Regulatory Barriers for Carbon Capture, Storage and Sequestration

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The success of carbon capture, storage and sequestration as a greenhouse gas mitigation strategy will be, in part, dependent on the regulatory framework used to govern its implementation. Creating a science-based regulatory framework that is designed with enough flexibility to encourage greenhouse gas offset activity, effective means of measuring the costs of taking action to reduce greenhouse gas emissions, and ample protection for human and ecosystem health may prove challenging. For the purposes of this paper we will assume that there is an existing incentive to capture, store and sequester carbon and focus on how to regulate the process. Accounting practices and precursory crediting rules for biological sinks (forestry, conservation and agriculture) have received significant attention through international climate change negotiations, and the issue will not be addressed in this short paper. Instead the focus will be on the social and technological concerns that will influence the regulatory landscape for geologic storage of captured carbon dioxide (CO_2). These issues affect the regulation of the storage process itself as well as regulations and rules for accounting for greenhouse gas emissions and trading offsets.

Background

Large-scale Activities in Geologic Storage

A clear regulatory framework has not emerged along with development of geologic carbon storage technologies, which have been a component of energy industry operations since the early 1970s. Efforts to more permanently store carbon in geologic formations as a method for mitigating greenhouse gas emissions began in October 1996, when Statoil began taking unwanted CO_2 from the Sleipner West field in the Norwegian North Sea and storing it 1,000 meters beneath the seabed in a saline aquifer reservoir. One million tonnes of CO_2 have been stored per year—2,800 tonnes each day, an amount equal to the CO_2 emissions of a typical 150 MW coal-fired power plant located in the United States. In Canada's Weyburn oil field, waste CO_2 from a Dakota Gasification plant in North Dakota is being used for enhanced oil recovery. Over the Weyburn project's 20-year lifetime, approximately 20 million tonnes of CO_2 will be stored in the Weyburn oil field, 0.3% of the world's total annual emissions.

Geologic Sequestration Transactions

The need for regulation is compounded by the inclusion of geologic storage project transactions in the emerging greenhouse gas market. In February 2002, CO2e.com announced it's largest greenhouse gas trade to date—a transaction between Ontario Power Generation and Bluesource. The forward purchase of 6 million tCO_2 equivalent and option for an additional 3 million tonnes CO_2 equivalent resulting from geologic sequestration projects in Texas, Wyoming, and Mississippi where CO_2 that would otherwise be vented by natural gas processing plants is used for enhanced oil recovery (EOR). The Government of Canada announced in October 2002 a plan to buy verified greenhouse gas emissions reductions from two sectors—landfill gas and geologic CO_2 storage.

Regulatory Analogs and Existing Regulatory Framework

There are several currently regulated underground storage practices that may provide insight into a future CO_2 storage regulatory framework. These analogs include waste disposal, energy storage, and energy production. Although there are important differences between storage of CO_2 and these analogs, experience in these areas will guide future regulatory practices.

Energy production, or enhanced oil recovery (EOR) and enhanced coalbed methane (ECBM) recovery is the most commonly used analog for geologic carbon sequestration. In both cases, a CO_2 flood can be used to extract formerly unrecoverable oil or methane. Both EOR and ECBM have been encouraged through tax incentives[1]. EOR and ECBM practices will likely experience tremendous growth under a carbon-constrained scenario (such as a carbon emissions cap or tax), as more affordable sources of CO_2 become available. Lessons learned and current industrial expertise in EOR and ECBM operations will help advance carbon storage technologies. The value-added benefits of oil and gas production will provide a needed incentive for CO_2 storage, in addition to any offset credit. There are important distinctions between EOR or ECBM and CO_2 storage. For example, in current industrial practices the injected CO_2 is recycled to minimize expenses and regulations addressing well closures do not include provisions for stored carbon. The paradigm shift to using wells as storage sites may bring new challenges including changes in the existing regulatory framework (EPA's UIC program, described below) and in industry practices.

Storage of natural gas, liquefied natural gas, and petroleum reserves is regulated with monitoring protocols to avoid leaks and potential human health or ecosystem impacts as well as siting and operations guidelines. Conceptually a societal decision has been made that the benefit of storage in terms of energy security and improved ability to meet demand outweighs the potential for negative impacts. In the case of CO_2 storage, we will ultimately engage in a similar risk analysis in which we weigh the costs of experiencing the impacts of climate change with the risks of investing in mitigation options (adaptation vs. mitigation). There is also a temporal difference, energy storage is temporary, but for CO_2 the goal is to find a long-term or "permanent" solution.

Waste disposal has historically suffered from a range of regulatory challenges. Ocean dumping and incineration (once accepted strategies) have been drastically restricted[2] in favor of waste prevention, waste minimization, land disposal and underground storage. The EPA's Underground Injection and Control (UIC) Program currently regulates underground waste storage. Under this system there are five classes of wells for waste injection. A "Class I" categorization is given for any deep injection of hazardous or non-hazardous industrial wastes. Class II permits are issued for wells associated with energy production (EOR). Class III permits apply to mineral extraction. A Class IV designation

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[1] Tax credits for CBM and EOR are offered under section 29 of the Federal Windfalls Profits Act.

