The Liability of Carbon Dioxide Storage

Mark de Figueiredo[1,2,3], David Reiner[1,4], Howard Herzog[1], Kenneth Oye[1,2,5]

[1]Laboratory for Energy and the Environment, M.I.T., Cambridge, MA 02139, USA

[2]Engineering Systems Division, M.I.T., Cambridge, MA 02139, USA

[3]University of Virginia School of Law, Charlottesville, VA 22903, USA

[4]Judge Business School, University of Cambridge, Cambridge, CB2 1AG, UK

[5]Department of Political Science, M.I.T., Cambridge, MA 02139, USA

Abstract

Widespread deployment of CCS will be contingent on containing liability for carbon dioxide storage. This paper analyzes the *in situ* post-injection liability of CCS, which arises if there is a loss of carbon dioxide containment by the geological formation and harm results to human health, the environment, or property. We begin with an analysis of the basis for carbon dioxide storage liability, the sources of which fall into five categories: toxicological effects, environmental effects, induced seismicity, subsurface trespass, and climate effects. We then consider how liability would be imposed under current public and private liability frameworks in the US. Although the focus of our analysis is the US liability system, our findings are broadly applicable across jurisdictions. Next, we investigate alternative public and private liability frameworks based on activities analogous from technical or regulatory standpoints, including the Alberta acid gas regime and the Price-Anderson nuclear regime. We conclude with a set of suggestions for addressing future carbon dioxide storage liability policy.

Keywords: CO_2, storage, liability, regulation, policy

Introduction

The liability issue for carbon capture and storage (CCS) can be framed in terms of operational liability and post-injection liability [1]. Operational liability includes the environmental, health, and safety risks associated with carbon dioxide capture, transport, and injection. Such risks have been successfully managed for decades in the context of enhanced oil recovery and analogous activities. The analysis of this paper concentrates on the post-injection liability of CCS, which is the liability related to the storage of carbon dioxide after it has been injected into a geologic formation. There are two types of post-injection liability: the *in situ* liability of harm to human health, the environment, and property, and the climate liability related to leakage of carbon dioxide from geological reservoirs and the effect on climate change. Climate liability will be a function of national and international policies enacted to control greenhouse gas emissions. We focus our analysis in this paper on the *in situ* liability issue. In general, post-injection liability presents a unique set of challenges because of the scale of projected carbon dioxide storage activities (estimated by the IPCC Special Report on Carbon Dioxide Capture and Storage to be 103-590 GtC in the time period 2000-2100) [2], the long timeframes over which the risks may manifest themselves, and the uncertainties of the geophysical system. The characteristics pose challenges to a purely private solution to liability.

Basis for Carbon Dioxide Storage Liability

The storage of carbon dioxide in the subsurface raises the issue of potential liability if there is loss of carbon dioxide containment and harm results to human health, the environment, or property. Because of the long time frames expected for carbon dioxide to be stored in the subsurface, it is possible that the risks may manifest themselves after injection operations have ceased. This is mitigated somewhat because the containment of stored carbon dioxide may become safer over time due to geophysical or geochemical trapping mechanisms. If liability is fully borne by the private sector, the potential unbounded liability would make widespread deployment of carbon dioxide storage unlikely. On the other hand, having the public sector bear the financial responsibility for future leakage could affect the precautions taken by storage operators in the near term.

Carbon dioxide storage risks may manifest themselves either due to migration of carbon dioxide within the subsurface or leakage to the surface. Probably the most likely mechanism for loss of containment would be via poorly abandoned wells. Although injection wells abandoned using proper procedures would likely contain the stored carbon dioxide effectively, carbon dioxide could escape through injection wells that have been poorly completed. The IPCC Special Report on Carbon Dioxide Capture and Storage has documented other potential pathways for carbon dioxide release, including leakage through the pores of low-permeability caprocks if the carbon dioxide is injected at too high a pressure, leakage through openings in the caprock, and migration via faults [2].

