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Carbon capture and storage policy in the United States: A new coalition endeavors to change existing policy

Melisa Pollak [a,*], Sarah Johnson Phillips [a,1], Shalini Vajjhala [b]

[a] Humphrey Institute of Public Affairs, University of Minnesota, 301 19th Avenue, S. Minneapolis, MN 55455, United States
[b] Resources for the Future, 1616 P St. NW, Washington, DC 20036, United States

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ABSTRACT

Carbon capture and storage (CCS) is considered by some to be a promising technology to reduce greenhouse gas emissions, and advocates are seeking policies to facilitate its deployment. Unlike many countries, which approach the development of policies for geologic storage (GS) of carbon dioxide (CO_2) with nearly a blank slate, the U.S. already has a mature policy regime devoted to the injection of CO_2 into deep geologic formations. However, the existing governance of CO_2 injection is designed to manage enhanced oil recovery (EOR), and policy changes would be needed to manage the risks and benefits of CO_2 injection for the purpose of avoiding GHG emissions. We review GS policy developments at both the U.S. federal and state levels, including original research on state GS policy development. By applying advocacy coalition framework theory, we identify two competing coalitions defined by their beliefs about the primary purpose of CO_2 injection: energy supply or greenhouse gas (GHG) emission reductions. The established energy coalition is the beneficiary of the current policy regime. Their vision of GS policy is protective: to minimize harm to fossil energy industries *if* climate policy were to be enacted. In contrast, the newly formed climate coalition seeks to change existing GS policy to support their proactive vision: to maximize GHG reductions using CCS *when* climate policy is enacted. We explore where and at what scale legislation emerges and examine which institutions gain prominence as drivers of policy change. Through a detailed textual analysis of the content of state GS legislation, we find that the energy coalition has had greater success than the climate coalition in shaping state laws to align with its policy preferences. It has enshrined its view of the purpose of CO_2 injection in state legislation, delegated authority for GS to state agencies aligned with the existing policy regime, and protected the EOR status quo, while creating new opportunities for EOR operators to profit from the storage of CO_2 The climate coalition's objective of proactively putting GS policy in place has been furthered, and important progress has been made on commonly held concerns, such as the resolution of property rights issues, but the net result is policy change that does not significantly revise the existing policy regime.

1. Introduction

Some individuals and groups concerned about the consequences of anthropogenic greenhouse gas (GHG) emissions advocate capturing carbon dioxide (CO_2) emitted from power plants and other industrial facilities and injecting it into deep geologic formations for permanent storage (Metz et al., 2005; IPCC, 2007a; IEA, 2008). Carbon capture and storage (CCS) is often referred to as an emerging technology, but in fact, it is a suite of existing technologies combined for a new purpose: avoiding GHG emissions. Technologies to separate CO_2 from natural gas and from the exhaust stream of fossil fuel combustion exist today at natural gas processing plants, synfuel plants, and integrated gasification combined cycle power plants (MIT, 2007; Dooley et al., 2009). Additionally, CO_2 injection into deep geologic formations for enhanced oil recovery (EOR) has been practiced for over 35 years in the western U.S.

Proponents of CCS as a climate mitigation technology identify the lack of legal and regulatory frameworks as a barrier to its deployment (Bachu, 2008; Wilson et al., 2008; Metz et al., 2005). However, in the U.S., the problem is not the absence of regulation; rather, it is the existence of a mature policy regime devoted to the injection of CO_2 into deep geologic formations for enhanced oil recovery (EOR), which does not manage the risks and benefits of CO_2 injection as a means of avoiding GHG emissions. Geologic storage (GS) of anthropogenic CO_2 is distinct from EOR in many ways. Foremost, with GS the injected CO_2 is intended to stay underground permanently, whereas with EOR, approximately half

* Corresponding author. Tel.: +1 612 625 3046.
E-mail address: fryxx035@umn.edu (M. Pollak).
[1] Now at Stoel Rives LLP, 33 S. 6th St., Minneapolis, MN 55402, United States.

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of the injected CO_2 is extracted with oil, separated, and then re-injected. Other major differences include the fact that GS could potentially involve orders of magnitude larger amounts of CO_2, and it could utilize deep saline aquifers as well as depleted oil and gas fields (Metz et al., 2005). The existing regulatory framework (under the EPA Underground Injection Control Program, see Section 2.3 for details) has no authority to address many of the issues of concern for advocates of CO_2 injection as a means of avoiding GHG emissions, such as monitoring and reporting to prove that injected CO_2 is permanently contained underground, managing all potential risks of CO_2 injection, and resolution of property rights issues. The GS policy debate in the U.S. has less to do with broad technology questions and more to do with the compliance requirements of current rules governing CO_2 injection. Proponents of CO_2 injection as a means of climate mitigation are seeking policy changes regarding operational decisions, such as site characterization, financial assurance, well construction, and leakage monitoring. The GS policy process in the U.S. is, therefore, one of potential policy change, not policy creation.

This report examines the nature of GS policy activity in the U.S. during the period from 1997 to the present through the lens of the advocacy coalition framework (ACF) developed by Sabatier and Jenkins-Smith (Jenkins-Smith and Sabatier, 1994; Sabatier, 1988, 1998; Sabatier and Weible, 2007). We mark 1997 as a starting point because it is the year that the Kyoto Protocol was signed, that the International Greenhouse Gas Control Technologies conference series was initiated, and that the U.S. Department of Energy (DOE) launched its carbon sequestration program. This study is the first to apply ACF theory to the GS policy process.

The ACF defines the process of policy change as a function of the interaction between powerful coalitions composed of actors from different institutions within a certain geographic area who are interested in a specific policy arena and share key beliefs (Sabatier and Weible, 2007). It holds that the most useful unit of analysis to understand the process of policy change is the policy subsystem comprised of the coalitions interested in a specific policy area (Sabatier, 1988). Policy subsystems are of interest because they represent the locus of policy conflict, policy learning, and policy change. Rather than assuming that actors' orientations and preferences are primarily a function of the institution with which they are associated (Scharpf, 1997), ACF theory postulates that actors form coalitions based on their policy beliefs and that the success of these coalitions in getting components of their belief systems translated into actual policy is a function of resource availability, policy-oriented learning and external shocks (Sabatier and Weible, 2007).

