Energy Policy Institute

Center for Advanced Energy Studies

The Energy Policy Institute

# ANALYSIS OF LIABILITY REGIMES FOR CARBON CAPTURE AND SEQUESTRATION: A REVIEW FOR POLICYMAKERS

*December 2011*

The Energy Policy Institute is an integral part of the Center for Advanced Energy Studies, which is a public/private partnership between the Idaho National Laboratory, Boise State University, the University of Idaho, Idaho State University, and private industry.

http://epi.boisestate.edu

# *ANALYSIS OF LIABILITY REGIMES FOR CARBON CAPTURE AND SEQUESTRATION: A REVIEW FOR POLICYMAKERS*


ELIZABETH ALDRICH[1]
*Boise State University*

CASSANDRA KOERNER
*Boise State University*

DAVID SOLAN
*Boise State University*


DECEMBER 2011



[1] Elizabeth Aldrich was employed at Boise State University at the time of the report's drafting. She is currently Chair of Sustainability Studies at the White Mountain School (NH).


The authors would like to thank Melisa Pollak, Research Fellow in the Science, Technology and Public Policy Program at the University of Minnesota Humphrey School of Public Affairs, for her insight into the state-level carbon capture and sequestration liability legislation that is analyzed in this paper.

Table of Contents

## Executive Summary

Liability coverage for carbon capture and sequestration (CCS) is of paramount importance if the industry is going to mature and develop in a way that will allow it to make a significant contribution to mitigating climate change. Liability for CCS can be broken into two phases. The first phase is the short-term, which covers the pre-injection, injection, and closure stages of the project. The second phase is the long-term, or post-closure stage. Since pre-injection, injection, and closure occur over a relatively short period of time that may cover 20 to 30 years, typical liability instruments like private insurance, letters of credit, performance bonds, trust funds, and escrow accounts may be utilized. For the post-closure phase, which lasts indefinitely after the site has been closed, more enduring liability instruments must be used in order to ensure that adequate and long-lasting coverage is provided. Examples of long-term liability instruments may include industry-pooled funds to cover damages in the future and three tiers of liability that include a combination of private insurance, an industry pool for long-term monitoring and remediation of wells and accidents that cannot be covered by private insurance, and federal indemnity of CCS sites for accidents that are too large to be covered by the private insurance and industry pool.

This paper describes these short and long-term insurance instruments and provides examples of how they have been used and proposed for CCS. This paper provides a critical review of the implementation of a variety of CCS liability schemes at the state and federal level in the US and within the EU. Finally, after reviewing existing and possible schemes, a proposal for a robust and comprehensive liability program for CCS is introduced.

## Introduction

The Energy Information Administration projects that coal consumption will increase 1.1% by 2035 (EIA, 2011). The United States uses coal for nearly 50 percent of its electricity production (EIA, 2010a), and compared to other fossil fuels like oil and natural gas coal releases more carbon dioxide ($CO_2$) when combusted (EIA, 2010b). Due to the warming potential of the $CO_2$ released, improved use of coal and sequestration of the $CO_2$ from combustion is being pursued avidly with public and private research. Carbon capture and sequestration (CCS),[1] which involves the separation of $CO_2$ from stack emissions and geologic sequestration of $CO_2$, is an apt technology to address $CO_2$ emissions from both natural gas and coal-fired power plants.

Carbon capture and sequestration could prevent the release of up to 90 percent of $CO_2$ emissions at a stationary power plant or industrial facility if $CO_2$ were captured directly at the source, separated from other byproducts, transported to a geologic formation, and stored for an indefinite period of time (Pacala & Socolow, 2004). The geologic formations conducive to CCS are often areas where coal, oil, or gas have been extracted or where saline water resides in the pore spaces of certain rock formations, thousands of feet underground. $CO_2$ has inadvertently been sequestered in recent years as it is injected to re-pressurize oil and gas fields in order to increase production. During this process, known as enhanced oil recovery (EOR) or enhanced gas recovery (EGR), approximately 50 to 60 percent of the $CO_2$ injected remains in the ground (International Energy Agency Greenhouse Gas Research and Development Programme, 2010).[2] CCS differs from EOR in that the goal of CCS is to maintain the $CO_2$ in the ground and maximize the storage potential of reservoirs.

### *CCS Risks*

There are some risks to human and environmental health associated with carbon injection. Many anti-CCS activists have pointed to the dangers of CCS by comparing it to incidents of natural $CO_2$ release in giant plumes from lakes near volcanoes. An instance of this type of release occurred in 1986 when Lake Nyos, located in northwestern Cameroon, released a lethal amount of $CO_2$ suffocating over 1,700 people in its wake and leaving hundreds of others injured (Barberi et. al, 1989). Since $CO_2$ is trapped tightly in the vacuous pore space of subsurface strata, a huge release as happened at Lake Nyos would not occur since $CO_2$ would

[1] Throughout the paper, the word sequestration instead of storage will be used to describe the permanent storage of $CO_2$ in geologic reservoirs because the word "storage" implies that the $CO_2$ will be retrieved at some future date. Since we assume that the $CO_2$ will permanently be stored, we prefer to use the word "sequestration," which has a more enduring connotation.

[2] The exact amount of $CO_2$ sequestered is heavily dependent on the capacity of the formation to hold $CO_2$.

only be allowed to seep slowly out of the ground (Klass & Wilson, 2009). The Intergovermental Panel on Climate Change (IPCC, 2005) explains that some risks related to injection of $CO_2$ in the subsurface are already being managed by the oil and gas industry on a regular basis via monitoring using controls that are already in place for enhanced oil recovery.

$CO_2$ does, however, present risks to plant life by raising the $CO_2$ levels in the soil. Large releases of $CO_2$ in the soil can be lethal to plants and animals (Klass & Wilson, 2009). Human health can also be at risk from the effects of $CO_2$ in the subsurface where the injection displaces brine and mixes with and degrades the quality of subsurface water reservoirs. Subsurface aquifers are highly regulated and will be monitored carefully through safeguards put in place by the new Environmental Protection Agency (EPA) Underground Injection Control Class VI well rule. This new regulation will be discussed in detail later in the paper.

In addition to these risks, maintaining the stability of the subsurface looms as a potentially large risk that must be managed. Choosing an appropriate site for injecting $CO_2$ can protect the injectors and regulators from a number of subsurface issues such as breaching of the caprock, ground heave, and induced seismicity. Outside the CCS context, researchers reported several earthquakes, some between 3 and 4 on the Richter scale, in the Denver area following the injection of waste fluids into subsurface spaces (Healy et. al., 1968), and more recently concerns have erupted in Arkansas over hydraulic-fracturing, or"fracking," which seems to be having a similar seismic impact in shale laden areas (Eddington, 2011). These risks have been addressed previously in some areas such as Ohio (Sminchak et. al., 2002). Findings show that injection into more porous formations are less likely to experience fracturing, seismic activity, and breaches to caprock integrity than less porous geologic features (Sminchak et. al., 2002). The In Salah CCS site in Algeria uses interferometric synthetic aperture radar technology to monitor surface changes on their site; preliminary data show a small amount of bulging around injection wells and other surface deformation which could be attributed to the injection of carbon nearly two kilometers below the surface (Knott, 2008). Time will tell whether or not this bulging induces seismicity or causes subsurface leakage.

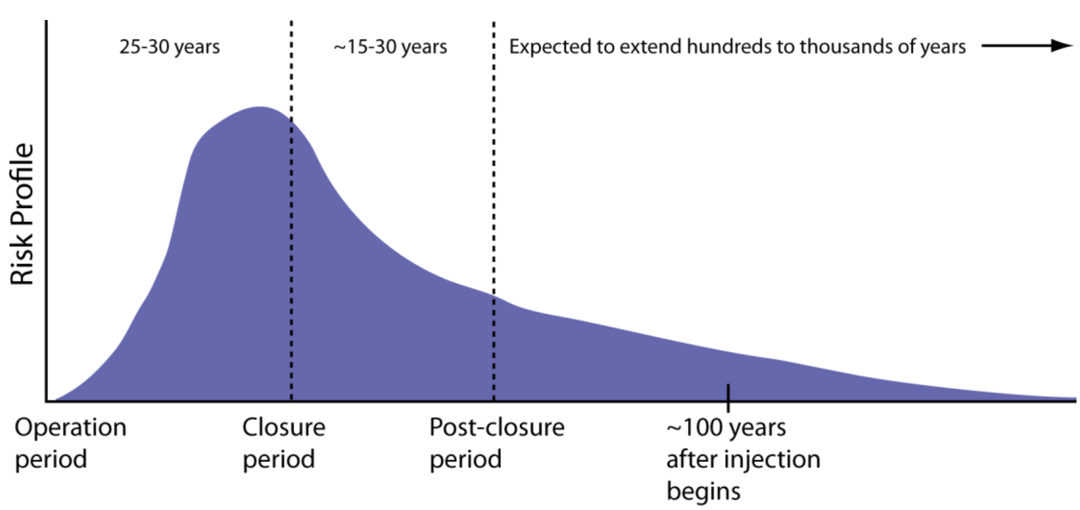
## Short and Long-Term Liability

Given the risks described above, liability schemes are emerging to protect against these risks in both the short- and long-term. Recent allegations against Cenovus, the primary carbon injector at the Weyburn site in Saskatchewan, claim that the site has sprung a leak and is threatening health and human safety on lands surrounding the oil field/injection site (Petro-Find Geochem, 2010). The Weyburn situation is the first allegation of leaked $CO_2$ made in regards to large-scale carbon injection worldwide and may highlight the need for greater attention to the risks and liabilities associated with CCS.

The purpose of creating liability schemes is to ensure a level of fiscal resources sufficient to protect human and environmental health, financial regimes, companies, and regulatory agencies from unintended consequences. For a detailed description of the way by which individuals could sue CCS owners and operators based on potential damages due to CCS, please see Appendix 1. Right now, although it is important to focus on protection from the risks of CCS, it is also crucial to not stifle the process with unnecessary or overly burdensome statutes or fees if CCS is to be utilized as a large-scale solution to climate change.

There are three main stages of CCS, which include capture, transport, and storage of the CO2. Within the storage phase, there are three separate stages, which include operation, closure, and post-closure; each of these phases has its own associated risks. The time of pre-injection and operation occur over a period of approximately 20-30 years (Klass & Wilson, 2008), which established insurance products can cover. Each jurisdiction that has chosen to address liability seems to define the closure phase, before liability can be transferred, differently. In Montana, the waiting period before the state assumes responsibility is 30 years, in Australia the time period is 15 years, and in the EU it is 20 years (Jacobs & Stump, 2010). Given these relatively short time frames, short-term liability instruments are most appropriate. Post-closure necessitates long-term liability since it spans an indefinite period of time picking up at the end of closure.

Figure 1: The Timing and Severity of CCS Risks (Adapted from Wilson et. al., 2007)



*Short Term Liability: Pre-injection, Operation, and Closure*

One of the most important periods for determining liability is prior to when injection begins. As previously mentioned, the most significant decision made in relation to injection is the selection and characterization of a site. The size, porosity, and location of a geologic formation will determine the economic viability of the site as well as the amount of time a site can safely be operated (Pollak et. al., 2010). Siting can come at a great cost to operators, depending on response of the local population or the amount of pipeline and rights needed to move the CO2 to the site.