There are essentially five major categories of risk bearing on carbon dioxide storage liability: toxicological effects, environmental effects, induced seismicity, subsurface trespass, and climate effects. The toxicological effects of carbon dioxide depend on the concentration and duration of exposure. The risk of a catastrophic release of carbon dioxide from a geological formation is unlikely. The accumulation of carbon dioxide in a topographically sensitive area could be a source of concern, but in virtually all cases the released carbon dioxide would be expected to dissipate quickly. Environmental degradation centers on groundwater contamination and the effects of carbon dioxide exposure on the ecosystem. With respect to groundwater contamination, the concern would be acidification due to carbon dioxide coming into contact with groundwater, displacement of brine and brine coming into contact with groundwater, or the mobilization of metals which enter the groundwater supply. With respect to ecosystem effects, although moderately elevated concentrations of carbon dioxide can be beneficial to plant life, the effects of high concentration carbon dioxide exposure are detrimental. Induced seismicity, or the potential for carbon dioxide injection and storage to induce stresses or increase pore pressure sufficient to produce seismic activity has not been observed in connection with CCS, but has been seen in other subsurface injection activities, generally in the form of micro-seismic events in already seismically active areas. Subsurface trespass would take place if the relevant property interests have not been acquired, and the stored carbon dioxide either wrongfully commingled with native substances or took up storage space which could have been used by the rightful property owner. The subsurface trespass issue is a function of the relevant jurisdiction’s property law. Finally, there is the potential that carbon dioxide leakage could harm the climate. Although leakage undercuts the benefits of carbon dioxide storage, studies have shown that storage might still have economic value even if it is only temporary [3]. The liability related to the climate risk is essentially a contractual liability for non-performance.

The risks related to carbon dioxide storage raise a number of legal and policy issues concerning prospective liability. One set of issues deal with the risks themselves. There are uncertainties in the physical system as to how the injected carbon dioxide will behave once it enters the subsurface. There are also questions of general causation, or the capacity of carbon dioxide to harm human health, the environment, or property. Although the risks appear to be small based on experience in analogous subsurface injection operations such as enhanced oil recovery, carbon dioxide storage projects will have larger injection rates and longer time scales for the carbon dioxide to remain in the subsurface. Any strategy addressing liability needs to take into account the current state of scientific knowledge and the potential for knowledge of the risks to change over time.

A second set of issues deal with compensation to victims in the event the risks manifest themselves. With the prospect that carbon dioxide is to remain in the ground for hundreds of years, it is possible that the firms responsible for the storage operation will no longer be in business when the harms occur. Those parties afflicted by the long-term risks could be hard-pressed to find potential defendants or adequate sources of compensation. Even if defendants could be identified, the injured parties may still have difficulties in showing specific causation, or that the defendant's carbon dioxide storage operation caused the particular injuries in question.

Finally, there is the issue of what role governments should play in a liability scheme. CCS will likely not occur without government policies constraining carbon dioxide emissions, perhaps even mandating CCS technologies. The California Public Utilities Commission, for example, is investigating the use of greenhouse gas performance standards for new power plants built in the State of California [4]. Government would essentially be mandating private firms to take actions that confer benefits on the broader public (reducing carbon dioxide emissions), but impose large, long-term private liabilities. Although the public benefit/private liability issues are seen in other areas of public policy, such as in the contexts of hazardous waste or pharmaceuticals, an argument could be made that because government is imposing an additional constraint on industry to act in ways that impose private liability but benefit the public, government should assume some responsibility.

Liability under the Current Regime

Under the current framework, liability could be imposed either through public mechanisms or private mechanisms. In the US, although there is no comprehensive legal and regulatory framework for carbon dioxide storage *per se*, the US Environmental Protection Agency (EPA) has a regulatory framework governing most types of underground injection, the Underground Injection Control (UIC) Program. The UIC Program, created under the federal Safe Drinking Water Act of 1974, was not developed with carbon dioxide storage in mind and the regulatory framework that eventually governs carbon dioxide storage will probably deviate from the current system. However, demonstration projects are being permitted under the UIC Program, and the current regulatory framework will certainly be relied upon heavily in the development of any future permitting system [5].

The UIC Program regulates underground injection under five different classes of injection wells, depending on the type of fluid being injected, the purpose for injection, and the subsurface location where the fluid is to remain. States are allowed to assume primary responsibility for implementing the UIC requirements in their borders, as long as the state program is consistent with EPA regulations and has received regulatory approval. Injection operators are required to provide financial assurance in case they cease operations, with the level of assurance a function of the estimated cost of plugging and abandoning the injection well. If there is a violation of a UIC permit, an enforcement action may be brought by the EPA Administrator or the applicable state agency. Violators may be subject to administrative orders, civil penalties, and criminal penalties. Because of its statutory mandate, the scope of the UIC regime is contamination of drinking water, and under its current application to carbon dioxide storage, the UIC Program gives more limited treatment, if any, to other harms to human health, the environment, and property.