The ACF hypothesizes that the belief systems of advocacy coalitions have a three-tiered structure. Deep core beliefs are the most fundamental; they involve normative value assumptions and are very difficult to change. At the next level are policy core beliefs, which are applications of deep core beliefs across a policy subsystem. Policy core beliefs are also very difficult to change. Finally, there are secondary beliefs, which apply to narrower issues within a policy subsystem and are more open to change either due to external shocks or policy-oriented learning (Sabatier and Weible, 2007). The ACF postulates two testable hypotheses regarding policy change (Jenkins-Smith and Sabatier, 1994) that we will consider in our analysis of GS policy activity in the United States:

Hypothesis 4. The policy core attributes of a government program are unlikely to be significantly revised as long as the subsystem advocacy coalition that instituted the program remains in charge.

Hypothesis 5. The policy core attributes of a government program are unlikely to be changed in the absence of significant perturbations external to the policy subsystem, i.e., changes in socio-economic conditions, system-wide governing coalitions, or policy inputs from other subsystems.

The policy subsystem of interest in this study is the network of actors in the United States concerned with the injection of CO_2 into deep geologic formations, which we refer to as the GS policy subsystem. This policy subsystem includes agencies, corporations, interest groups and researchers with expertise related to the injection and geologic storage of CO_2. The GS policy subsystem in the U.S. emerged approximately a decade ago as the intersection of two distinct groups; one with roots in the century old and politically powerful U.S. energy industry and the other with roots in the relatively young international climate change movement. Using ACF terminology, we refer to these groups as the energy coalition and the climate coalition[2].

The energy coalition believes that the primary purpose of CO_2 injection is to support domestic energy production, either through EOR or as a means of continued use of fossil fuels in a carbon-constrained world (e.g., API, 2010; National Coal Council, 2010). The pre-existing policy regime serves the current interests of the energy coalition, and their primary policy goal is to protect the status quo. They are only motivated toward policy change to the extent that they perceive that climate policy is imminent.

The climate coalition believes that the primary purpose of CO_2 injection is to avoid GHG emissions (e.g., Metz et al., 2005). It seeks to induce policy changes that its members believe would facilitate widespread deployment of CCS by broadening legal and regulatory frameworks to cover CO_2 injected for the primary purpose of climate mitigation. In the vision of the climate coalition, EOR exists only as a secondary function that is useful to offset costs in early deployment but is of minimal importance in the long run.

There is much detail and complexity related to these coalitions that is beyond the scope of this report. For example, there are actors who see energy supply as the primary purpose of CO_2 injection but also support climate policy (e.g. Galbraith, 2009). Additionally, there are actors from the larger climate change movement who oppose CCS as a climate mitigation technology (e.g. Rochon et al., 2008). Future studies to elucidate the effects of these nuances related to GS policy development would be valuable, but for this study, we take a simplified view focusing on the major differences between the energy coalition and the climate coalition.

The ACF provides an appropriate theoretical framework to assess whether recent GS policy activity in the U.S. represents fundamental change to pre-existing policy because it provides a means of analyzing policy processes involving substantial goal-related conflicts, important technical disputes, and multiple actors (Sabatier and Weible, 2007). The GS policy development process includes advocacy coalitions with fundamentally different beliefs about the purpose of CO_2 injection, contentions as to the risks of CO_2 injection, and a wide range of actors, including the following: state and federal legislatures and administrative agencies; several types of businesses, including oil and gas companies, coal companies and electric utilities; academics from the U.S. and abroad; and environmental interest groups.

The ACF perspective also provides a useful lens to understand how GS policy activity in the U.S. is shaped by federalism with competing coalitions exhibiting differing capabilities to mobilize resources to influence policy at the state versus the federal level. The ACF postulates that resources are central to a coalition's odds of success in changing the existing policy regime. Resources include the following: formal authority to make policy decisions; public opinion; information; mobilizable troops; financial resources; and skillful leadership (Sabatier and Weible, 2007).

[2] Our basis for defining these two coalitions, their beliefs and objectives is detailed in Sections 3 and 4.

Our application of the ACF framework differs from previous studies in three main ways. First, the coalitions described in this report are not defined by a policy problem, such as coastal flooding or the protection of marine resources (Weible, 2007; Meijerink, 2005) but, instead, by an activity: the injection of CO_2 into deep geologic formations. The two coalitions in the policy subsystem do not differ in their preference related to how a problem should be solved; they differ in their beliefs about the primary purpose of an activity. Second, unlike other studies using the ACF framework in which establishing the existence of advocacy coalitions is a central focus of the research, in this case, the GS policy subsystem was created when the climate coalition became interested in an activity that had previously been completely in the domain of the energy coalition. Energy coalition members responded by initiating research and policy advocacy related to GS. Future studies could provide more detailed network analysis of coalition membership, but for this report, we define coalition membership by an actor's belief about the primary purpose of CO_2 injection. Third, in addition to differences in beliefs and resources, there is a strong temporal difference between the two coalitions in the GS policy subsystem. This temporal dimension arises for two primary reasons. First, the energy coalition has existed for decades longer than the climate coalition and has well-established modes of influence at both the state and federal levels. Second, the coalitions' preferences for policy change are focused on different time periods. The temporal focus of actors in the energy coalition is driven by the lifetimes of the related infrastructure from the present to approximately 20 years in the future, whereas the temporal focus of actors in the climate coalition is driven by concern for future generations on the scale of centuries.

Before turning to a description of the advocacy coalitions and examination of policy activity over the past decade, it is important to understand the existing policy regime because scholars of path dependence have documented the many ways that history matters in shaping institutions (Thelen, 1999) and influencing technical change (Ruttan, 2001).

2. Attributes of the pre-existing policy regime

2.1. History and economic context

Enhanced oil recovery has a rich history in the United States. Starting in the 1930s, oil companies began injecting brine or natural gas that had been co-produced with oil back into depleting formations to stimulate oil production. The motivation for enhanced oil recovery was (and is) to produce more oil, but industry and regulators appreciated the fact that reinjection of the produced brine had the secondary benefit of solving the pollution problems created by discharging large volumes of salty water into the soil or surface water (Gorman, 1999).

CO_2 was first used for enhanced oil recovery at the west Texas SACROC oil field in 1972 (Meyer, 2007). Initially, most of the CO_2 injected for EOR came from natural deposits, but as oil prices have increased sharply over the last 10 years, the number of EOR projects has increased and natural supplies of CO_2 are becoming depleted. Demand for CO_2 now outpaces the natural supply (Doll et al., 2009). Approximately 60 million metric tons (tons) of CO_2 were purchased in 2009 (double the amount sold in 2004), with 10 million tons coming from anthropogenic sources, such as natural gas processors, ethanol distilleries, and synfuel plants (Doll et al., 2009).

