in the Coming Decades*, 452 Nature, 301, 306-08 (2008), *available at* http://www.nature.com/nature/journal/v452/n7185/full/nature06599.html (discussing emerging desalination technologies available to enable use of seawater and brackish waters from saline aquifers).