Liability can also be addressed under private litigation mechanisms under the laws of tort and contract.

Examples of potential tort causes of action include trespass, nuisance, negligence, and strict liability. Virtually all of the private litigation concerning analogous subsurface injection activities has involved the subsurface trespass issue. For some of the risks of carbon dioxide storage, proving causation will be difficult. For example, induced seismicity would be more likely to occur in areas that are already seismically active. Even if harm can be attributed to carbon dioxide injection, the private litigation system may not be able to adequately compensate victims whose harms occur far into the future. Storage operators will likely seek to abandon their injection wells after operations have ceased. With respect to future harms, the parties responsible for the carbon dioxide injection in question may not even be in existence, let alone operating carbon dioxide injection wells. Finally, there are issues whether the injured parties could even bring a private litigation suit to begin with because the tort system often has statutes of limitation or statutes of repose, requiring a suit be brought before a certain period of time has elapsed.

In the case of contractual liability on the issue of carbon permits, liability would be premised on there being a legally enforceable storage contract, breach of the contract because some quantity of carbon dioxide escaped from the geological formation, and damages proximately related to the breach (such as a carbon permit's loss in value). Unless the parties bargained on the liability issue *ex ante*, the contractual liability would be a function of the amount of carbon dioxide that escaped and the future price of carbon. Thus the contractual liability determination would depend on there being an effective monitoring system to quantify the extent of carbon dioxide leakage.

Alternative Liability Frameworks

Beyond the current liability regime, CCS liability could be managed by insurance, modifying existing regulation, or enacting specific new legislation. Private insurance operates by risk evaluation, risk transfer, risk spreading, and charging premiums to reflect the level of risk posed. A private insurer may seek to enter into a reinsurance contract, where one insurance company (the reinsurer) charges a premium to indemnify another insurance company against all or part of its potential loss. In certain cases, firms may seek to self-insure their liabilities. In other cases, government has the potential to operate as an insurer or reinsurer. Government may also use legislation or regulation to manage liability, including mandating liability in law or regulation, providing immunity caps, administering compensation funds, exempting certain types of liability, or mandating the taking of actions that have the effect of limiting externalities.

Alberta's liability regime for acid gas injection is a useful framework to consider with respect to alternative liability constructs for CCS. Since 1989, acid gas has been injected into geological formations in Alberta because of environmental regulations governing sulfur emissions. The subsurface injection of acid gas presents liability concerns because acid gas contains hydrogen sulfide, a poisonous, flammable substance. Alberta uses a combination of stringent regulations, continuing liability, financial assurance, and industry pools of funds to address the liability issue. First, before acid gas injection can commence, licensees must comply with rigorous regulatory requirements, including a showing of acid gas containment, reservoir properties, hydraulic isolation, and notification of relevant parties. There are similar requirements for the suspension and abandonment of an injection well, with costs attributable to those owning an interest in the well (known as working interest participants). Second, working interest participants are subject to continuing liability, or responsibility for the control or further abandonment of the injection well even if the well has already been "abandoned". Third, all licensees must report financial information monthly to the Alberta Energy and Utilities Board, which compares the deemed assets and deemed liabilities of the licensee. If the licensee's deemed liabilities exceed its deemed assets under this licensee liability rating system, the licensee must place a security deposit for the difference in the form of cash or a letter of credit meeting regulatory requirements.

Finally, all licensees must pay into an orphan fund, which is used to fund the suspension, abandonment and reclamation of orphan wells.