Overall, the existing business environment for EOR is characterized by economic strength and projected growth. While the climate coalition views CO_2 as a waste product that threatens the global climate, EOR operators see CO_2 as a valuable commodity for which they were willing to pay approximately US$ 38 per ton (US$ ~ 2/Mcf) in 2008 (Kuuskraa and Ferguson, 2008). Each ton of CO_2 used for EOR produces an average of 1.5 barrels of oil (Meyer, 2007), meaning that a US$ 38 investment in CO_2 for EOR returns oil valued at over US$ 100 (with oil priced at approximately US$ 70 a barrel).

The market for CO_2 (~US$ 2 billion in 2008) is projected to grow. As U.S. oil production declines and oil prices rise, the role of EOR has increased from 0.3% of total U.S. oil production in 1986 to 5% in 2008 (Doll et al., 2009; U.S. EIA, 2009). This trend is projected to continue (NETL, 2010). In fact, one analyst estimates that there is total unmet[3] demand for over 7 billion tons CO_2 to extract all the U.S. oil that is economically recoverable through EOR (Kuuskraa and Ferguson, 2008). This demand, which represents an optimistic upward boundary, could potentially provide storage capacity for 20% of the emissions from the electric power sector for approximately 15 years.[4] Many authors project that the role of EOR will be minimal in the long-term if climate policy is enacted and CCS is widely deployed (U.S. DOE, 2008; Dooley et al., 2003), but the trends discussed above suggest that CO_2 injection for EOR and the policy regime that supports it could continue to be major players for decades, even if binding limits on national GHG emissions were to be adopted in the U.S.

2.2. Key institutions in the pre-existing policy regime

State-level institutions dominate pre-existing policy regarding CO_2 injection. While governance of CO_2 injection derives its legal authority from the Federal Safe Drinking Water Act (SDWA) of 1974 and operates under rules of the U.S. Environmental Protection Agency (EPA) Underground Injection Control (UIC) Program governing Class II wells (CFR parts 144-147), the actual governance authority for CO_2 injection has rested mostly at the state level because Federal Class II rules largely incorporate earlier state rules governing injection activities associated with oil and gas production. The regulator under the UIC program can be the EPA regional office, but it is more often a state regulator (which is allowed if a state seeks primacy and passes rules that are at least as stringent as the federal UIC rules.) Specifically, in states with CO_2 EOR operations, the Class II program is usually administered by state oil and gas regulators (9 of 10 states) (U.S. EPA, 2010a; U.S. EPA, 2006; Koottungal, 2008).

Another important state-based institution in the pre-existing policy regime is the Interstate Oil and Gas Compact Commission (IOGCC), which is comprised of state oil and gas regulators from 39 states (IOGCC, 2010). The IOGCC was founded in 1935 to maximize the production of oil by combating wasteful practices of the unregulated petroleum industry.

2.3. Objectives and standards of existing CO_2 injection policy

The purpose of the SDWA is to protect underground sources of drinking water, and UIC Class II rules include procedural requirements for permitting, well construction, mechanical integrity testing, monitoring, and financial assurance. Rules under the UIC program are strictly limited to addressing potential impacts to groundwater; they have no statutory authority to address several of the climate coalition's priorities, such as monitoring and reporting to verify that injected CO_2 remains underground or management of all of the potential risks of CO_2 injection.

3. Advocacy coalitions in the GS policy subsystem

The GS policy landscape in the U.S. is shaped by the interactions between the energy coalition and the climate coalition which are

[3] Demand in excess of available natural supply or currently used anthropogenic supply.

[4] 2008 U.S. electric sector emissions were 2.5 billion tons/yr.

distinguished by actors' beliefs about the primary purpose of CO_2 injection. This simple framework offers insights about the policy preferences of the participants and their preferred venues to seek policy change. Determining which coalition an actor falls into is generally unambiguous because most organizations and institutions publish statements of purpose, and most academic work states its premise. The attributes, objectives and beliefs of the two coalitions are described below and summarized in Table 2.

3.1. The energy coalition

3.1.1. Energy coalition actors and resources

The energy coalition includes actors from the U.S. oil and gas industry, especially those engaged in EOR, as well as coal producers and coal-dependent electric utilities, which see CCS as necessary to their survival if GHG limits are enacted. The energy coalition also includes many state and federal elected officials from fossil fuel-producing states. Institutional actors include state oil and gas regulators and the Interstate Oil and Gas Compact Commission (IOGCC). The U.S. Department of Energy (DOE) is an important actor included in this coalition because the number one objective of the agency is "Promoting America's energy security through reliable, clean, and affordable energy" (U.S. DOE, 2010).

The energy coalition benefits from strong public support for its core beliefs. Table 1 shows public opinion data for 2002, which is toward the beginning of the period when the GS policy subsystem formed, and then yearly data from 2007, which is the time period during which the policy activity described in Section 5 took place. The year 2007 was also the first time that the Pew political survey asked about climate change. During the period covered by our analysis, twice as many Americans rated energy supply as a top priority than those who rated global warming as a top priority (Pew, 2010). This suggests a greater likelihood of legislators willing to vote for policy in line with energy coalition beliefs, as well as a greater availability of mobilizable troops to work for policy favorable to the energy coalition.

3.1.2. Energy coalition policy beliefs and objectives

The energy coalition's core beliefs center on the importance of domestic energy production and economic development. This coalition is well served by the current policy regime and had no motivation to engage in GS policy activity until the climate coalition began to advocate for GHG emission controls and policy change to facilitate CCS as a climate mitigation technology. In engaging with the GS policy subsystem, the energy coalition seeks to insure that if the existing regime is changed, the changes will be designed to maximize future energy production opportunities and to minimize disruption of the status quo (Doll et al., 2009). Proposals for climate policy are generally perceived as a risk, but CCS is viewed as a hedge to mitigate the damage if climate policy is enacted. The model state rules and regulations for geologic storage of CO_2 published by the IOGCC (2007) are representative of the energy coalition's preferences for GS policy.

Within the energy coalition, oil and gas companies perceive slightly different benefits and risks than do coal-dependent industries. Oil and gas companies see potential business opportunities in GS. EOR operators recognize that climate policy might allow them to profit by storing CO_2, and oil and gas companies have the skills and equipment needed to construct and operate GS sites (Melzer, 2009). However, EOR operators are concerned that the climate coalition's efforts to create a regulatory framework to facilitate injection of CO_2 as a means of avoiding GHG emissions could result in requirements for more expensive well construction or more extensive site characterization and monitoring that would threaten EOR's status quo (Eugene, 2009; Doll et al., 2009). For coal companies and electric utilities, CCS is purely a hedge to allow continued use of coal in a carbon-constrained world. They support policy that keeps EOR costs low because they recognize that EOR has the potential to reduce their costs for sequestering CO_2. Despite these differences, the policy interests within the energy coalition are well aligned.