Many of the short-term risks associated with carbon sequestration have been based on decades of injecting carbon for EOR purposes (US DOE, 2011). Some expected operational liabilities include the following: injury to workers, difficulties earning access to storage/access rights, poor well construction, poor siting of wells in areas of low injectivity, surface and subsurface property damage, induced seismicity, groundwater contamination, environmental damage, damage to confinement zone, and atmospheric release of CO2 (NETL, 2009). The expectation is that as time passes, the risk levels will decrease.

In some jurisdictions, site closure requires additional financial assurances to guarantee well plugging and monitoring (Texas General Land Office et. al., [3] 2010). Well plugging and abandonment plans are created during project development stages and have different requirements based on the location and type of well. Many abandonment plans require reclamation at and around the site to prevent environmental impacts (Fesmire, et. al., 2007). Integrity of wells and the formation will be of utmost importance to monitor during the closure phase. In addition to any faults or fractures in the geologic formation, improperly constructed wells could provide a migration pathway for CO2 (Federal Requirements under the UIC Program for CO2 GS Wells, 2010). Subsurface migration of CO2 and later mixing with water to leach minerals such as arsenic or hard metals into drinking waters is an additional risk during the closure phase (Federal Requirements under the UIC Program for CO2 GS Wells, 2010).

*Long-Term Liability: Post-Closure*

Although in the short-term subsurface CCS liabilities are similar to those in EOR, the long-term implications require much more analysis because of their complexity. One major difference between EOR and CCS is the volume of CO2 being injected into a formation. An 800 MW capacity coal-burning power plant will necessitate between 300 to 11,000 $km^2$ of pore space to

[3] Hereafter referred to as "Texas."

store the CO2 from this plant for 30 years; the huge discrepancy in these numbers is due to the depth of the formation and its ability to sequester CO2 (Gresham, 2010). The increased volume and pressurization anticipated by CCS requires a certain type of stable geologic formation if operators intend on sequestering a great volume at a high pressure over thousands of years. Geologic formations where CCS occurs should be deep in the subsurface and covered by one or more impervious layers of rock to avoid leakage. The structure of the formation should have adequate porosity and permeability to hold CO2. An additional formation benefit would be to contain nonpotable water, which could potentially react with the CO2 and could improve the affixation of the CO2 within the formation (Office of Indian Energy and Economic Development, 2011).

One of the primary concerns in the post-closure phases is maintaining the CO2 plume in the allotted space for centuries. The IPCC notes in its 2005 Special Report on Carbon Capture and Storage that there is little concern over seepage at well-selected sites and even minimal releases will be acceptable so long as they do not affect human and environmental health. The IPCC (2005, p. 34) reported that CO2 storage in an "appropriately selected and managed reservoir is very likely[4] to exceed 99 percent over 100 years, and is likely to exceed 99 percent over 1000 years." The longer the CO2 remains in the subsurface, the more likely it is to combine with other minerals and be absorbed into either the rock or water (Federal Requirements under the UIC Program for CO2 GS Wells, 2010).

During all stages of CCS, monitoring of pressure, wells, and the geology should be the operator's primary focus to reduce risk and associated damages. Monitoring can also provide insight into modifications that can be made to improve sequestration processes. Additionally, constant monitoring provides injectors with precise information so they might know when closure is appropriate or necessary.

## Analysis of Possible and Existing Liability Schemes

Investment and liability risks are tied to the volume of gas being injected, gas composition, and structure of the subsurface space the gas is being injected into. Financial assurance is a necessary mechanism for successful CCS but could potentially hold up development if the rules are too stringent. Alternatively, CCS could damage the environment and underground sources of drinking water (USDWs) if the rules for injection and financial mechanisms to cover damages are not restrictive enough. The most likely assurance program will be provided by operators

[4] 90-99% probability

over the short-term and some public sector over the long-term (Klass & Wilson, 2008). Different liability instruments will be better suited for some phases of injection; therefore the mechanisms will be discussed separately. First the liability instruments for pre-injection, injection, and closure or the short-term risks will be discussed. Then, liability instruments for post-closure or the long-term risks will be discussed. As each of these liability instruments for both short and long-term risks are discussed, existing liability schemes of each type will be analyzed, and gaps in liability schemes will be highlighted to show how the existing schemes may fail to provide the comprehensive coverage necessary to allow for full commercialization of CCS.

*Short-Term Liability Instruments*

While the risk for damage during operations and shortly thereafter during closure may be great, this risk can most likely be quantified based on the area of injection, amount of injectate, and proximity of populated areas. Therefore, some insurance options are available during injection and closure that are not appropriate for coverage of long-term liability. Some of the institutions or financial mechanisms that can provide coverage of projects during operations and closure cannot offer their service beyond this time frame because of the uncertainty of their long-term existence. The financial instruments to cover the operational phase of CCS, which begins with locating a suitable injection site and ends with well closure, include some form of bonds, which require some upfront commitment to pay for costs of future potential damages. Typically these financial commitments come in the form of trust funds, escrow accounts, letters of credit, and performance bonds. These instruments are most applicable to the short-term time frame since longer term damages can be hard to assess and predict. Therefore, the amount of the upfront payment and capacity to pay for full damages if they occur could be contentious. Also, financial institutions that would back up these financial commitments may not be in existence in the long term, and may unnecessarily keep capital for remediation and payment of potential damages tied up and unable to be used. Alternatively, private insurance can be used to cover short-term risks (Klass & Wilson, 2008). However, like the drawback of the other short-term financial instruments to pay for damages, private insurance companies may not exist long enough to provide post-closure coverage.

Trust Fund

A trust fund involves a third party trustee that holds funds sufficient to cover estimated costs of damages (Federal Requirements under the UIC Program for CO2 GS Wells, 2010). This is the surest form of funding but can be seen to put a burden on the cash flow of the operator and often is based on the lowest estimates of damage (Texas, 2010).

Escrow Account

An escrow account is a trust held by a third party that develops over time with a defined period of pay-ins instead of having the fund financed and available at the start of the coverage period. These funds would have to be segregated from all other accounts and appropriated for the financial obligations caused from damage to human health or the environment. This mechanism could entail a higher risk than a Trust Fund if the operator stopped paying into the account or if there was a significant draw on the account early in development (Texas, 2010).

Letter of Credit

A letter of credit (similar to bonds) is funding provided through a financial institution that can guarantee financial responsibility will be met if there is a demand for it. Most letters of credit are created based on estimated costs and do not require operators to pay up front; however, the operator must pay fees of 1-3% per year (Texas, 2010; Federal Requirements under the UIC Program for CO2 GS Wells, 2010).

Performance Bonds

Performance bonds allow for a financier or owner of a CCS project to be guaranteed compensation for monetary loss if the contractor who is conducting the operations of the CCS project fails to construct the project properly (Texas, 2010; Federal Requirements under the UIC Program for CO2 GS Wells, 2010).

Private Insurance

Some private insurance companies like SwissRe and ACE have begun exploring insurance for certain aspects of CCS like the injection and closure stage. Zurich Financial Services Group even provides an offering for this type of insurance (Zurich creates two new insurance policies, 2009). However, other private insurance companies are reluctant to enter this field as they are having a difficult time setting premiums because they do not have a good model to estimate CCS risk.

Private insurance differs from other financial mechanisms as it is a cost reimbursement mechanism and no company provides an automatic payout upon claim, but rather the provider may challenge the claim based on terminology used in the contract. These complex contracts would likely be different for each project, and it would be difficult to determine the likelihood of reimbursement for any foreseeable event. This mechanism may force the operator or (more likely) the state to pay the costs up front. Additionally, because of the long-term nature of the post-closure stage and the expressed concern over the costliness of insurance required for monitoring and remediation over long time horizons, private insurance is not a preferred financial assurance mechanism for long-term liability (Texas, 2010; Federal Requirements under the UIC Program for CO2 GS Wells, 2010). Insurance could however be beneficial in shorter time frames, such as injection and closure phases. Most insurance companies are likely to only provide short-term offerings because they cannot guarantee their existence and accountability for the long-term contracts that would be required in the post-closure phase of injection.

Example of the Use of a Combination of Short-Term Liability Instruments for CCS

Now that instruments to cover short-term liability risks have been discussed, the following section will provide an example of a how a combination of these short-term liability instruments have been used. The US EPA's Underground Injection Control (UIC) Program finalized a new set of rules for wells that contain CO2. The UIC Program was created under the Safe Drinking Water Act to safeguard underground sources of drinking water. Under this Program, there are six categories of wells for injection of products, ranging from hazardous waste to brine for enhanced extraction of oil and gas. The Class VI well designation for CO2 is the most recent, with finalization on December 10, 2010 (Federal Requirements under the Underground Injection Control Program for CO2 Geologic Sequestration Wells, 2010).

These rules emphasize site selection for CO2 injection and cover liability only with regards to how leakage would impact underground sources of public drinking water. The Rule does not cover private aquifers, CCS conducted offshore, or reservoirs with more than 10,000 mg/L of total dissolved solids, which may become important sources of drinking water in the future as water supplies become scarce (Jacobs & Stump, 2010). Avoiding release of CO2 into the atmosphere is also outside of the scope of the Class VI rule (Federal Requirements under the Underground Injection Control Program for CO2 Geologic Sequestration Wells, 2010).

Similarly, the requirements for financial assurance are vague (Rankin, 2009). Financial assurance is necessary for the site during and after operations during a post-closure stage, which is slated to last for 50 years, unless otherwise determined by the EPA Director or official responsible for permitting, implementation, and compliance of the UIC program. The amount of insurance necessary is up to the discretion of the EPA Director and contingent on the size and characteristics of the geologic formation. A number of different financial instrument combinations including trust funds, surety bonds, letters of credit, escrow accounts, and private insurance may be used. In addition to this financial assurance, the operator must make a detailed emergency response plan. Some states are concerned that if the chosen financial instrument fails to provide backing, then the state where the project is located could be found liable (Texas, 2010).

While short-term liability can be covered comprehensively using a variety of the short-term liability tools available, long-term liability is less well defined in the Class VI rule. Despite the 50-year closure period suggestion, the EPA can extend liability and hold the owner and operator of the site responsible for damages indefinitely. Due to the uncertain nature of CCS, the EPA has taken an adaptive approach, which allows it to modify its regulations as the science in the field advances. Since this Rule allows the possibility for the owner or operator to retain long-term liability, it is recommended that this liability be transferred to a third party, such as the state or federal government, who could assume and cover long-term risks. However, the Class VI rule does not allow for liability to be transferred to third parties due to a lack of statutory authority under the Safe Drinking Water Act. The possible retention of liability by the project owner or operator and inability to transfer liability to a third party under the Class VI rule could slow the advance of CCS since this structure creates an uncertain and risky environment for project developers (Rankin, 2009).