[2] Marine Protection, Research, and Sanctuaries Act of 1972 and Ocean Dumping Ban of 1988.

is no longer given, but once applied to hazardous waste injected above the drinking water source. All other types of injection wells receive a Class V designation. The UIC program has experience managing large quantities of waste over long time frames and will most likely oversee geologic CO_2 storage projects, although greenhouse gas emissions issues are generally under the purview of the EPA's Office of Air and Radiation.

The first U.S. injection of CO_2 in a saline reservoir, an NETL-funded research project with the Texas Bureau of Economic Geology, has received a permit for a Class V research well. This example highlights the regulatory differences between carbon sequestration and other forms of geologic storage. Because hydrocarbon production is not a part of the research project, the well could not be categorized as a Class II. On the other hand, given the small scale of the experiment, the history of CO2 injection for EOR in the area, and the nature of CO_2, it did not need to be given a Class I designation.

Preliminary discussions on the wide-scale permitting of CO_2 injection wells have resulted in debate. Some argue for a Class II designation, with the rationale that CO_2 injection is a standard practice and the cost of a more stringent, Class I permit would discourage CO_2 storage. The costs are not trivial; EPA estimates the permitting process for a Class I well (including needed geologic characterization and modeling) can cost more than $2,000,000. Class I designation advocates argue that the assurance that the injected CO_2 will not migrate outside the injection reservoir is worth the cost. Ultimately we will need a permitting system that balances industry's need for an economic motivation to act on the greenhouse gas issue and public assurance of safety and environmental efficacy.

There is no current regulatory framework governing the reporting or accounting of greenhouse gas emissions and transactions. Enhanced oil recovery projects can register offsets made in the DOE Voluntary Reporting of Greenhouse Gases Program or other national registries.

Regulatory Scope

Project Siting

Any future geologic CO_2 storage project will encounter regulatory needs throughout the project lifetime, beginning with site selection. As discussed earlier, storage sites may first be located in conjunction with EOR or ECBM operations. Because these areas are already familiar with energy production and drilling operations, the local communities may be very receptive to CO_2 storage projects. As the need for greenhouse gas offsets increases and storage in deep saline aquifers becomes more common, there may be new siting concerns. Environmental justice may be raised as an issue because of the historical correlation with siting waste facilities in economically depressed and often minority-dominated areas.

Injection

Another area where regulation may prove important is in limiting the rate and amount of injection in a given reservoir. Science-based regulatory standards will need to be set based on the characterization of the reservoir and known dynamics of injected CO_2

plumes. In this case, regulations will be based on experience in EOR and ECBM as well as information gained through monitoring of proof-of-concept scale research projects.

Monitioring

Monitoring and mitigation requirements will also need to be established for regulatory purposes. Monitoring protocols that allow for early detection of any leaks or seepage out of the reservoir will be critical for effective risk management. At a project scale monitoring can ensure human and ecosystem health, and on a global scale monitoring will provide assurance that greenhouse gas emission reduction goals are being met. If problems are found through monitoring, a mitigation process will need to be employed.

Accounting

There are a series of regulatory and policy issues that will need to be resolved with respect to accounting for emissions offsets gained through geological CO_2 storage. Many of these questions are being answered through private sector and international greenhouse gas markets as Verified Emissions Reductions (VERs) are traded, but uncertainties regarding permanence, leakage, and data tracking may take time to resolve. Other accounting uncertainties will be answered as revised reporting requirements are established for DOE's voluntary reporting program under section 1605(b) of the EPAct. The voluntary reporting program for greenhouse gases has been in operation since 1994[3], but is currently undergoing revisions in response to a presidential directive. The new reporting guidelines are expected by January 2004 and will[4]:

- Develop fair, objective, and practical methods for reporting baselines, reporting boundaries, calculating real results, and awarding transferable credits for actions that lead to real reductions
- Standardize widely accepted, transparent accounting methods
- Support independent verification of registry reports
- Encourage reporters to report greenhouse gas intensity, in addition to emissions or emissions reductions
- Encourage corporate or entity-wide reporting
- Develop a process for evaluating the extent to which past reductions may qualify for credits
- Assure the voluntary reporting program is an effective tool for reaching the 18% goal established in the President's Global Climate Change Initiative
- Factor in international strategies as well as State-level efforts
- Minimize transaction costs for reporters and administrative costs for the Government, where possible, without compromising the foregoing recommendations

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[3] EIA released a February 2002 report which stated that in 2000, 222 companies had undertaken 1,882 projects to reduce or sequester greenhouse gases. These achieved 269 million metric tons of carbon dioxide equivalent reductions – equal to 3.9% of national emissions.