The temporal focus of actors in the energy coalition is from the present to approximately 20 years in the future, which is determined by the business cycle and the lifespan of the relevant infrastructure. Their geographic focus is largely at the state level because both the oil and gas industry and the electric power industry are primarily regulated by states and because the smaller oil and gas industry players that dominate U.S. production (non-major companies produce approximately 60% of domestic oil and gas, U.S. EIA, 2008) maintain strong economic and political influences in energy-producing states. Energy policy, especially as it relates to energy production, has historically been controlled by local or state government in the U.S. (Tomain, 1990). Furthermore, severance taxes and royalty payments provide a significant source of revenue for energy-producing states, giving the energy industry political influence in their state capitols.

3.2. The climate coalition

3.2.1. Climate coalition actors and resources

The climate coalition in the U.S. is an offshoot of the international climate change movement. Researchers concerned about climate change identified CCS as a potential means of avoiding GHG emissions and began to devote significant resources to developing knowledge about GS, starting with the initiation of the Greenhouse Gas Control Technologies Conference series in 1997. The climate coalition is largely comprised of researchers, as shown by the affiliations of the contributors to the IPCC Special Report on Carbon Capture and Storage (Metz et al., 2005), but it also includes a wide range of state, national and international environmental organizations. Institutional actors include the Intergovernmental Panel on Climate Change and a number of major U.S. environmental organizations, such as the World Resources Institute (WRI), the Natural Resources Defense Council, and The Pew Center on Global Climate Change. The U.S. Environmental Protection Agency (EPA) is an important actor included in this coalition because it leads U.S. domestic regulatory action on climate change.

The resources of the climate coalition include the fact that several of their members (WRI, EPA) have convening power and sufficient prestige to bring professionals from both coalitions together in a forum to stimulate policy learning, as detailed in Section 3.3. However, coalition members generally hold office in

Table 1
Percent of American public ranking energy supply and global warming as a top priority.[a]

Do you think the following problem should be a top priority for political leaders?	2002	2007	2008	2009	2010
Dealing with U.S. energy problems	42%	57%	59%	60%	49%
Dealing with global warming		38%	35%	30%	28%

[a] Data from (Pew, 2010).

insufficient numbers to force the passage of national climate policy, and coalition core beliefs suffer from weak public support, as shown in Table 1.

3.2.2. Climate coalition policy objectives and beliefs

The climate coalition's core beliefs center on the importance of addressing global climate change. They view CCS as a desirable climate mitigation technology because it has the potential to achieve deep GHG emission reductions while allowing the ongoing use of fossil fuel resources to meet growing energy demand (IEA, 2008; WRI, 2008).The policy changes envisioned by the climate coalition would require both new legislation and modifications to existing rules and institutions. First and foremost, they would require passage of federal limits on GHG emissions. Unlike other low-carbon energy technologies that create energy (e.g., renewable energy sources or nuclear power), CCS consumes energy (Rubin et al., 2007) and, thus, there is no reason for its deployment unless climate policy is in place or is perceived to be imminent. From the point of view of the climate coalition, the existing policy regime has a number of additional shortcomings. For example, due to statutory limitations, the UIC program cannot comprehensively manage all potential risks of CO_2 injection (only risks to groundwater), and it has no authority to establish accounting mechanisms to track emission reductions from GS. A core policy belief of the climate coalition is the importance of monitoring and reporting to verify that injected CO_2 does not leak back to the atmosphere; this is tied directly to their belief about the primary purpose of CO_2 injection.

The climate coalition's vision of GS policy change can be represented by the European Parliament directive on geologic storage of CO_2 (European Parliament, 2009). This is a policy with an international scope that was developed in close coordination with the IPCC in a policy environment in which climate policy was in place and there was no pre-existing policy regime regarding CO_2 injection.

The temporal focus of actors in the climate coalition is on the scale of generations, which is the timeframe over which climate change is projected to impact global systems (IPCC, 2007b). Their geographic focus is largely global, as climate change is a global problem, and efforts to address climate change have been largely led by an international organization, the Intergovernmental Panel on Climate Change (IPCC). The larger climate change movement in the U.S. (not just the subset of actors involved with the GS policy subsystem) has had greater success achieving policy objectives at the state than at the federal level (Rabe, 2004; Selin and VanDeveer, 2009), but there is little geographic overlap between the states with strong support for climate policy and those exhibiting GS policy activity (compare Figs. 1 and 4).

3.3. Major policy forums

During the time period of our study, there have been several major forums where actors from the GS policy subsystem engaged in debate and policy formulation. The first was the Geological CO_2 Sequestration Task Force, which was convened in 2002 by the IOGCC, which is a key institutional member of the energy coalition. This task force, which is comprised primarily of actors aligned with the energy coalition, produced the model state GS legislation and rules that have proven highly influential in shaping subsequent state GS legislation, as discussed in Section 4.2.

Two other forums attracted participation by high-level professionals from both coalitions. One forum was the series of workshops and meetings that the EPA conducted from 2005 to 2008 to gather information before drafting the rules for UIC class VI wells that inject CO_2 for geologic storage. The second forum was the WRI CCS workgroup that met from 2006 to 2008 and produced guidelines for CCS (WRI, 2008). These processes were conducted according to rigorous professional standards and were designed to be broadly inclusive, creating conditions amenable to policy learning (Jenkins-Smith and Sabatier, 1994).

4. GS policy activity and outcomes

Concrete efforts to shift GS policy toward the preferred objectives of the two coalitions have accelerated over the past several years. In this section, we describe the outcomes of policy activities of interest in the GS policy subsystem, specifically climate policy and policies related to CO_2 injection. We examine GS policy activity at both state and federal levels, identifying institutional, geographic, and substantive features of recently enacted GS laws and rules to better understand the roles of the two advocacy coalitions in influencing GS policy.

4.1. Climate policy

The U.S. has yet to enact a national climate policy, and this represents the bedrock of the climate coalition's GS policy change agenda. The momentum created with the June 2009 passage of a climate change bill by the U.S. House of Representatives (H.R. 2454, which included a variety of supplemental measures to support the development of CCS, including bonus allowances) was lost in the 2010 midterm elections, and prospects for federal climate policy appear to be dim in the next few years. Support for climate policy, which has historically been strongest on the populous east and west coasts and weaker in the center of the country, where fossil fuel production is concentrated (Fig. 1), has been undermined nationwide by the economic downturn (Friedman and Lehmann, 2010).