In addition to possibly being held responsible for future liability under the Class VI rule, CCS generators face possible regulation under the Clean Air Act (CAA), the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).[5] Releases of CO2 from reservoirs could implicate the CAA since the EPA recently ruled that CO2 qualifies as a pollutant under this Act and is actively taking steps to regulate the release of CO2 from stationary and mobile sources (Prevention of significant deterioration and Title V greenhouse gas tailoring rule, 2010). It is unlikely that RCRA, which gives EPA the authority to control hazardous waste from its creation to after its disposal, would apply to CCS since under the Class VI rule, CCS could not occur if the injectate was considered hazardous waste (Federal Requirements under the UIC Program for CO2 GS Wells, 2010). CERCLA, however, could be implicated since CERCLA's language is broader. CERCLA allows many of the project proponents to be liable for damages. If there is no existing entity still associated with the project and no responsible party can be found, then under CERCLA, remediation can be accomplished from a general cleanup fund that chemical and petroleum industry members have paid into through annual operation taxes. Whether or not CERCLA is implicated for damages associated with CCS would depend on the purity of the CO2 stream injected; a less pure stream would have a greater chance of being considered a contaminant that would cause CERCLA to be employed. Currently, the Class VI rule does not stipulate the minimum CO2 content of the injectate. Therefore, it is likely that highly impure streams of CO2 could be

[55] If CCS occurred on federal land, then other regulations like the National Environmental Policy Act could be implicated.

injected (as long as they do not qualify as hazardous waste). Also, if the injected $CO_2$ combined with or mobilized hazardous subsurface strata, CERCLA could be implicated. The EPA has determined that it will decide on a case-by-case basis how to handle claims for damages (Rankin, 2009).

*Long-term Liability Instruments*

The types of long-term liability schemes that exist or are contemplated include comprehensive liability funds, funds that cover only monitoring and remediation, total indemnification of a site by the state or federal government, and a three-tiered scheme that blends personal insurance with industry pooling and federal indemnification.[6] As in the previous section, these types of liability schemes will be described and then examples of them will be provided.

Comprehensive Industry-Pooled Liability Funds with State Indemnification

Some experts have suggested the government (or a private entity with government oversight) create a fund that multiple operators would pay into to cover liability rather than use private insurance. This method would pool risk for multiple operations through a required contribution or fee program which would likely be based on the project size and activity expectations (metric tons of $CO_2$ injected). Having operators pay into this fund during operations could promote responsible action if the amount being paid were tied to risk assessments (Interagency Task Force on Carbon Capture and Storage, 2010).

Federal compensation systems built off of basic pooling mechanisms have also been discussed by several authors (Klass & Wilson, 2008; Interagency Task Force on Carbon Capture and Storage, 2010). This program would be modeled after a portion of the Price-Anderson Nuclear Industries Indemnity Act of 1957, which will be described in more detail in the three-tiered liability section, and CERCLA of 1980, which was discussed in the previous section (US EPA, 2008). Under CERCLA, strict, joint, and several liabilities, which could make any of the parties participating in the project potentially responsible for damages to the environment, applies. If none of these entities is found responsible or can be identified and pay, then cleanup is paid for by the fund from the Superfund tax collected from chemical and industrial industries. Alternatively, the industry-pooled fund could be based off the Oil Spill Liability Trust Fund

[6] Other options for insurance schemes used to cover catastrophic events like floods, hazardous waste, and oil pipelines will not be covered because they are already covered in an EPA report and are not perfect corollaries for CCS (EPA, 2008).

(OSLTF), which is funded by a per-barrel tax on petroleum produced or imported in the US (Jacobs & Stump, 2010).

Application of this type of pooling mechanism for CCS has been proposed and would entail the collection of a charge per metric ton of CO2 injected. Alternatively, the fund could be collected based on a fee on all major CO2 emitters, which would involve taxing many entities that do not engage in CCS. This fee would more closely resemble the fee that on-shore petroleum producers pay into the OSLTF since only oil producers that use vessels or deepwater ports would take advantage of the fund (Jacobs & Stump, 2010). Due to the resistance that this type of fund may face, most funds contemplate the collection of fees on a per metric ton injected basis. Most of the proposed pooling plans with comprehensive coverage and state indemnification omit strict, joint, and several liability in order to encourage the CCS industry (Rankin, 2009).

Within the US, six states have also created industry-pooled funds to cover monitoring of sites, and the EU has created a fund to cover liability into the future. However, these schemes differ in coverage and approach, with some states creating a long-term stewardship fund that requires the state to assume only limited long-term liabilities. Other states created a stewardship fund but require the state to assume all long-term liability. It is also interesting to note that in contrast to the states that have created liability schemes, some states like Oklahoma, Utah, Washington, and West Virginia have passed legislation creating state-level permitting for CCS, but these states have refrained from creating any schemes to cover liability. It is possible that these states expect that liability will be covered at the federal level in future years. Even in Wyoming which has a limited liability scheme, former Governor Dave Freudenthal has noted that the federal government will have to "address the long-term liability . . . as no state will be able to assume the risk" (Freudenthal, 2008).

North Dakota

North Dakota has created two funds for geologic sequestration, one for administrative expenses during site operation, and the other for long-term site management (North Dakota SB 2095 §38-22-14 & 38-22-15, 2009). The short-term site management fund is reserved for "defraying the commissions' expenses in processing permit applications; regulating storage facilities during their construction, operational, and preclosure phases; and making a storage amount determination" (North Dakota SB 2095 §38-22-15(2), 2009). The long-term site management fund is broadly authorized to cover "expenses the commission incurs in long-term monitoring and management of a closed storage facility" (North Dakota SB 2095 §38-22-14(2), 2009). The short-term fund requires operators to pay $.01/metric ton injected while the long-term fund requires $.07/metric ton injected (North Dakota Industrial Commission, 2010). The state explicitly takes on all long-term liabilities by acquiring title to the injected CO2 and the storage facility: "Title acquired by the state includes all rights and interests in, and all responsibilities associated with, the stored carbon dioxide." The legislation also releases the operator from all regulatory responsibilities (North Dakota SB 2095 §38-22-17(6), 2009). North Dakota legislation adds the caveat that the state will be responsible for long-term CCS site monitoring and management *just until* the federal government takes responsibility.

Montana

Montana set up a fund for long-term site management with SB 498 in 2009. However, this fund is different from other states in that operators have the option to voluntarily retain long-term liability, in which case they are not required to pay into the fund (Montana SB 498 §2, 2009). This fund is broadly authorized to cover monitoring and managing geologic storage reservoirs after the operator has fulfilled all required closure procedures 15 years after injection has stopped, at which point the state takes title. The amount required by operators to be put into the fund has not yet been decided. The state explicitly takes on all long-term liabilities by acquiring title to the injected CO2 and the storage facility: "Title acquired by the state includes all rights and interests in and all responsibilities associated with the geologic storage reservoir and the stored carbon dioxide" (Montana SB 498 §4, 2009). Montana grants the operator a broad release from liability in verbiage that states "the geologic storage operator and all persons who generated any injected carbon dioxide are released from all regulatory requirements and liability associated with the geologic storage reservoir and the stored carbon dioxide" (Montana SB 498 §4, 2009).

EU

Not only do examples of long-term liability instruments that are in use exist in the US, the EU has taken steps to address long-term liability as well. The EU has created a set of rules to guide the injection and storage of CO2 and created a skeleton of a fund and system to cover long-term liability of the site. However, many details of these rules have not been outlined in a detailed way since they will be modified and implemented by national authorities. These rules are laid out in Directive 2009/31/EC (2009) of the European Parliament and of the Council and were created on April 23, 2009. The Directive demands sites be safeguarded during and after operations, but relies heavily on national-level authorities to carry out the enforcement of these safeguards (Official Journal of the European Union, 2009).

The Directive requires that the operator make a post-closure plan that is approved by a national authority. Monitoring must be done during the project by the operator and should be enforced by the appropriate national authority. For post-closure monitoring, the operator should make a financial contribution into a fund that national authorities will use to monitor leakage in the future. The expectation is that the operator pay at least enough into this fund to cover 30 years of monitoring. The EU Directive leaves much of the details about the amount that emitters will pay into the fund and how it will be used up to the national governments (Official Journal of the European Union, 2009). The EU's assumption that monitoring will be carried out by national authorities with proceeds from the fund reflects the fact that the subsurface minerals are owned by the national government of each country.

Liability for environmental damage of protected species, natural habitats, water, and land is not covered specifically by this Directive, but instead is covered under a previous Directive (Directive 2004/35/EC, 2004). Liability for climate change associated with leaked CO2 is covered by the inclusion of storage sites in Directive 2003/87/EC (2003), which requires the surrender of European Union Allowances (EUAs) to repay the leaked amount. If the owner of the site was not able to repay these leaked metric tons because the leak occurred far into the future, then it is possible that the national government would be able to pay for these leaked metric tons and any other damages that occur since the EU Directive does allow liability to be transferred to the national government (Official Journal of the European Union, 2009).

*Industry-Pooled Funds for Long-Term Monitoring and Remediation*

Louisiana, Kansas, Wyoming, and Texas have created stewardship funds to cover limited long-term liability. These funds require CCS operators to pay a certain amount per metric ton of CO2 injected into a general fund that handles the long-term monitoring and liability of sites. Each of these funds covers slightly different aspects of the long-term liability. The likely impact of these funds on the CCS industry is not yet known, but their incomplete nature could lead to litigation and a reluctance of CCS industry members to engage in operations.

Louisiana

Louisiana created a CO2 Geologic Storage Trust Fund with HB 661 in 2009. With the creation of this fund, the state exempts operators and owners whose sites have been closed for ten years and received a completion of injection certificate showing that the site has complied with all permitting and safety requirements from "all liability associated with or related to that storage facility which arises after the issuance of the certificate of completion" (Louisiana HB 661 §1109 (A), 2009). Additionally, the injector and owner are released from performance bonds when they receive their certificate of completion of injection operations. With this exemption of liability, the state assumes ownership of the site. However, the Bill also declares that "the state shall not assume or have any liability by the mere act of assuming ownership of a storage facility" (Louisiana HB 661 §1109(A)(2), 2009). Therefore, by assuming ownership of the site, the state is *only* agreeing to have the site cared for by the CO2 Geologic Storage Trust Fund, which does not provide comprehensive coverage and could be exhausted. In this way, HB 661 creates a liability responsibility vacuum, making it neither the duty of the state nor the owner or operator.

This fund is collected from a monthly fee incurred per metric ton of CO2 injected. The fee amount has not been set since the trust fund has not yet been set up. The injector must pay the fee for a minimum of 120 months; no more than $5 million can be collected from each injector (Louisiana HB 661 §1110 (C), 2009). The fund only provides money for operational and long-term monitoring and repair of mechanical problems with injection wells or other types of leaks (HB 661 §1110 (E), 2009). If damages deplete the fund, future projects may not be covered, but more importantly, the existing project has no other recourse for cleanup funds because the state does not indemnify the project or assume liability if this fund dries up. Furthermore, climate liability for escaped tons of CO2 would not be covered by this fund. The Bill sets civil liability caps for the owner at $250,000 for non-economic losses, except for death and major injury: "Permanent physical or mental injury that prevents independent care and prevents life-sustaining activities" cannot exceed $500,000. However, after ownership has been transferred to the state for the post-closure time frame, it is unclear where payments for this type of tort liability would come from since the state can only pay for mechanical repair and monitoring from the fund and assumes no responsibility for civil or climate liability.