The Price-Anderson Act, which governs the liability for nuclear power plants in the US, provides another conceptual basis for CCS liability. Price-Anderson was enacted to ensure adequate funds would be available to satisfy liability in case of a catastrophic nuclear accident, and to permit private sector participation in the industry by removing the threat of potentially enormous liability [6] (considerably greater than CCS liability). Price-Anderson supplements US Nuclear Regulatory Commission safety standards that all operators must abide by and limits operator liability. Under Price-Anderson, each nuclear facility is required to have primary insurance in the amount of $300 million per plant, the maximum amount of liability insurance which can be purchased from private sources. In the event of harm exceeding the primary insurance, each facility would be required to acquire secondary insurance in the amount of $15 million per plant per year, up to $95.8 million per incident. The secondary insurance would be pooled among the 104 licensed power plants to create a secondary pool of about $8.6 billion. Insurance is typically purchased through American Nuclear Insurers, an insurance pool of about sixty investor-owned insurance companies. The average annual primary insurance premium for a single nuclear power plant is $400,000 [7]. If damages exceed the primary and secondary insurance, the US Congress is to investigate and take whatever actions it deems necessary. Industry faces no financial responsibility beyond the primary and secondary insurance expenditures.

Suggestions for Future CCS Liability Policy

There appear to be two sources of uncertainty which bear on future CCS liability policy. One source of uncertainty deals with the properties of the physical system and the risks resulting from loss of containment of the carbon dioxide from the geological formation. Our analysis indicates that although the risks appear to be small, demonstration projects need to be structured to inform actuarial models of CCS risks and future liability policy. These projects not only need to address the likelihood of risks per se, but may also provide an evidentiary basis for future CCS liability litigation or policy. Thus demonstration projects will need to provide empirical evidence of the extent to which carbon dioxide can cause the risks in question.

Our analysis also indicates that post-injection monitoring will play a key role in determining future liability. Monitoring technologies are not only useful in gathering information about risks, but may affect the liability of the parties carrying out the monitoring. CCS liability policy will need to address the optimal level of monitoring and what parties should be responsible for the long-term monitoring of a storage reservoir. We suggest that post-injection monitoring requirements for storage operators could be built into a CCS underground injection control permitting scheme, but that government will need to play a supervisory role in the short-term and perhaps a more active role in the long-term. For example, as a condition for receiving a carbon dioxide injection permit, operators could be required to monitor the post-injection flow of carbon dioxide during the injection phase of operations plus a limited time after injection (such as 5-10 years post-injection), and any subsequent long-term monitoring would be the responsibility of government.

A second source of uncertainty deals with the choice of policies that may be used to manage liability. Although current public and private liability mechanisms for CCS could address liability during the injection phase of operations, alternative liability mechanisms will need to be considered with respect to long-term post-injection risks. We make an assumption that those parties affected by long-term risks should be compensated for their harm or damage suffered.

Policy should explicitly define the roles and financial responsibilities of industry and government. We advocate a hybrid arrangement where industry has liability for carbon dioxide storage in the short-term, but government would be responsible in the long-term. Private operators need to have some financial responsibility for potential harm or damage in order to avoid the problem of moral hazard, or changes in the level of precaution taken if operators no longer bear the costs of liability, which could potentially increase the probability of loss. However, if individual operators are made fully liable for harm or damage resulting far into the future, there could be a negative impact on future carbon dioxide storage activities. In addition, long-term government responsibility could better assure that affected parties would be adequately compensated.

There are a number of ways in which a hybrid public-private liability strategy could proceed. One method that looks attractive would be to combine certain aspects of the current and alternative liability regimes. Carbon dioxide storage operators would be subject to stringent requirements with respect to injection well design, operation, and monitoring. During the injection phase plus a limited post-injection monitoring period of 5-10 years, the private operators would have financial responsibility under public and private liability mechanisms. This could be supplemented by mandatory financial assurance or primary insurance requirements. After the storage operator has fulfilled its post-injection requirements, government would have financial responsibility for compensating harm, but with funds derived from a pool of industry set-asides from the injection phase of operations, analogous to an insurance pool or compensation fund arrangement.

Finally, we recommend that particular attention be paid to the process that would create a CCS liability regime. We suggest two sets of timelines for moving forward. It is imperative that a liability system and protocols governing demonstration projects be implemented without delay. In the longer term, such as within the next five years, a more permanent CCS liability regime could be created. To ensure the integrity of the process, we suggest that a multi-stakeholder platform be used to lead the development of any liability policy recommendations. Certainly, members of industry, academia, government, and non-governmental organizations will need to play an active role in the development of any liability regime. However, it is critical that experts from the reinsurance and finance sectors, who often are not a part of the CCS conversation, also be engaged in this effort. Although certain aspects of the liability regime, such as monitoring, could be subsumed under UIC regulatory requirements, *per se* limits on private liability would likely need to be embodied in legislation.

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