Regional and voluntary carbon markets have been created in the U.S., including the Regional Greenhouse Gas Initiative, a cap and trade market created by ten northeastern states to cut GHG emissions from electric power 10% by 2018, and the Chicago Climate Exchange, which is a voluntary carbon market. However, the current price for CO_2 in these markets (US$ 2.00 and 0.10 to per ton of CO_2, respectively[5]) is far below the level of US$ 50–75 per ton that most analysts calculate is necessary to make CCS economically viable (IEA, 2008) and is below the US$ 38 per ton value of CO_2 in the U.S. EOR market.

Greater progress on climate policy has nominally been made at the state level. Many authors have documented the proliferation of 'bottom-up' climate policy in the U.S. (Lutsey and Sperling, 2008; Rabe, 2004; Selin and VanDeveer, 2009); however, GHG emission reductions resulting from these activities have largely yet to be documented, and there is growing recognition that states are unlikely to meet their GHG targets (Selin and VanDeveer, 2009). Furthermore, very little state-level climate policy activity has occurred in states that are key to GS deployment. Only four states, California, Massachusetts, Minnesota, and Washington, have enacted both GS policy and state GHG targets.

4.2. State GS policy

It is at the state level where the most extensive GS policy activity has occurred in the U.S. States are important for GS deployment because they control property rights issues; they approve the sitting of energy facilities, and they have extensive local expertise in their oil and gas agencies and UIC agencies (Pollak and Wilson, 2009). Even a federal GS policy would likely delegate implementation to the states, and the early actions of states will create precedents that subsequent federal policy must deal with.

The following analysis is based on our research on state GS policy, which included extensive searches of state legislative

[5] Prices in October 2009.

Fig. 1. Support for national greenhouse gas limits. States whose congressional delegations gave majority support to H.B. 2454 (Waxman-Markey) are shaded. Data from (New York Times, 2009).

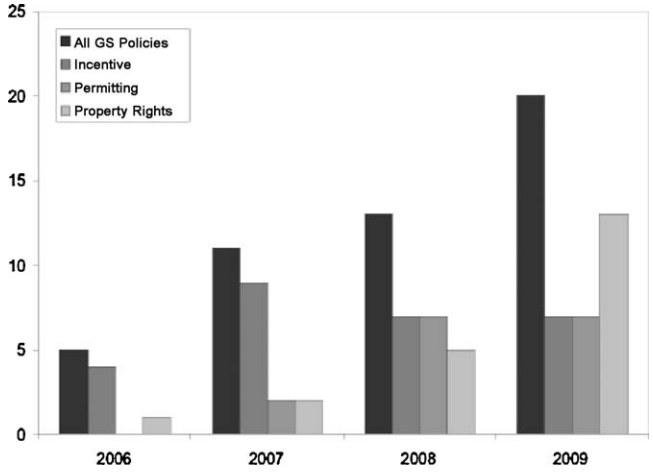

Fig. 2. State Policies Enacted on Geological Storage. *Source*: Authors' research. Note that some state GS policies fall into more than one category; that is, the same policy might address both property rights and permitting for GS. That means the totals shown for each year in the "All GS Policies" category might be lower than the sum of the sub-categories.

records to identify bills related to geologic storage of CO_2, followed by detailed textual analysis of enacted legislation. Here, we concentrate on selected aspects of state GS policy. Additional details are available in Pollak and Phillips (2009).

State policy activity related to GS has steadily increased over the past few years, and 2009 was the most active year to date in this arena (Fig. 2). Since 2006, states have enacted over 50 different policies addressing GS (largely legislation but also rulemaking and other official actions.) In 2006 and 2007, most state GS policies focused on incentives, including tax incentives, regulatory incentives, and state funding for studies of GS. In 2008 and 2009, policy activities became increasingly focused on tactical issues, such as permitting, property rights, and long-term stewardship of GS sites.

Twenty-three states have enacted GS legislation, as shown in Fig. 3. Of these, our results show that nine states have emerged as leaders in GS policy, which we define as enactment of policies for GS that address two or more of the issues that must be resolved for GS projects to be viable: permitting, property rights, and long-term stewardship (CCSReg Project, 2009a). Appendix A documents our basis for selecting these nine states as GS policy leaders.

Fig. 3. States with Geological Storage Policies Enacted as of September 2009. Source: Author's research. This figure shows all states that have any enacted policy on GS, including relatively minor incentives, such as Minnesota's US$ 90,000 state grant for a study on GS, as well as states that have emerged as leaders in GS policy by enacting multi-dimensional policies that address two or more of the critical issues that could make GS projects viable, including permitting, property rights and long-term stewardship.

For the deployment of CCS, some states are more important than others. Comprehensive GS policy is only needed in states with geologic storage capacity where GS projects could potentially be built. Generally, state GS activity is concentrated over sedimentary basins that are key to deployment, as shown in Fig. 4. These basins also produce oil and gas, and CO_2 EOR is currently underway in 10 of the states in these regions[6] (Koottungal, 2008), including five of the GS policy leader states.

To evaluate the relative influence of the energy and climate coalitions on the content of state GS legislation, we focus on how the nine states we identify as GS policy leaders have dealt with the key policy areas identified as areas of conflict in Table 2, including core policy beliefs, such as statement of purpose, choice of implementing agency, and treatment of EOR, as well as secondary policy beliefs, such as long-term stewardship. Policy related to most secondary policy beliefs will largely be worked out as state agencies draft permitting rules over the next few years.

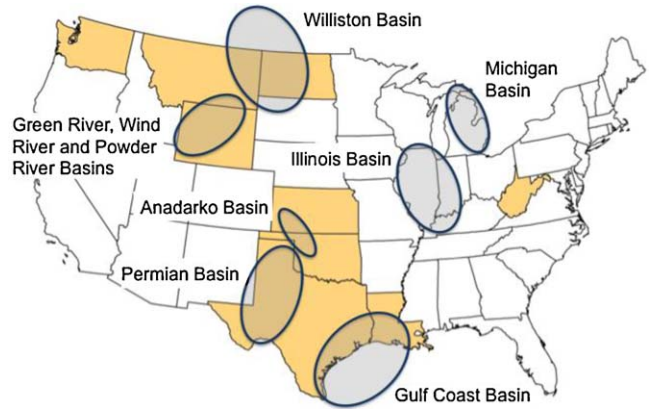

Fig. 4. Regulatory development is proceeding fastest in regions key to the success of CCS. GS policy leader states are shaded, and major basins with large geologic sequestration capacity are indicated.