Kansas

With HB 2419 passed in 2007, Kansas created the Carbon Dioxide Injection Well and Underground Storage Fund, to be used for expenses related to GS site permitting, regulatory oversight, enforcement, as well as long-term monitoring and remediation. The Kansas Corporation Commission (KCC) set fees for this fund at $.05/metric ton injected (Carbon Dioxide Storage Facilities, 2010). The KCC is allowed to subject properties and facilities to this fund in order to prevent the release of CO2, which incurs a penalty of $10,000 per violation per day under the Carbon Dioxide Reduction Act (Kansas HB 2419 §3, 2007).

Further details regarding the extent of liability transfer to the state and what the fund will cover are unclear as the remainder of HB 2419 has no mention of liability and instead covers accelerated depreciation for CCS equipment and exemptions of property taxes for landowners who have CCS operations on their property. The draft of HB 2419 in July of 2009 proposed that after the state approves post-closure status, "any financial assurance instrument maintained by the facility operator shall be released . . .[and] Any future remediation or monitoring activities will be performed by the state using funds from the commission's $CO_2$ remediation fund" (Postclosure Determination, 2010). By February 2010 when the rules for the Bill were adopted, this language was omitted. Therefore, it is unclear exactly what the fund covers since it is not specified in HB 2419, and it is not explicitly stated to cover tort, climate, or remediation and monitoring.

Wyoming

In 2010, Wyoming passed HB 17, which created the Geologic Sequestration Special Revenue Account, which is for the measurement, monitoring and verification of geologic sequestration sites following site closure certification (Wyoming HB 17 §1, 2010). The fee per metric ton injected has not yet been decided. Despite Wyoming's creation of this fund, HB 17 states, "The existence, management and expenditure of funds from this account shall not constitute a waiver by the state of Wyoming of its immunity from suit, nor does it constitute an assumption of any liability by the state for geologic sequestration sites" (HB 17 §1(d), 2010). This ambiguous statement seems to leave liability in question since the State of Wyoming takes over some monitoring of the site, but neither assumes nor releases operators from any liability. And, the state does leave open the possibility that it could be sued for damages resulting from CCS.

Texas

Texas created a fund for long-term stewardship for on-shore geologic sequestration sites in 2009 with SB 1387 and designated the Railroad Commission as the entity in charge of adopting the rules and procedures for this fund (Texas SB 1387, 2009); see Table 1 for fees and structures for selected states. The Anthropogenic Carbon Dioxide Storage Trust Fund is authorized to pay for expenses related to CCS site permitting, regulatory oversight, enforcement, as well as long-term monitoring and remediation of mechanical leaks. Interestingly, the fund also covers technology transfer of CCS and compliance and enforcement of well operations. Fees for this fund are to be determined by rule-making procedures. Rules may flesh out details regarding long-term site management and whether or not the fund could cover unintended migration of $CO_2$ (Texas, 2010). A preliminary report on SB 1387 will address the "allocation of long-term liability for the post-operational phases of geologic storage projects" (Texas, SB 1387 §10 (c)(5)(B)). At this point, however, the long-term civil and climate liabilities remain unaddressed.

Long-term stewardship for off-shore CCS sites that are within 12 miles of the coast and still within the territory of Texas are covered by SB 1796 (2009). Under this Bill, the state, specifically the School Land Board, would be the owner of offshore CCS sites, and is authorized to operate the site and set fees for $CO_2$ storage. The producer of the $CO_2$ holds title to the injected $CO_2$ until the state certifies that storage is permanent, at which point the state takes title. The Bill specifies that "the transfer of title to the state . . . does not relieve a producer of carbon dioxide of liability for any act or omission regarding the generation of stored carbon dioxide performed before the carbon dioxide was stored," such as when the CO2 traveled to the site in a pipeline (Texas SB 1796 §382.508, 2009). However, "the producer of the carbon dioxide is relieved of liability for any act or omission regarding the carbon dioxide in the carbon dioxide repository" (Texas SB 1796 §382.508, 2009). It is interesting to note that while the state of Texas does not assume ownership of the stored CO2 or provide comprehensive liability for on-shore CCS sites through SB 1387, it does assume this responsibility and liability for off-shore sites through SB1796.

**Table 1. Fees to State Geological Sequestration Funds**

| State | Application fee | Annual fee | Per ton fee |
|---|---|---|---|
| Louisiana[1] | | | Not to exceed ($5 million/120 months)/volume injected |
| Kansas[2] | $4,500 + $100/well | $1,000/well | $0.05/metric ton CO2 |
| Texas[3]* | $75,000 | $50,000 for each year post-injection and pre-closure | $0.10/metric ton CO2 |
| North Dakota[4] – admin fund | | | $0.01/metric ton CO2 |
| North Dakota[4] – long-term fund | $150 + actual processing costs | | $0.07/metric ton CO2 |

[1] H.B. 661 §1109 (La 2009).
[2] H.B. 2419 § 3 (Ks 2007).
[3] S.B. 1387, 81st Gen. Sess. (Tx 2009).
[4] S.B. 2095, 61st Leg., Gen. Sess. (ND 2009)

*Indemnification*

In order to promote CCS, some states have offered to provide indemnification of liability. In the US, the states of Texas and Illinois both offered this luxury for the FutureGen project proponents as they competed for federal funding. Through legislation, the State of Texas offered to transfer the property rights of the CO2 from the operator to the state and then exempt the project from tort liability. Subsequently, the State of Illinois passed legislation that involved the transfer of title of CO2, the purchase of third party insurance for long-term storage if available, and indemnification for the FutureGen operator (Klass & Wilson, 2008).

The government of Alberta has taken this concept even further by assuming long-term liability for *all* CCS sites (Brooysman, 2010). This blanket assumption of liability in Alberta may have seemed logical to Albertans since the Crown owns all subsurface minerals.

This type of liability assumption in the US, however, is likely to only be offered for only a discreet number of demonstration projects in order to stimulate the industry. It is not likely to provide a means for long-term support of the industry.

*Three-Tiered Liability*

The EPA has considered a three-tiered CCS liability proposal, much like the Price-Anderson Nuclear Industries Indemnity Act of 1957 for nuclear facilities (Interagency Task Force on Carbon Capture and Storage, 2010). The Price-Anderson Act was created in the late 1950s as a method to incentivize private development of nuclear power while still providing adequate compensation for public damages from accidents tied to the industry. The nuclear developers' concerns in the 1950s were similar to those of CCS developers today; the available insurance offerings did not seem adequate to cover catastrophic events, and therefore developers were wary of entering into contracts to begin activities with potentially high financial risks (Indemnification and limitation of liability, 2005).

To evaluate analogs between the commercial nuclear power industry and a fledgling CCS industry, it is important to discuss operations, insurance, waste storage and overall liability for the nuclear industry. The nuclear industry and federal government (and public) have a segmented liability system. Price-Anderson is largely an industry-funded system with government backstopping, and long-term high level waste disposal is the responsibility of the federal government. Nuclear reactor owners are required to carry two types of insurance: onsite property insurance supplied by Nuclear Electric Insurance Limited (NEIL), and off-site Price-Anderson liability insurance supplied by American Nuclear Insurers. By rule, operators must carry at least $1.06 billion of onsite property insurance. In reality NEIL has two levels of coverage, with one being less than the minimum required so operators need to purchase both levels or $2.75 billion per occurrence in property coverage. This ensures that owners can stabilize and decontaminate a reactor site in the case of an accident (Faure & Vanden Borre, 2008).

According to the Nuclear Regulatory Commission (2011), Price-Anderson provides liability insurance for incidents that may occur

> in the course of transporting nuclear fuel to a reactor site; in the storage of nuclear fuel or waste at a site; in the operation of a reactor, including the discharge of radioactive effluent; and in the transportation of irradiated nuclear fuel and nuclear waste from the reactor.

The liability premiums are calculated and collected against nuclear reactors; all 104 operating commercial power reactors in the US are participants in the program. The amount of coverage required is different for reactors that operate below and above a 100 Megawatt Electric (MW) cutoff in size (Holt, 2011). Average premiums range from $800,000 to $1 million per site annually (US NRC, 2011; Kane, 2011), depending on the reactor technology and particulars of the plant design and location.

Finally, under the Nuclear Waste Policy Act of 1982 and as amended in 1987, the Department of Energy is responsible for the design, siting, construction, and operation of a high level waste storage facility (US NRC, 2007). In effect, it is the federal government's ultimate responsibility for long-term liability once the waste is stored or taken off-site from the power plant. The facility and disposal are largely paid for by the commercial power industry and the consumers of electricity it produces,[7] through a one-tenth of one cent fee per kilowatt hour of electricity produced (Nuclear Energy Institute, 2011). The federal government's failure to license and complete the facility at Yucca Mountain is instructive for proposed CCS regimes because the federal government, and thus the public, now has a massive financial liability without adequate storage and disposal.

The Price-Anderson Act involves a shared liability between the operator and general public, which may be more palatable than full federal or state assumption of liability for CCS, especially since CCS will require many sites and not just one or a few sites as with nuclear power. Nuclear generators pay for insurance that is capped at $375 million total liability per facility. If an accident depletes the individual plant insurance (the first tier of insurance), then the pooled-industry fund that totals $12.2 billion is tapped. This Fund is collected after the accident from each of the operating plants through "retrospective premiums," which the operators pledge to pay to American Nuclear Insurers through vehicles such as bonds, letters of credit, revolving

[7] High level waste is also produced by the Department of Defense, which contributes to the fund.

loans, or escrow deposits of government securities (Faure & Vanden Borre, 2008). Each plant must pay $17.5 million per year up to a maximum of $119 million per incident into this Fund if needed (Indemnification and Limitation of Liability, 2010; Inflation Adjustment to the Price-Anderson Act, 2008). Finally, if this Fund is depleted, then the federal government assumes liability and indemnifies the operator (US EPA, 2008).

This three-tiered liability places some responsibility on the individual operator and then shares responsibility with the industry as a whole. This scheme has the advantage that it creates a type of peer pressure on both the operator and the industry as a whole to be responsible (Rankin, 2009). This approach may betailored for CCS since the appropriate minimum amount of insurance purchased may be contingent upon the amount of CO2 injected in the site. So, instead of requiring all facilities to purchase the mandated level of $375 million in insurance as occurs in the nuclear industry, perhaps for CCS the amount of insurance purchased could be directly proportional to the amount of CO2 injected and/or an assessment of the reservoirs suitability, or have a similar cutoff between large and small sites as nuclear does with the 100 MW size. In addition, the premium cost structure might differ for the same required amount of insurance, depending on the volume injected. Likewise, instead of having industry participants pay retroactively for accidents that occur, perhaps a fee per metric ton as have been enacted by state-level laws should be collected so that the Fund could accumulate over time, even after CCS operators retire. A fund that accumulates in this way could help pay for on-going maintenance and remediation, and it is very similar to the fee the nuclear industry pays for development of the permanent disposal site.