[4] Letter from Secretaries of Energy, Commerce, and Agriculture, and the Administrator of the EPA to President Bush, July 8, 2002.

Regulatory Challenges

Perhaps the primary regulatory issue for CO_2 storage is risk management. As noted, there are several important differences between CO_2 storage and existing regulatory analogs. At the local, or project scale there are risks associated with a surface release of CO_2, potentially impacting human and ecosystem health. Although CO_2 is a plant nutrient and major component of our atmosphere, there are adverse effects for human and ecosystem health at high concentrations. For human health, the Occupational Health and Safety Administration (OSHA) has specified the maximum average exposure of CO_2 over an eight-hour workday at 0.5%. Exposure, even over short periods of 1 to 5% CO_2 results in physiological effects (including increased breathing); loss of consciousness occurs above 10%; and most concentrations above 30% are lethal. With respect to ecosystem health there are some species of microbes, fungi and insects that have adapted to inhabit ecological niches high in CO_2, but others (particularly large mammals) show tolerances comparable to humans.

There are two often-cited examples of worst case scenarios for potential surface release of CO_2. In 1986, there was a large-scale release of CO_2 from a natural CO_2 reservoir under Lake Nyos near Cameroon, Africa that killed more than 1,700 people. Human fatalities and ecosystem impacts were experienced in a 15 mile-radius surrounding the lake. Although plants are generally more resistant to high concentrations of CO_2, soil acidification and "suffocation" of root zone respiration have been reported in areas with frequent volcanoes or earthquakes. At Mammoth mountain California the release of CO_2 following several small earthquakes has been blamed for a 100-acre tree kill zone. Releases of equal amounts of CO_2 have occurred in other cases without resulting in harm to people or ecosystems; duration of exposure plays a critical role in determining the impact of a release. Although these natural releases occur in unmonitored situations, at concentrations and volumes higher than we would expect to permit for geologic sequestration, there is a perceived correlation and need to address these concerns.

In addition to a surface impacts, there are also potential risks of subsurface leakage. Researchers[5] have expressed concern over the potential of migrating CO_2 interacting with groundwater supplies and mobilizing heavy metals. Although, this possibility is remote—geological storage sites under consideration are not located in areas where interactions with groundwater are believed possible—it is essential that we have a thorough understanding of the potential implications of large-scale carbon storage on our groundwater supplies. Under the current UIC guidelines, injection would never be permitted above groundwater resources.

If the regulatory framework does not set quantity-based limits for the amount of CO_2 that can be stored in a given reservoir, there are additional risks. Potential problems of overfilling a reservoir include ground heaving, induced seismicity, displacement of groundwater resources, and damage to hydrocarbon reservoirs.

On a global scale, there is the potential that widespread seepage to the surface would counteract any greenhouse gas benefit gained in the short term. Experience gained

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[5] Personal Communication, Princeton University.

through early industrial operations like Weyburn and Sleipner as well as small-scale demonstrations with stringent monitoring modeling will help protect against such an event. Similarly, the permanence of storage underground has not been verified. In this case, we need to draw on research and experience in waste and energy storage. One of the regulatory challenges associated with the climate change issue in general is the global nature of the problem. Regulatory decisions may be made at the national, regional, or state level—yet the global community assumes any benefits (as well as risks).

There are also challenges that result from the long and varied time scales involved with geologic storage. Political decision making may take place within the next five years, with a regulatory framework emerging sometime shortly afterwards. However, carbon management is an issue that will likely to take centuries to resolve. Generally we presume that decisions made in the near term will benefit future generations, but the costs will be incurred (at least in part) today.

Public acceptance and understanding of carbon storage and sequestration is a critical step in establishing it as a viable greenhouse gas mitigation option. We must develop an appropriate regulatory framework that puts safety and human and ecosystem health at the forefront. The challenge may come in balancing the public need for assurance with the regulated industry's need for a cost-effective solution for mitigating greenhouse gas emissions. Even if the public accepts the general concept of CO_2 storage and society as a whole agrees that the benefits for future generations are worth the costs (risks) today, there may be a reluctance to have storage sites in particular areas—the NIMBY, or "not in my backyard" syndrome.

Finally, there may be difficulty in establishing an agreed-upon regulatory framework because of the involvement and overlapping jurisdiction of multiple regulatory agencies. In some cases multiple state and Federal regulatory agencies, as well as divisions within each agency, will need to cooperate and agree on standards.

The Path Forward

Although there are challenges in establishing a regulatory framework for CO_2 storage, the issue has been recognized by academics, federal officials, and industry leaders. Researchers are working to model behavior of injected CO_2 in geologic reservoirs, designing field experiments that emphasize monitoring and verification, working to characterize reservoirs that may be suitable for CO_2 storage, engaging the public in discussions about the issue, and brainstorming potential regulatory proposals.

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