4.2.1. Purpose of legislation

In the U.S., legislation often includes explicit statements about its purpose. In many bills, such statements are found in the act's title, a preamble, a section describing legislative findings, or a section putting forth general policy. These statements may not capture the full legislative intent, but they provide insight into the strategy underlying the substantive provisions of the legislation

[6] CO, KS, LA, MI, MS, NM, OK, TX, UT, WY.

Table 2
Attributes, objectives and beliefs of the energy and climate coalitions.

	Energy Coalition[a]	Climate Coalition[b]
Characteristics		
Policy Objectives	Protective: defend EOR business as usual and keep coal viable *if* climate policy passes.	Proactive: lay the groundwork for CCS to reduce GHG emissions *when* climate policy passes.
Institutional affiliations	Industry (oil, gas, coal electricity) U.S. DOE	Researchers, some environmental organizations U.S. EPA
Geographic scope	Local (project scale) and State	Global and National
Temporal scope	Present to 20 years	Centuries
Core Policy Beliefs		
Purpose of CO_2 injection	Energy production and economic development	GHG emission reductions
Binding federal GHG limits	Opposition or weak support	Strong support
Implementing Agency	State Oil and Gas agency	Environmental agency
Treatment of EOR	Protect business as usual	No unified position
Secondary Policy Beliefs[c]		
Long-term stewardship	State assumes liability after 10 year post-injection period	Federal gov't assumes liability when CO_2 is completely contained.
Well construction requirements for GS wells	Same as current EOR wells	More stringent than current EOR wells
Monitoring of injected CO_2	Subsurface monitoring	Extensive surface and subsurface monitoring
Credit for carbon storage at EOR sites	Yes	Only if EOR site meets all monitoring and well construction standards that apply to GS sites
Subsurface property rights	Should be clarified	Should be clarified
GHG emission accounting rules for GS	Based on quantity injected	Includes monitoring for leakage

[a] Position represented in IOGCC report (IOGCC, 2007).
[b] Position represented by European Parliament GS directive (European Parliament, 2009), the EPA draft class VI well rules (U.S. EPA, 2008), and the EPA draft GHG reporting rule for GS sites (U.S. EPA, 2010b).
[c] This is a limited selection of secondary policy beliefs.

and can provide guidance for the resolution of subsequent court proceedings.

The legislation that has been enacted in seven of the nine GS policy leader states has included statements of core policy beliefs, including energy supply, economic development and avoidance of GHG emissions. Typical examples are given below.

> "Carbon dioxide is a valuable commodity to the citizens of the state, particularly for its value in enhancing the recovery of oil and gas and for its use in other industrial and commercial processes and applications."—Oklahoma S.B. 610 (2009)

> "The geologic storage of carbon dioxide will benefit the citizens of the state and the state's environment by reducing greenhouse gas emissions."—Louisiana H.B. 661 (2009)

The energy coalition has had greater success than the climate coalition in influencing the statements of purpose in enacted legislation, as shown in Table 3.

4.2.2. Implementing agency

The fundamental choice of which agency will draft GS rules and take the role of regulating GS sites represents a core policy belief because it directly relates to the purpose of CO_2 injection. In most states, the choice is between an agency charged with environmental protection and an agency charged with managing natural/mineral resource development (such as oil and gas regulators). This issue has been a major source of contention in the debate over state GS legislation. For example, in 2009 in the Montana Senate, the choice of whether to give the lead to an environmental agency (Montana Dept. of Environmental Quality) or an oil and gas regulator (Montana Board of Oil and Gas Conservation) was one of the key factors that brought competing GS bills to a standstill until the governor brokered a compromise (Tollefson, 2009).

Table 3
Stated purpose of state GS legislation.

	Energy Coalition		Climate Coalition
	Economic Development	Energy supply	GHG emission reduction
Louisiana	•[a]		•
Montana	•		
North Dakota	•[a]	•	•
Oklahoma	•[a]	•	
Washington	•		•
West Virginia	•	•	
Wyoming	•		

[a] Bill specifically mentions EOR.

Kansas, Louisiana, and North Dakota chose to direct their oil and gas agencies to develop rules for GS, which are typically the same agencies that currently oversee EOR operations. In Montana, Oklahoma, and Texas, oil and gas regulators will take the lead with input from environmental agencies, while Washington, West Virginia, and Wyoming chose their environmental agencies for this purpose. Based on the dominance of state oil and gas regulatory agencies in implementing new state GS legislation, we can see that the energy coalition has had greater success than the climate coalition at delegating the authority for implementation to institutions that generally share its policy vision.

4.2.3. Treatment of EOR

State GS legislation overwhelmingly reflects the vision of the energy coalition on the treatment of EOR under GS policy by protecting EOR's status quo while creating new opportunities for EOR operators to profit from the storage of CO_2 (Table 4). Seven of the nine GS policy leader states exempt EOR from the new GS legislation. Furthermore, the GS legislation in several states creates additional opportunities for EOR, including laying the groundwork for EOR sites to receive carbon credits, offering tax incentives for EOR, and creating pathways by which EOR sites could ultimately transfer long-term liability to the state.

4.2.4. Long-term stewardship

Examination of how the issue of long-term liability has been handled in GS policy leader states provides evidence for policy

Table 4
Treatment of EOR in state GS legislation.

State	Bill	EOR exempt from GS policy	Conversion from EOR to GS	Emission Credits for EOR	Notes
Louisiana	HB 661 HB 1117	Yes			EOR is in the public interest
Montana	SB 498	Yes	Yes		After conversion former EOR sites would be eligible to transfer long-term liability to the state.
North Dakota	SB 2095 SB 2034	Yes	Yes	Yes	Incremental oil produced by EOR is exempt from the oil extraction tax.
Texas	SB 1387	Yes	Yes		Permitting rules will differentiate between (1) Non-hydrocarbon (HC) producing reservoirs; (2) reservoirs with incremental HC production; and (3) reservoirs with EOR
West Virginia	HB 2860	Yes		Yes	
Wyoming	HB 90	Yes	Yes		
Oklahoma	SB 610	Yes			

learning on the part of the energy coalition and reveals limitations related to what either coalition can accomplish at the state level. For CCS to be effective, injected CO_2 must remain sequestered for hundreds to thousands of years (Metz et al., 2005), which is a horizon that is more compatible with the climate coalition's policy vision than with that of the energy coalition. However, both coalitions envision that a government entity should assume long-term liability at some point after the GS site is closed because the long-term stewardship phase will be longer than the lifespan of most corporations (IOGCC, 2007; European Parliament, 2009). This is a secondary policy belief, and the disagreement here lies in details related to how many years must pass after injection stops before an owner can shed liability and what the conditions for liability release should be.