Due to the differences between CCS and the nuclear industry, there are some pitfalls of this system that need to be addressed. Commercial nuclear power reactors usually have a permitted operating life of 40 years (Webster & LeMense, 2009), with up to a 20-year relicensing extension, and nuclear operators can therefore hold an insurance policy that covers this length of time. Furthermore, the insurance pools for property and liability insurance are tied together. The property insurer for nuclear plants is a mutual insurer, or essentially owned by policy holders, and it is reinsured by American Nuclear Insurers, which is the Price-Anderson liability underwriter (Faure & Vanden Borre, 2008). The endless nature of CCS sites poses an issue to the first tier of insurance as the operator may not be an eligible liable entity since he and his insurance plan will not persist well into the future. Furthermore, as shown by the section in this paper on private insurance, carriers are hesitant to take on long-term risks.

The second downfall of this approach is that the buildup of an industry fund to cover disasters may not be achieved in the short term and is highly dependent on how many CCS projects are created. Therefore, this three-tiered approach will most likely resemble a two-tiered approach in the short term as the federal government would have to provide indemnification after private insurance fails. This drawback also applies to the aforementioned comprehensive liability funds in Montana and North Dakota.

Figure 2: Summary of Existing Liability Schemes in the US

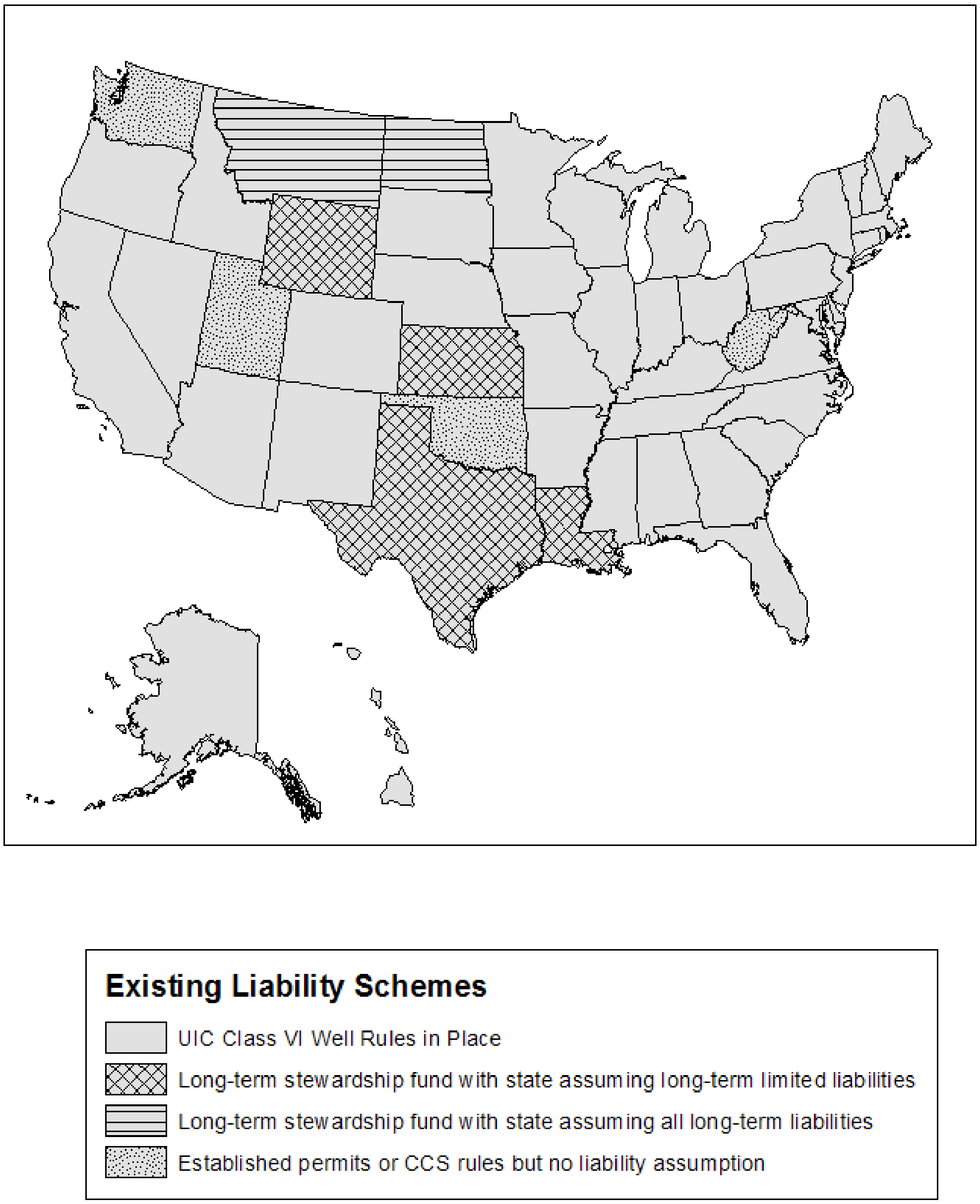
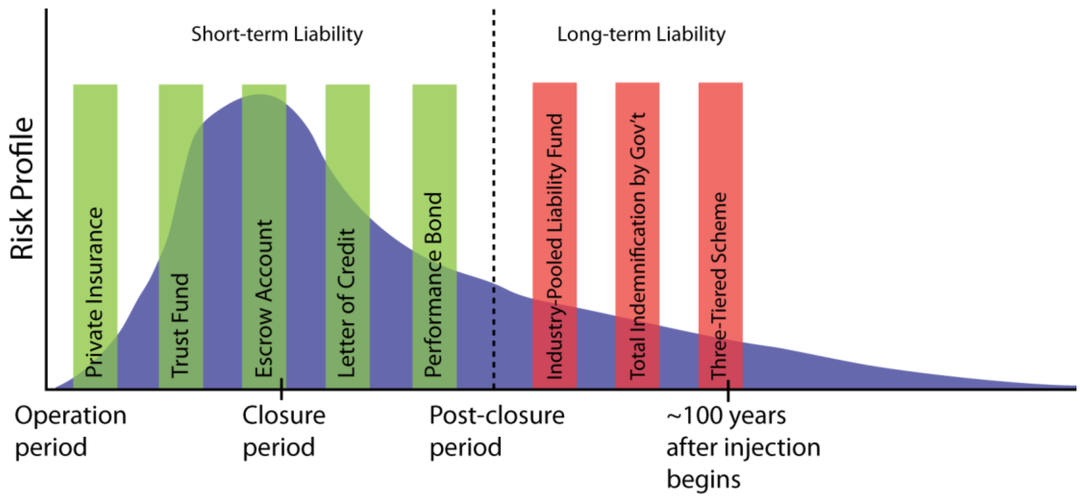


Figure 3: Summary of Short and Long-Term Liability Schemes (Adapted from Wilson et. al, 2007).




**Proposal for a Comprehensive Liability Scheme**

Given the dramatic difference in the amount of risk associated with each stage of CCS, it is only appropriate that different liability schemes be used during these distinct periods. For the operation and closure stage of CCS, a variety of products including private insurance, bonding, trust funds, escrow accounts, and other mechanisms are appropriate. All of these options are possible due to the limited time frame of injection and closure, which could be defined as anywhere between five and 50 years. Because the closure timeframe is short, there is reasonable assurance that the institutions providing the coverage will be in existence throughout the duration of the project, and private insurance companies and traditional financial instruments like escrow accounts, performance bonds, and letters of credit will be able to cover the risk. For this limited timeframe, policies can be put in place that provide recourse action if the institutions fail. The more interesting question arises when one considers what the best long-term liability schemes will be.

*Criteria for Evaluating a Comprehensive Liability Scheme*

Prior to analyzing all liability schemes and recommending any one liability scheme for all stages of the CCS process, it is essential to identify the key features of a preferred comprehensive liability scheme. While these criteria are somewhat arbitrary, the six points described below are what the authors deem most important for a CCS liability scheme. These criteria aim to strike a balance between providing coverage that is as comprehensive as possible and not overly burdening the fledgling CCS industry with cumbersome requirements. Furthermore, these criteria attempt to provide a shared burden of responsibility with the owner/operator, who will benefit from the carbon credit associated with CCS in a carbon-constrained policy environment, and the public, who will both benefit from the decreased CO2 in the atmosphere.

- This scheme should be designed to facilitate commercialization of CCS. If the liability scheme chosen puts too much risk or financial burden on the operator, it is likely to stifle development. If CCS is deemed to be an important solution to climate change, then a goal of the liability approach selected should be to encourage development.
- The approach selected should not overly burden the public by placing all liability on federal or state governments. A scheme of this type would create an unfair subsidy for the CCS industry and could lead to careless practices during injection.
- The scheme should clearly identify liable parties so as to prevent litigation, which could slow cleanup efforts and waste taxpayer dollars.
- Coverage should be complete and comprehensive, encompassing all damages due to escaped metric tons, so as to minimize litigation and lack of full remediation.
- The scheme chosen should encourage operators and the industry as a whole to act responsibly during operations and closure.
- The scheme should have funds readily available when needed so that delays in cleanup or payment for damages do not occur.

*Analysis of Comprehensive Liability Schemes*

Very few of the liability schemes that have thus far been implemented, with the exception of the schemes in Alberta, North Dakota, and Montana, cover long-term liability in a comprehensive way. As a result, these incomplete liability schemes are likely to cause confusion, misunderstandings, and litigation as they are implemented.

The EPA Class VI well rule has a limited scope of liability in that it only covers contaminated groundwater. Damage to vegetation, animals, or induced seismicity is not covered by this rule. And, given the recent allegations of leaked CO2 at the Weyburn site in Canada, which have allegedly caused damage to the flora and fauna of the area, and reports of induced seismicity from injected water and natural gas in Colorado and Alabama, it appears that safeguards to protect more than just underground sources of drinking water are needed (Eddington, 2011;

Johnson, 2009; Robertson, 2011). Furthermore, climate liability for escaped metric tons of $CO_2$, which may qualify as a stationary source of pollution under more stringent future EPA greenhouse gas regulations or comprehensive, federal greenhouse gas legislation, is not addressed by this rule.

The Class VI rule is also arguably flawed in that it leaves much up to the discretion of the EPA Director. Whether or not operators and owners of the site are held liable for a period beyond the 50-year closure period is unclear. And, if owners are held liable for a period beyond the 50-year closure period, under the Class VI rule owners and operators are unable to transfer liability to a third party in the future. This limitation will pose a huge threat to the industry since no owner or operator will want to face the threat of assuming permanent liability for the site. Furthermore, it is up to the discretion of the Director to determine the amount of funding and time necessary to insure the project (Federal Requirements under the Underground Injection Control Program for $CO_2$ Geologic Sequestration Wells, 2010). Both of these unknowns could stymie the CCS industry as developers may be hesitant to invest under these circumstances. In contrast to the EPA Class VI rule, the EU Directive on CCS allows the transfer of authority and responsibility for the site. The EU Directive collects money for future monitoring from operators, creating a sustainable system for funding (Journal of the European Union, 2009).

The liability schemes implemented in Louisiana, Kansas, Wyoming, and Texas fail to provide coverage of civil and climate liabilities. While these states have made efforts to set up funds that cover the monitoring and remediation of CCS sites in the future, these funds do not cover civil or climate liabilities. And, these states have taken differing approaches to the amount of ownership of $CO_2$ and liability they assume. Louisiana has stated in its law that neither the owner nor the state is responsible for the $CO_2$ after closure (Louisiana HB 661 §1109(A)(2), 2009). Kansas's law does not mention transfer of liability or ownership of the $CO_2$ (Kansas HB 2419 §3, 2007). Wyoming claims that the state is neither liable for nor immune from suit for damages from the $CO_2$ in the long-term (Wyoming HB 17 §1, 2010). Texas has assumed liability and ownership of the $CO_2$ from offshore applications, but is silent on this issue for onshore CCS operations (Texas SB 1796, 2009 and Texas SB 1387, 2009).

The liability schemes implemented in Alberta, North Dakota, and Montana involve the state or province taking title to the $CO_2$ and assuming the long-term liability after a designated period of time. North Dakota and Montana have set up funds for long-term management; both of these funds are based on a charge per metric ton of $CO_2$ injected (North Dakota SB 2095, 2009; Montana SB 498, 2009). These schemes are similar to an Interstate Oil and Gas Compact Commission (IOGCC) proposal calling for a 10-year closure period followed by monitoring and remediation with a fund that is generated from payments made by CCS operators (IOGCC, 2007).

While these schemes may be successful at the state and provincial level, assumption of this much liability by the federal government or by other states may not be feasible or desirable. Essentially, the type of fund created by North Dakota and Montana and proposed by the IOGCC has two tiers. The first tier consists of an industry-generated fund with revenues from injectors. If funding from this tier is depleted, then the second tier, which allows the state to indemnify the project and assume all liability, is utilized. Until the first tier has accumulated funds to cover a disaster, this type of liability scheme essentially involves the state assuming all liability for the project and indemnifying it. Similar to full indemnification provided by Alberta, Indiana and Texas for the FutureGen project, this system places a large burden on the public to help subsidize this industry.

These two-tiered proposals mimic a CERCLA post-closure liability fund that was imposed until the mid-1980s. Under this now defunct scheme, hazardous waste disposal operators could apply to have liability and future monitoring and maintenance costs covered by an industry-generated fund, capped at $200 million, after they had operated for 5 years and remained within the confines of their permits. This fund, however, was abandoned in the mid-1980s because it was discovered that there was less incentive for hazardous waste disposal operators to pursue permanent management techniques when they knew that they would not be responsible for the site in the medium- and long-terms (Rankin, 2009). Likewise, the two-tiered state liability schemes that transfer all liability away from the operator too soon after operations or closure may not place enough responsibility on individual site managers and may also fail to adequately incentivize the long-term stewardship of the site. Due to the drawbacks of a two-tiered liability structure, consideration of other schemes is necessary.

*Recommendation for a Homogenous US Comprehensive Liability Scheme*

The three-tiered approach to liability seems to provide the best solution for CCS as it best fulfills the criteria laid out by the authors. These criteria called for a liability scheme that balances comprehensive coverage with the need to allow the CCS industry to grow and shares the responsibility of the site with both the owner/operator and the public, who will both benefit from CCS. Requiring CCS operators to hold private insurance for a specified amount, which may be dependent on the amount of CO2 injected, correctly incentivizes owners to ensure that their operations are safe and prudent. Of course, the problem of how to hold an entity responsible for private insurance far into the future becomes challenging. However, a prescribed number of years on the liability scheme could be defined, and since the risk associated with a site tapers off dramatically after the operations and closure phase (See Figure 1), it may be appropriate and necessary, due to the ability of operators to get a private insurance policy, for the individual insurance plan to be eventually abandoned. Given the nuclear industry's ability to receive insurance for the initial 40 years that plants are permitted, a requirement of private insurance for at least 40 years of CCS project operations should be reasonable. Also, given insurance companies' early interest in insuring CCS operations for short time horizons, the free market will most likely fill the need for this type of policy.

If an operator preferred an escrow account, letter or credit, or other financial instrument to back up his operations and closure, it is possible that this type of insurance could replace private insurance for this time period. However, it is important that some synchronization of expectations on the length and coverage of the insurance policy to cover the pre-operation, operation, and closure time frame be made in order to ensure that the second tier of liability not be tapped into unnecessarily. The exact number of years that an operator must hold this private policy will be up for debate, but it seems likely that it would need to persist at least through pre-operation, operation, and a set amount of time defined as closure. It seems logical that the amount of coverage necessary be correlated to the amount of CO2 injected, but the type of reservoir and its characteristics may also be important in determining coverage details.

The second tier of liability, a shared-pool that covers large-scale disasters that deplete the first tier and ongoing monitoring and remediation of wells, helps encourage industry participants to be prudent in their operations as use of funds from this pool. Poor operation of a site, which leads to a disaster, would taint an operator or industry partner in the eyes of colleagues. The pitfall of this industry-pooled fund not being available until adequate funds have been paid into it is definitely a "chicken-and-egg" problem that can probably only be solved by relying on the federal assumption of liability (the third tier of the scheme) to cover damages that surpass the first tier, or by copying the Price-Anderson scheme where short-term debt instruments collateralize retrospective premiums. Alternatively, the fund could start with an initial minimum balance borrowed by the US Treasury (Jacobs & Stump, 2010). Also, since an operator will not pay into the fund indefinitely, use of this second tier to cover monitoring and remediation costs of old sites necessitates the continued existence of future CCS operators who will pay into this fund.

Finally, the third tier of liability would ideally not need to be used. In the nuclear industry, the second tier of liability was utilized after the Three Mile Island meltdown in 1979 for payouts of $71 million, but the third tier has not ever been utilized, costing the US public nothing (Nuclear Energy Institute, 2010). Therefore, in the long term, this type of liability scheme does not overly burden the public through use of federal funds for cleanup costs that subsidize the industry, provided CCS proves at least as safe as the US nuclear industry. It is possible that if CCS is deemed an inappropriate solution to climate change in the future and there are not future CCS operators who pay into a fund that supports the monitoring and remediation of old sites, then the government may have to assume this financial role with the third tier of liability.

In order for this scheme to be successfully implemented, CCS would probably need to be explicitly exempt from environmental statutes like the RCRA, CERCLA, CAA, and the current Class VI rules under the Safe Drinking Water Act. If it were not exempt from these acts, then there is the possibility that CCS would be subject to multiple liability regimes, and the industry would continue to be stifled. However, despite exemption from these statutes, protection against all possible damages due to CCS (climate change, induced seismic activity, contamination of groundwater, impact on human health or health of flora and fauna, etc.) should be provided by the three-tiered scheme.

**Table 2: Suitability of Three-Tiered Scheme to CCS**

| **Criteria for Successful CCS Liability Scheme** | **Three-Tiered Scheme** |
|---|---|
| Allow for commercialization of CCS | CCS incentivized in same way as nuclear industry |
| Does not overly burden public with costs | Federal government only assumes responsibility if first two tiers depleted |
| Clearly identifies liable parties | All parties clearly identified during each stage of project |
| Complete and comprehensive so as to minimize litigation | Insurance would cover all damages due to deep pockets of federal government |
| Encourages operator to act responsibly during operations | Operator bears part of the insurance burden, and industry as a whole is pressured to act responsibly by their peers |
| Funds available | Personal insurance and federal indemnification used until adequate funds accumulate in the industry pool |

**References**


A.B. 8802 (NY 2009) regarding a pilot program to enable the capture and storage of carbon dioxide. Retrieved from: http://e-lobbyist.com/gaits/text/36382.

The American Law Institute. (1978). Restatement of the Law, Second, Torts § 329, 822.

Barberi, F.; Chelini, W.; Marinelli, G.; Martin, M. (1989).The gas cloud of Lake Nyos (Cameroon, 1986): Results of the Italian technical mission. *Journal of Volcanology and Geothermal Research, 39*(2-3), p.125-134.

Brooymans, H. (2010, November 1) Alberta to assume liability for long-term carbon storage. The Vancouver Sun. Retrieved from: http://www.vancouversun.com/technology/Alberta+assume+liability+long+term+carbon+storage/3761163/story.html

Carbon Dioxide Storage Facilities. Kansas Adm. Reg. 82-3-1100 to 1120. (2010).

de Figueiredo, M. A. (2005). Property interests and liability of geologic carbon dioxide storage. A special report to the MIT Carbon Sequestration Initiative. Retrieved from: http://sequestration.mit.edu/pdf/deFigueiredo_Property_Interests.pdf

Eddington, S. (4 March 2011). 'Fracking' disposal sites suspended, likely linked to Arkansas earthquakes. The Huffington Post. Retrieved from: http://www.huffingtonpost.com/2011/03/06/fracking-arkansas-earthquakes_n_831633.html

Energy Information Administration. (2010a). Annual Energy Outlook with Projections to 2035. Retrieved from: http://www.eia.doe.gov/oiaf/aeo/demand.html.

Energy Information Administration. (2010b). International Energy Outlook 2010. Retrieved from: http://www.eia.doe.gov/oiaf/ieo/emissions.html

Energy Information Administration. (2011). Annual Energy Outlook 2011 with Projections to 2035. Retrieved from: http://www.eia.gov/forecasts/aeo/pdf/0383(2011).pdf

Environmental Protection Agency (2008). Approaches to Geologic Sequestration Site Stewardship After Site Closure. Office of Water. EPA 816-B-08-002. Retrieved from:

http://www.epa.gov/ogwdw000/uic/pdfs/support_uic_co2_stewardshipforsiteclosure.pdf

Faure, M., & Vanden Borre, T. (2008). Compensating nuclear damage: a comparative economic analysis of the U.S. and international liability schemes. *William & Mary Environmental Law & Policy Review , 33* (1), 219-287.

Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO2) Geologic Sequestration (GS) Wells, 75 Fed. Reg. 77230, (2010) (to be codified at 40 C.F.R. pt. 124, 144, 145, 146, and 147.

Fesmire, M.E.; Rankin, A.; Brooks, D.; & Jones, W.V. (2007). A blueprint for the regulation of geologic sequestration of carbon dioxide in New Mexico. New Mexico Energy, Minerals, Natural Resources Department, Oil Conservation Division. Pursuant to Exec. Order. 2006-69. Retrieved from: http://www.gwpc.org/e-library/documents/co2/Mark%20Fesmire.pdf

Flatt, V. B. (2009). Paving the legal path for carbon sequestration from coal. *Duke Environmental Law & Policy Forum 19*, p. 211-246.

Freudenthal, D. (2008). Carbon Sequestration: A Lawyer's Cornucopia or Pandora's Box? *Wyoming Lawyer Review, 31* (1).

Garner, B. A. (Ed.). (2004). *Black's Law Dictionary* ($8^{th}$ ed.). Thompson-West Publishers.