The IOGCC model legislation, which is representative of the energy coalition position, proposed that states assume liability from operators 10 years after injection stops. Of the states that have agreed to liability transfer (four of nine), the majority have adopted the 10-year time frame (Table 5). However, in the provisions regarding the conditions for liability release, we see divergence from the IOGCC position. Whereas the IOGCC preferred that operators should only need to demonstrate where the injected CO_2 is and to predict any future migration, the states have generally added at least slightly more protective performance criteria. For example, Kansas requires that an operator demonstrate that the CO_2 plume has stabilized and is not a threat to public health, safety and usable water (KS HB 2419, 2007). While the types of performance criteria adopted by these states are nowhere near as stringent as those articulated in the European parliament directive (which is representative of the climate coalition vision), they move incrementally in that direction, using ideas and specific phrases that emerged during the WRI and EPA GS policy meetings. This could be interpreted as evidence for policy learning on the part of the energy coalition because the state legislatures are generally a venue where the energy coalition has greater influence.

Five of the nine GS policy leader states have not accepted liability transfer as of this date. This issue has proved to be the most problematic of the three broad topics that we identify as important in moving toward comprehensive GS regulation. All of the GS policy leader states have acted in the other two areas, i.e., permitting rules and property rights issues (Appendix A). This suggests that there is a limitation in what types of GS policy change can be accomplished at the state level. States may be reluctant to assume this type of liability out of concern for tight state budgets, or because it is unclear whether having individual states assume this liability would be cost effective for commercial-scale deployment. Risk pooling could be more effective if the federal government manages long-term stewardship so that risks could be spread over more projects and across varying geologic circumstances (CCSReg Project, 2009b). Despite the fact that both coalitions agree on the overall goal of transferring long-term liability to a government entity and evidence that policy learning is creating openings for compromise on policy details, our results suggest that state legislatures may be a less suitable venue for addressing long-term liability than they are for other GS issues, such as property rights and permitting.

Table 5
Positions on transfer of long-term liability to the state.

Institution	Time frame	Requirements for liability release
IOGCC (Energy Coalition)	10 years	Document the position and characteristics of the areal extent of the CO_2 and predict the extent and movement of the CO_2 volume anticipated during the CSP closure period.
European Parliament (Climate coalition)	When stable	All available evidence indicates that the stored CO_2 will be completely contained for the indefinite future.
EPA Class VI rules (both coalitions contributed)	50 years	Demonstrate that the CO_2 plume and pressure front have stabilized, and that no additional monitoring is needed to assure that groundwater will not be endangered
WRI (both coalitions participated)	When stable	Demonstrate: magnitude and areal extent of CO_2 plume and pressure footprint; that monitoring results match model predictions; there is no evidence of leakage; and the CO_2 is not expected to migrate in a manner that encounters a potential leakage pathway.
Kansas	When stable	Demonstrate that the CO_2 plume has stabilized and is not a threat to public health, safety and usable water.
Louisana	10 years	Demonstrate that the reservoir is reasonably expected to retain mechanical integrity and the CO_2 will reasonably remain emplaced
Montana	15 years	Show that the carbon dioxide in the geologic storage reservoir has become stable.
North Dakota	10 years	Show that the storage reservoir is reasonably expected to retain the carbon dioxide stored in it

Table 6
GS policy outcomes at federal and state levels. Outcomes that represent change to the existing policy regime are designated in bold.

Policy outcome	Federal policy	State policy
GHG limits	No	**Yes**, but not in states key to GS deployment
Purpose of CO_2 injection	**GHG emission reduction**	Economic development (7 states), energy supply (3 states), **GHG emission reduction (3 states)**
Implementing agency	State chooses	Oil and gas (6 states), **Environmental (3 states)**
Post injection site care timeframe	**50 years**	Generally 10 years
Treatment of EOR	Business as usual	Business as usual

4.3. Federal GS policy

Federal GS policy developments have occurred through rulemaking, rather than legislation. Two rules governing CO_2 injection were finalized by the EPA in December 2010, one of which came from the Office of Water regulating GS wells under the UIC program (U.S. EPA, 2010b), while the second came from the Office of Air, requiring reporting of GHG emissions from GS sites and EOR operations (U.S. EPA, 2010c). The new UIC rules regulate the injection of CO_2 for the purpose of climate mitigation through the UIC Program by designating a new well class (Class VI). The injection of CO_2 for EOR remains unchanged under the UIC Class II rules. The Class VI rules are significantly more stringent than the Class II rules and would be more expensive to comply with. For example, a permit application for a Class II EOR well in Texas is a one-page form that requires only the proposed depth of the well, data about the injection formation, such as its porosity and permeability, and the locations of existing wells within a half-mile (Texas Railroad Commission, 2004). In contrast, the EPA estimates that under the Class VI rules, the cost of obtaining a permit would be approximately US$ 2 million[7] (U.S. EPA, 2008).

The GHG reporting rules (issued under the authority of the FY2008 Consolidated Appropriations Act H.R. 2764; Public Law 110–161) take a two-tiered approach, requiring that GS sites conduct site-specific subsurface and surface monitoring to verify that injected CO_2 remains underground and to quantify any emissions due to leakage, while EOR sites are merely required to report the quantities of CO_2 injected. EOR operations may elect to be classified as GS sites if they meet GS monitoring requirements.

With regards to the three key issues for GS deployment, permitting, property rights, and long-term liability, new federal GS rules address the first, but due to statutory limitations, they are silent on the second and third. The new federal rules explicitly identify GS as a means of avoiding GHG emissions and lay the groundwork for more extensive monitoring and well construction requirements. Importantly, the EOR status quo is undisturbed by new Federal GS rules, which is a major accomplishment for the energy coalition.

5. Discussion

The outcomes of policy activities within the GS policy subsystem clearly support the ACF hypotheses that policy change is unlikely when there have been no significant perturbations from outside the policy subsystem and when the coalition that instituted the existing regime is still in power. During the timeframe of this study, potential policy perturbations, such as international climate policy agreements or binding U.S. GHG limits, have not garnered support. The energy coalition, which is deeply embedded with the pre-existing policy regime, maintains substantive control, retaining power in both legislative and executive bodies with influence in the GS policy subsystem. Actors aligned with the energy coalition are able to block climate legislation at the federal level and are able to pass GS legislation that is favorable to the energy coalition in states crucial to GS deployment.