Geistfeld, M. (1998). Should enterprise liability replace the rule of strict liability for abnormally dangerous activities? *UCLA Law Review* 45, p. 611. Retrieved from LexisNexis 11 Feb 2011.

Gresham, R. L., McCoy, S. T., Apt, J., & Morgan, M. G. (January 01, 2010). Implications of compensating property owners for geologic sequestration of CO2. *Environmental Science & Technology, 44,* 8, 2897-903.

Healy, J.H.; Rubey, W.W.; Griggs, D.T. & Raleigh, C.B. (1968). The Denver Earthquakes. *Science 161*(3848), p. 1301-1310.

H.B. 461 §1109 (La 2009). Conservation: Provides with respect to the geological sequestration of carbon dioxide, Cessation of storage operations; liability release. Retrieved from: http://www.legis.state.la.us/billdata/streamdocument.asp?did=659193

H.B. 2419 § 3 (Ks 2007). Carbon Dioxide Reduction Act. Retrieved from: http://www.kansas.gov/government/legislative/bills/2008/2419.pdf

H.B. 17 § 1, 60th Gen. Sess. (Wy 2010). Geologic sequestration special revenue account. Retrieved from: http://legisweb.state.wy.us/2010/Enroll/HB0017.pdf

H.B. 0057, 60th Leg., Gen. Sess. (Wy. 2009) provides amendment to W.S. 34-1-152 (e) Ownership of pore space underlying surfaces. Retrieved from: http://legisweb.state.wy.us/2009/Enroll/HB0057.pdf.

H.B. 0058, 60th Leg., Gen. Sess. (Wy. 2009) relating to the responsibilities of injectors and pore space owners. Retrieved from: http://legisweb.state.wy.us/2009/Introduced/HB0058.pdf

H.B. 0080, 60th Leg., Gen. Sess. (Wy. 2009) relating to the unitization of carbon sequestration sites. Retrieved from: http://legisweb.state.wy.us/2009/Bills/HB0080.pdf.

H.B. 0089, 59th Leg., Gen. Sess. (Wy. 2008) relating to the ownership of subsurface pore space. Retrieved from: http://legisweb.state.wy.us/2008/Introduced/HB0089.pdf

H.B. 0090, 59th Leg., Gen. Sess. (Wy. 2008) relating to carbon sequestration, regulation of injection and appropriation. Retrieved from: http://legisweb.state.wy.us/2008/Enroll/HB0090.pdf

H.B. 149, 78th Gen. Sess. (Tx 2009) relating to the ownership of carbon dioxide captured by a clean coal project. Retrieved from: http://www.legis.state.tx.us/tlodocs/793/billtext/html/HB00149F.HTM

H.B. 2860 (WV 2009) relating to regulating the sequestration and storage of carbon dioxide. Retrieved from: http://www.legis.state.wv.us/Bill_Status/bills_text.cfm?billdoc=HB2860%20ENR%20SUB.htm&yr=2009&sesstype=RS&i=2860

Indemnification and Limitation of Liability, 42 U.S.C. § 2210 (2010). Retrieved from: http://www.law.cornell.edu/uscode/42/usc_sec_42_00002210----000-.html

Inflation Adjustment to the Price-Anderson Act Financial Protection Regulations, 73 Fed. Reg. 56451, (2008) (to be codified at 10 C.F.R. pt. 140).

Interagency Task Force on Carbon Capture and Storage. (2010). Report of the Interagency Task Force on Carbon Capture and Storage. Retrieved from: http://www.epa.gov/climatechange/policy/ccs_task_force.html

Intergovernmental Panel on Climate Change (IPCC). (2005). Special Report on Carbon Dioxide Capture and Storage. Edited by Bert Metz, Ogunlade Davidson, Heleen de Coninck, Manuela Loos & Leo Meyer. Cambridge University Press, UK. pp. 431.

International Energy Agency Greenhouse Gas Research and Development Programme. (2010). Weyburn Enhanced Oil Recovery Project. Retrieved from: http://www.co2captureandstorage.info/project_specific.php?project_id=70

Interstate Oil & Gas Compact Commission. (2007). CO2 Storage: A legal and regulatory guide for states. Retrieved from: http://iogcc.myshopify.com/collections/frontpage/products/co2-storage-a-legal-and-regulatory-guide-for-states-2008

Jacobs, W. & Stump, D. (2010). Proposed Liability Framework for Geological Sequestration

of Carbon Dioxide. Emmett Environmental Law and Policy Clinic and Harvard Law School. Retrieved from: http://www.law.harvard.edu/programs/about/elp/ccswhitepaper.pdf

Johnson, K. (12 June 2009). Quake zone: The natural gas industry's big fracking problem. The Wall Street Journal- Environmental Capital Blog. Retrieved from: http://blogs.wsj.com/environmentalcapital/2009/06/12/quake-zone-the-natural-gas-industrys-big-fracking-problem/

Kane, B. (2011, March 21). Glastonbury insurer of nuclear plants sees no exposure in Japan tragedy. *Hartford Business Journal Online*.

Klass, A.B. & Wilson, E.J. (2008). Climate change and carbon sequestration: Assessing a liability regime for long-term storage of carbon dioxide. *Emory Law Journal 58*, p. 108-180.

Klass, A.B. & Wilson, E.J. (2009). Carbon capture and sequestration: Identifying and managing risks. *Issues in Legal Scholarship 8*(3). (Balancing the risks: Managing technology and dangerous climate change).

Knott, T. (2008). Sealed under the Sahara. *Frontiers, 23*. Published by BP Global online at: http://www.bp.com/sectiongenericarticle.do?categoryId=9027098&contentId=7049642

Manchisi, F. P. & Gallagher, L. E. J. (2006). A Nationwide survey of statutes of repose. Produced by Wilson, Elser, Moskowitz, Edelman, & Dicker LLP. Retrieved from: http://www.wilsonelser.com/files/repository/NatlSurveyRepose_March2006.pdf

National Energy Technology Laboratory. (2009). Storage of captured carbon dioxide beneath federal lands. DOE/NETL-2009/1358. Retrieved from: http://www.netl.doe.gov/energy-analyses/pubs/Fed%20Land_403.01.02_050809.pdf

Nuclear Energy Institute. (2011). Key issues: repository development. Retrieved from http://www.nei.org/keyissues/nuclearwastedisposal/yuccamountain/

Nuclear Energy Institute. (2010). Price-Anderson Act provides effective liability insurance at no cost to the public. Retrieved from: http://nei.org/resourcesandstats/documentlibrary/safetyandsecurity/factsheet/priceandersonact/

North Dakota Industrial Commission, Department of Mineral Resources, Oil and Gas Division

Rules and Regulations. (2010). 43-05-01-17. Storage Facility Fees. Retrieved at: https://www.dmr.nd.gov/oilgas/rules/rulebook.pdf

Official Journal of the European Union. (13 October 2003). Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 on establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. Retrieved from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:275:0032:0032:EN:PDF.

Official Journal of the European Union. (21 April 2004). Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage. Retrieved from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0035:EN:NOT

Official Journal of the European Union. (6 May 2009). Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/ 2006. Retrieved from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF

Office of Indian Energy and Economic Development. (2011). Geologic sequestration of carbon dioxide: Sequestration process and geologic reservoirs. Retrieved from: http://teeic.anl.gov/er/carbon/apptech/geoapp/index.cfm

Pacala, S. & Socolow, R. (2004). Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. *Science 305*: 968-972.

Percival, R.V.; Schroeder, C.H.; Miller, A.S. & Leape, J.P. (2009). Environmental Regulation: Law, Science and Policy (6th ed.). New York: Aspen Publishers.

Petro-Find Geochem, Ltd. (2011). Geochemical soil gas survey. A site investigation of SW30-5-13-W2M. Weyburn Field, Saskatchewan. Retrieved from: http://www.ecojustice.ca/media-centre/media-release-files/petro-find-geochem-ltd.-report/at_download/file

Pollak, M.; Gresham, R. L.; McCoy, S.; Phillips, S. J. (2010, May 10). State regulation of geologic sequestration: 2010 Update. Lecture presented at Hilton Pittsburgh/David L. Lawrence Convention Center, Ninth Annual Conference on Carbon Capture & Sequestration. Pittsburgh, Pennsylvania.

Postclosure determination. Kansas Adm. Reg. 82-3-117 (d). (2010).

Prevention of significant deterioration and Title V greenhouse gas tailoring rule. 75 Fed. Reg. 31514 (2010) (to be codified at 40 C.F.R. pt, 51, 52, 70, and 71. Retrieved from: http://www.gpo.gov/fdsys/pkg/FR-2010-06-03/pdf/2010-11974.pdf#page=1

Ragsdale, T. D. (1993). *Hydraulic Fracturing: The Stealthy Subsurface Trespass*, 28 TULSA L.J. 311, 344-46. (quoting Osborne M. Reynolds, Jr., *Distinguishing Trespass and Nuisance: A Journey Through a Shifting Borderland*, 44 OKLA. L. REV. 227 (1991)).

Rankin, A. G. (2009). Geologic Sequestration of CO2: How EPA's proposal falls short. *Natural Resources Journal, 49*, p. 883-942.

Robertson, C. (4 March 2011). Waste Wells to be closed in Arkansas. *The New York Times*. Retrieved from: http://www.nytimes.com/2011/03/05/us/05fracking.html?_r=1&ref=earth

S.B. 145, 49th Gen. Sess. (NM 2010) regarding ownership of pore space. Retrieved from: http://www.nmlegis.gov/lcs/_session.aspx?chamber=S&legtype=B&legno=%20%20%20145&year=10

S.B. 610, 52nd Gen. Sess. (Ok 2009). General storage of carbon dioxide act – Create. Retrieved from: http://www.statesurge.com/bills/sb610-oklahoma-571159

S.B. 1387, 81st Gen. Sess. (Tx 2009). relating to the implementation involving the capture, injection, sequestration, or geologic storage of carbon dioxide. Retrieved from: http://www.legis.state.tx.us/billlookup/Text.aspx?LegSess=81R&Bill=SB1387

S.B. 1796 §382.508 (Tx 2009). Texas Health and Safety Code- Offshore geologic storage of carbon dioxide. Retrieved from: http://www.legis.state.tx.us/tlodocs/81R/billtext/html/HB01796F.HTM

S.B. 2095, 61st Leg., Gen. Sess. (ND 2009) relating to the geologic storage of carbon dioxide. Retrieved from: http://www.legis.nd.gov/assembly/61-2009/bill-text/JQTA0300.pdf

S.B. 498, 61st Leg., Gen. Sess. (Mt 2009) relating to permitting for carbon dioxide injection wells. Retrieved 11/18/10 from: http://data.opi.mt.gov/bills/2009/BillPdf/SB0498.pdf

S.B. 2139, 61st Leg., Gen. Sess. (ND 2009) relating to the ownership of subsurface pore space. Retrieved from: http://www.legis.nd.gov/assembly/61-2009/bill-text/JQTB0400.pdf

S.B. 775, 95th Leg., Gen. Sess. (Mi 2009) regarding carbon sequestration fees and liability waivers. Retrieved from: http://www.legislature.mi.gov/documents/2009-2010/billintroduced/Senate/pdf/2009-SIB-0775.pdf

Sminchak, J.; Gupta, N.; Byrer, C. & Bergman, P. (2002). Issues related to seismic activity induced by the injection of CO2 in deep saline aquifers. Retrieved from: http://www.netl.doe.gov/publications/proceedings/01/carbon_seq/p37.pdf

The Texas General Land Office, The Railroad Commission of Texas, The Texas Commission on Environmental Quality, The Bureau of Economic Geology. (2010). Injection and geologic storage regulation of anthropogenic carbon dioxide: A preliminary joint report to the legislature required under Sections 9 and 10 of SB 1387, 81st Leg, 2009. Retrieved from: http://www.rrc.state.tx.us/forms/reports/notices/SB1387-FinalReport.pdf

United States Department of Energy. (2011). Enhanced Oil Recovery/ CO2 Injection. Retrieved from: http://www.fossil.energy.gov/programs/oilgas/eor/index.html

United States Environmental Protection Agency. (2008). Approaches to geologic sequestration site stewardship after site closure. Retrieved from: http://www.epa.gov/ogwdw/uic/pdfs/support_uic_co2_stewardshipforsiteclosure.pdf

U.S. NRC. (2011, June). Nuclear Insurance and Disaster Relief Funds: Fact Sheet. U.S. Nuclear Regulatory Commission.

U.S. NRC. (2007, April). Radioactive Waste: Backgrounder. U.S. Nuclear Regulatory Commission.

Webster, R. & LaMense, J. (2009). 40 Years and Counting: Relicensing the First Generation of Nuclear Power Plants: Spotlight on Safety at Nuclear Power Plants: The View from Oyster Creek. *Pace Environmental Law Review 26*(2), p. 365-390.

Wilson, E. J. (2005). Subsurface property rights: Implications for geologic CO2 sequestration. In Tsang, C.F & Apps, J. A. (Eds.), Underground Injection Science and Technology. Developments in Water Science, 52 (pp. 681-693). Elsevier Science. Amsterdam; Boston: pp. 730.

Wilson, E.J.; de Figueiredo, M.A.; Trabucchi, C.; Larsen, K. (2007). Liability and financial responsibility frameworks for carbon capture and sequestration. World Resources Institute Issue Brief, Carbon Capture & Sequestration, 3. Retrieved from: http://pdf.wri.org/liability-and-financial-responsibility.pdf.

Zurich creates two new insurance policies to support greenhouse gas mitigation technologies, addressing the unique needs of carbon capture and sequestration. (2009, January 19). Business Wire. Retrieved from: http://www.businesswire.com/news/home/20090119005535/en/Zurich-creates-insurance-policies-support-green-house

**Appendix 1**

*Liability at the State Level*

Most environmental liability issues are addressed at the state level, and standards for assessment of damages vary with location and historical land uses. This appendix provides details on how CCS liability could be implicated at the state level based on various claims.

Obtaining property rights to set up a CCS project will include gaining rights to not only the area planned for injection wells and other surface facilities but also rights-of-way for pipelines, offsite areas to monitor groundwater and plume movement, and possibly additional access routes to injection or monitoring sites. Pore space ownership (whether geologic formations or saline storage areas) is likely the most complicated of the property rights issues and varies on a state-by-state basis; decisions about sub-surface pore space designation are left up to legislatures or may be settled in court if states do not take action (Wilson, 2005). Some states[8] have taken early action in defining property rights under their jurisdiction in terms of pore space ownership, unitization rules, and eminent domain issues (Interagency Task Force on Carbon Capture & Storage, 2010).

Rights to elements such as gas, water, and oil have often been compared to those of wild animals, which move freely. Some states originally set precedents for "fugitive resources" by only permitting ownership of a subsurface element if it was captured in aboveground storage containers; however, ownership was lost upon reinjection when the elements could freely move under other property ownerships, especially in the case of gas (Klass & Wilson, 2008). Most states have established rulings through court cases[9] that if a gas is injected into an underground reservoir of known size and integrity that the owner of the space and injected gas maintains ownership of the gas and is responsible for its accompanying liability (de Figueiredo, 2005). A major concern for many constituencies has been the idea of gas migrating outside of the pore space it was injected into and causing damages by changing pressure gradients resulting in ground heave, polluted drinking waters, migration of saline water into aquifers, or release of CO2 into the atmosphere (Flatt, 2009). The remainder of this appendix will address the specific ways in which various laws can be implicated during CCS operations.

Injection wells have been used in the United States for a number of different applications ranging from the storage of natural gas to the disposal of hazardous waste. However, a

[8] Oklahoma SB 610, 2009; North Dakota SB 2139; Montana SB 498; Louisiana SB 1117; Texas HB 149; West Virginia SB 2860; Wyoming HB 57, 58, 80, 89, and 90; Michigan SB 775; New Mexico SB 145; and New York AB 5836 and 8802.

[9] *White v. New York State Natural Gas Co.*, 190 F. Supp. 342 (Pa. 1960); Lone Star Gas Co. v. J. W. Murchison, 353 S.W.2d 870, 879 (Tex. 1962).

comprehensive knowledge of the migration of gases and fluids and monitoring system for the subsurface geology are still developing. **Trespass** or the "intentional and unprivileged use or other invasion of another person's real property" (The American Law Institute, Restatement of Torts §329, 1978) is one of the most common claims against injectors by their neighbors. Courts have had difficulty defining subsurface property lines and have placed the burden of proof on the plaintiff to show that trespass has interfered with a reasonable use of the plaintiff's land, including the surface or perhaps subsurface minerals (Klass & Wilson, 2008). Because trespass is a common law issue, it will likely be dealt with at the state-level, and some states may contest that the benefits of CCS outweigh any losses caused by trespass, especially in cases where trespass is difficult to prove. The Restatement of Torts §822 (The American Law Institute, 1978) states "liability is imposed only in those cases where the harm or risk to one is greater than he ought to be required to bear under the circumstances, at least without compensation."

**Nuisance** is a common law occurrence very similar to trespass except it is meant to protect the "invasion of interests in the use and enjoyment of land" (Percival et. al., 2006) and is not based on actual encroachment of the land. Nuisance law is the basis of most environmental law where members of the public can claim that industrial/commercial activities are causing a significant harm to an interest the public has to a right to such as air, water, soil, etc. (Klass & Wilson, 2008). Similar to trespass cases, the court is often presented with a case that requires a cost/benefit analysis of the two interests or activities in question. At times, even lawful activities can result in nuisance cases because of unexpected externalities. In CCS, leakage of CO2 could incite a nuisance claim if CO2 seeped into a neighboring landowner's subsurface land. Both trespass and nuisance claims will likely result in some form of payment either for restoration costs or loss of property value (Flatt, 2009; de Figueiredo, 2005).

**Negligence** is "the failure to exercise the standard of care that a reasonably prudent person would have exercised in a similar situation; any conduct that falls below the legal standard established to protect others against unreasonable risk of harm, except for conduct that is intentionally, wantonly, or willfully disregardful of other's rights" (Garner, 2004). Causes of negligence that might be brought before a court for CCS could include improper identification of a geological storage formation that resulted in leakage, ground upheaval, or other damages or poorly installed injection well sites. Again, the burden of proof lies with the plaintiff in these cases and information on the siting of a CCS site or injection well may be difficult to obtain. Many plaintiffs bring cases to court as instances of trespass, especially in the case of subsurface issues, because they are more likely to receive damage costs than in negligence cases (Ragsdale, 1993).

**Strict liability** is for abnormally dangerous activities and implies legal responsibility of an entity for any harm that comes from their actions, even if the activity is carried out under the "standard of reasonable care and violated no regulations" (Fesmire et. al., 2007, p.60). This "harsh" standard requires that any harm caused by an activity be paid for by the entity responsible. Some courts support strict liability as the only reasonable method to employ claiming, the defendant has engaged in an activity for profit and is therefore in the best position to bear the loss (Geistfeld, 1998). Supporters of CCS are leery of absolute liability for CCS, at least in its developmental stages, because they are concerned it will drive away potential operators based on the sheer cost of potential damages.

**Climate liability** is anticipated damage or effects to the climate caused by unexpected emissions from a geologic reservoir created for the storage of carbon (de Figueiredo, 2005). In such a situation, the injector would be obligated to return credits or otherwise compensate the emissions reduction program for leakages in its operations. This form of liability is one of the greatest concerns in implementing CCS on a large scale as it addresses the success of geologic carbon sequestration as a solution to climate change. The US may create programs to limit carbon emissions and improve accounting for storage of CO2 through CCS. Regulators will most likely reward storage capabilities with credits or count emissions sequestered as never released as occurs in the EU (Directive 2003/87/EC); however, CCS enthusiasts are concerned about losses from storage formations and what that could mean not only to carbon accounting but also to the overall goal of mitigating climate change (Rankin, 2009).

Of particular concern for CCS projects is the timing of when one can seek damages or payment for injuries, property remediation, and other costs or losses that are sought through trespass, nuisance, negligence, strict, or future climate liability (Klass & Wilson, 2008). A major concern for any liability scheme being built for CCS is around the issue of **statutes of limitations**, which "bars the plaintiff's action at a specified time period after the cause of action accrues (usually from the plaintiff's knowledge)" (Klass & Wilson, 2008). In other words, this statue limits the amount of time when an entity may sue in a state court for damages caused by the activity, usually between two and six years from the identified cause of action. Because of the extended period of time expected for CCS activities, it is necessary to determine the timing of harm, especially if there are additional impacts occurring from the same incident. The issue of timing is often presented in environmental cases; the results seem to vary by state and on a case-by-case basis depending on whether the court is focusing on the harm and whether it has been abated or if the court considers the event that triggered the harm (Klass & Wilson, 2008). Harm is more likely to be rapidly discovered in a case of negligent well installation or plugging which could have more immediate impacts than in the case of seepage from a geologic formation which has been used for 20 years.

A **statute of repose** is stricter than a statute of limitations because it bars any suit being brought after a specified time period starting at the point of a cause (Garner, 2004). This period generally ranges from four to twenty years in the United States (Manchisi & Gallagher, 2006). The statute of repose limits actions and is in no way based on the occurrence of injury, it differs from other statutes because it is only based on a specific event (such as designing/manufacturing a product) and not on action being brought (Garner, 2004). The most common complaint against the use of the statute of repose is that the defined time period excludes long-term harms that do not take place until after the period has ended, and then it is often not possible for claims to be made. There is no method to extend this time period as in the statute of limitations, which can be extended when additional injury is found or fraud is discovered. The statute of repose extinguishes the cause of action after a defined time period and if harm has not occurred before this point, the plaintiff can make no claim for damages if harm is caused (Klass & Wilson, 2008).

States have the opportunity to use these two different statutes depending on the needs of their industries and citizens (Klass & Wilson, 2008). Although statutes of limitation and repose expire, states have the option of allowing a "**revival statute**" which allows for the renewal of actions or documents that previously expired (Garner, 2004). In the case of CCS, the current legal framework may not be sufficient to field expected claims over the extended time period of CCS implementation.