Significant outcomes of recent state and federal GS policy activity align to a greater extent with the preferences of the energy coalition than the climate coalition (Table 6). Both state laws and federal rules have entirely protected the EOR status quo and have largely delegated authority for CO_2 injection to agencies aligned with the energy coalition. Policy changes preferred by the climate coalition emerge in federal rules slightly more than in state legislation, which is not surprising because of the following: (1) rulemaking requires less political capital than does legislation, making incremental change more feasible; and (2) the climate coalition's focus has been more at the federal than at the state level.

Major advantages of the energy coalition include the fact that it had a powerful pre-existing institution (the IOGCC) that was able to engage early and effectively in the GS policy process in support of the coalition's policy preferences. By creating model state legislation and supporting its passage in states that are key to GS deployment, the energy coalition both reinforced the existing policy regime at the state level and created facts on the ground that influenced the subsequent federal rulemaking process toward positions favored by the energy coalition (as acknowledged by the preamble to the Class VI rule, 75 FR 77242). The economic power of the energy coalition in energy producing states has effectively translated into the political power needed pass laws that reinforce the existing policy regime against changes proposed by the climate coalition.

The pattern of GS policy activity does suggest that there is policy learning taking place, although it is limited. This is an area that would benefit from additional research, but this study provides preliminary evidence that inter-coalition dialogue facilitated by the WRI and the EPA has induced policy learning that has resulted in state legislation taking positions on secondary policy beliefs that are incrementally different that the positions proposed by the IOGCC.

Looking forward, our results suggest that state policymaking related to GS may taper off. First, most of the states with EOR potential have now acted. One of the energy coalition's top priorities, which is to protect the EOR status quo, has been largely achieved. Second, the energy coalition is only motivated to engage in the GS policy subsystem to the extent that they perceive that climate policy is imminent. The issue of climate change largely gained prominence in the U.S. during the period from 2006 thru 2009 following Hurricane Katrina, the 2006 release of the film *An Inconvenient Truth*, the 2007 Nobel Peace Prize to the IPCC and former U.S. Vice President Al Gore, and the release of the 4th IPCC Assessment Report. Public support for addressing climate change increased to its highest level to date during this period, and policy making on GS surged. More recently, the issue of climate change appears to have lost salience following the world economic crisis and the uncertainty surrounding the future of the Kyoto Protocol due to the perceived failure of the December 2009 Meeting of the Parties in Copenhagen. Members of the energy coalition may perceive this trend as suggesting that climate policy in the U.S. is less likely to be enacted, which would potentially undermine their motivation to devote resources to developing GS policy.[8]

[7] Based on costs of site characterization, area of review, and permitting administration.

[8] Note: State-level data through 2009 were analyzed for this study. In 2010, only one state law regarding GS was passed.

6. Conclusion

Significant policy activity regarding the injection of CO_2 took place over the past decade such that laws related to the injection of CO_2 for the purpose of geologic storage now exist in 23 states, and rules governing GS have been finalized by the U.S. EPA. While both coalitions have achieved certain objectives, for example, the climate coalition's objective of proactively putting GS policy in place has been furthered, and important progress has been made on commonly held concerns, such as the resolution of property rights issues, overall, the energy coalition has had greater success than the climate coalition in shaping laws and rules to align with its policy preferences. The energy coalition has enshrined its view of the purpose of CO_2 injection in state legislation, largely delegated authority for GS to state agencies aligned with the existing policy regime, and protected the EOR status quo, while creating new opportunities for EOR operators to profit from the storage of CO_2. Furthermore, the most fundamental objective of the climate coalition, which is binding GHG limits, remains unfulfilled. The net result is policy activity that does not significantly change the existing policy regime.

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Appendix A Geologic storage policy leader states

State	Permitting Rules	Property Rights	Long-Term Stewardship
Kansas 2009: KAR 82-3-1100-1120[a] 2007: HB 2719	Agency: KS Corporation Commission. Rules adopted February 2010	Gap: property rights issues not addressed beyond permit requirements.	State will assume long-term ownership and liability. Fund: established.
Louisiana 2009: HB 661 2008: HB 1220, 1117	Agency: Office of Conservation, Dept. of Nat. Resources Rules not yet proposed.	Addresses CO_2 ownership, liability during operations, and eminent domain. Gap: does not address pore space ownership.	State will assume long-term ownership and liability Fund established for long-term monitoring and remediation.
Montana 2009: SB 498	Agency: MT Board of Oil and Gas Conservation, with comments from MT Board of Env. Review. Rules not yet proposed.	Addresses pore space ownership, liability during operations, relationship to mineral rights, CO_2 ownership, and provides for unitization.	State will accept long-term ownership and liability for GS sites at least 15 yrs after CO_2 injection ends.
North Dakota 2009: SB 2095, SB 2139	Agency: ND Industrial Commission Rules adopted November 2009	Addresses pore space ownership, CO_2 ownership, liability during operations, relationship to mineral rights, and provides for unitization.	State will assume long-term ownership and liability at least 10 yrs after CO_2 injection ends. Fund established for long-term mgmt. and monitoring.
Oklahoma 2009: SB 610 2008: SB 1765	Agency: Corporation Commission for fossil fuel-bearing formations, Dept. of Env. Qual. for all others. Rules not yet proposed.	Addresses CO_2 status and ownership and mineral rights primacy. Inventory accounting rules adopted. Gaps: pore space ownership and liability during operations not addressed.	Gap: Long-term liability and stewardship otherwise not addressed.
Texas 2009: HB 1387, 1796	Agency: Railroad Commission, Texas Commission on Env. Quality. Rules not yet proposed, study with recs due 12/01/10.	Addresses CO2 ownership, liability during operations. Gap: pore space ownership not addressed.	Fund established from permitting fees for inspection, long-term monitoring, repairs, and enforcement, but release of liability not authorized.
Washington 2008: WAC 173-407-110 2007: ESSB 6001	Agency: Department of Ecology Rules adopted in 2008.	Gap: property rights issues not addressed beyond permit requirements.	Governed by pre-existing laws. Owner liable in perpetuity.
West Virginia 2009: HB 2860, W.V. Code, Chap. 22, Art. 11A	Agency: Dept. of Env. Protection Rules not yet proposed, will await study group recs.	Addresses mineral rights primacy. Assigns study group to make recommendations on other issues such as pore space ownership by 2011.	Gap: Long-term stewardship not yet addressed.
Wyoming 2009: HB 57, 58, 80, Water Qual. Rules & Regs. Chap. 24[a] 2008: HB 89, 90	Agency: Dept. of Env. Quality Draft rules published 3/13/09, rev. 9/25/09	Addresses pore space ownership, CO_2 ownership, liability during operations, mineral rights primacy, and provides for unitization.	Gap: Long-term stewardship not yet addressed.

[a] Proposed Rules.

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