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A Regulatory Framework for Migrating from Enhanced Oil Recovery to Carbon Capture and Storage: the USA Experience

Philip M. Marston, Esq.[a]*

[a] *Marston Law, 218 N. Lee Street, Suite 300, Alexandria, VA 22314 USA*

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Abstract

The significant CO2 pipeline and CO2 injection well infrastructure developed in the United States over four decades of underground injections of CO2 for Enhanced Oil Recovery ("EOR") operations was accompanied by development of a legal and regulatory framework for the incidental geologic storage of CO2 during EOR operations. That framework currently forbids incremental injections of anthropogenic CO2 beyond those required for oil recovery but that could be injected for the sole purpose of reducing atmospheric emissions of CO2.

This paper summarizes some key aspects of the current legal and regulatory framework applicable to the transportation and underground injection of CO2 in connection with EOR operations and identifies those elements that are adequate to support CO2 transport and injection for carbon capture and storage ("CCS") purposes. The paper next discuses regulatory changes underway that are intended to fill the regulatory gaps to allow for incremental injections of CO2 in the CCS context. Particular attention is paid to the current rulemaking proceedings before the USA Environmental Protection Agency governing permitting of CO2 injection wells for CCS purposes as well as some approaches to addressing potential regulation of CO2 pipelines and related matters.

In concluding, the paper seeks briefly review the status of transposition of the European Union's CCS Directive into binding national norms and points out some contrasts with the USA experience due to the absence of an EOR industry in Europe.

Keywords: Regulation; regulatory frameworks; legal developments; enhanced oil reocvery; EOR

1. FORTY YEARS OF CARBON CAPTURE AND GEOLOGIC STORAGE

The United States has forty years of experience with carbon capture and geologic storage of CO2 in the context of enhanced oil recovery ("EOR") operations. The geologic storage or sequestration occurs as an inherent part of EOR operations in which vast quantities of CO2 are injected into oil bearing formations that are no longer productive using primary or secondary production techniques. The CO2 acts as a kind of lubricant, causing the oil droplets trapped in the pore space to expand and reducing the surface tension that holds the oil in place, thereby allowing the oil to begin to flow again to production wells and from thence to the surface. While EOR operators attempt to recover and reuse as much of the injected CO2 as feasible in order to maximize the value of this scarce CO2 resource, the injected CO2 accumulates in the reservoir as the oil is produced, such that at the end of the EOR production cycle (which may last decades), the CO2 fluid has essentially displaced the oil-bearing fluids and is again effectively geologically sequestered in its place. This form of geologic storage of CO2 is referred to here as "EOR-based storage".

Successful CO2-based EOR operations require very large quantities of CO2 and a considerable infrastructure of CO2 pipelines, injection wells and related surface handling facilities. There are roughly 14,000 wells that have received permits under current environmental regulations as CO2 injection wells. These are classified as "Class II" injection wells under the Underground Injection Control ("UIC") program of the Environmental Protection Agency (a program that is administered principally by the major oil-producing states under what is known as "primacy" where the state adopts and administers a permitting program under the general aegis of the federal Safe Drinking Water Act ("SDWA") and under the general supervision of the federal EPA).

Current geologic injections of CO2 for EOR purposes are running at an annual rate of approximately 50 million metric tons. Total geologic injections over the last forty years had reached some 560 million metric tons through 2008.[1] The bulk of this CO2 supply (about 80 percent) is produced from naturally-occurring geologic formations. The use of naturally-occurring CO2 for EOR operations does not reduce atmospheric emissions of CO2 because the CO2 essentially moves in a closed loop from the geologic formation from which is produced, through a closed pipeline system for transport to an EOR site and is then injected down into the geologic formation for oil production. The remaining 20 percent of supply is obtained by capturing CO2 that would otherwise be released to the atmosphere (principally from natural gas processing plants and from a 1980-era coal gasification plant in North Dakota).

The large scale of these CO2 production, transport, injection and recycling operations in the USA for EOR purposes (and EOR-based storage of the CO2) has resulted in the creation of an extensive legal and regulatory framework that is now being adapted at both the federal and state levels to apply to carbon capture and geologic storage that is undertaken for emissions-reduction purposes (referred to here as "non-EOR storage").

2. THE POTENTIAL FOR EOR OPERATIONS TO USE CO2 CAPTURED FOR EMISSIONS REDUCTION PURPOSES

The rule of thumb in the EOR industry is that for appropriate EOR target formations the injection of between approximately six to twelve thousand cubic feet of CO2 ("Mcf") is required to produce one barrel of oil. The present level of injections at CO2-based EOR sites allows for the production of roughly 270,000 barrels per day of oil. EOR-based oil production is constrained, however, by the shortage of CO2 supply, which has been recognized by the Obama Administration as "an important limiting factor" in new EOR production projects. [1]

A report prepared for the Natural Resources Defense Council in 2010 has estimated that if there were no limitation on CO2 supply – for example, through widespread deployment of carbon capture technology – oil production from CO2-based EOR operations could reach 3.0 to 3.6 million barrels a day by 2030, an increase of approximately 14 fold.[2] As CO2 injections and associated geologic storage would increase as a result, a similar increase in CO2 geologic injections and storage could be in the range of 700 million metric tons per year. If such an expansion were to occur, EOR operations would be absorbing for oil production operations and ultimately storing the great bulk (if not essentially all) of the CO2 captured from power plant or industrial sources for emissions reduction purposes for many years to come. For example, of ten commercial-scale demonstration projects being developed in the USA for deployment prior to 2020 with financial support from the USA government, nearly 80 percent of the CO2 proposed to be captured is planned to be injected in EOR operations (or at mixed EOR/saline aquifer sites).[1]

In light of this experience and the expected future role of EOR operations in storing CO2 to be captured for emissions-reduction purposes, the relevant starting point for developing a legal and regulatory framework for CCS in the USA is the existing framework developed over the last four decades. The necessary changes to the legal and regulatory rules will need to be integrated as seamlessly as possible into the existing legal and commercial framework.

3. ENVIRONMENTAL REGULATION OF INJECTIONS AND STORAGE

3.1 The regulatory implications of the differing risk profiles of EOR storage and non-EOR storage of CO2

As noted above, CO2 injected during EOR operations is stored in the formation as it replaces the oil in the underground pore spaces as the oil is being produced; in effect, the CO2 is essentially replacing the oil in the formation such that there is no continuous build-up of pressure on the subsurface formation rocks. As CO2 is injected at a pressure that is sufficient to force it into the formation at the injection well sites, the prevailing subsurface pressure is simultaneously being reduced at the production wells where the oil (mixed with some of the CO2 that has accomplished its job as a production enhancing agent) is brought to the surface. In contrast, CO2 injections for non-EOR based storage are entirely incremental, in the sense that the injections add the CO2 injectate to the pre-existing subsurface fluids (e.g. brine in a saline aquifer). As a result, in these non-EOR based storage situations, there is no continuous reduction in pressure at the production wells, such that a pressure front gradually expands out from the point of CO2 injection. This pressure front would normally continue to expand throughout the injection period (which could be decades) and only stabilize following the completion of CO2 injections.

This basic difference in subsurface conditions means that EOR-based CO2 storage presents a fundamentally different risk profile as compared to non-EOR based storage. Attempting to develop tools for tracking and predicting the future movement of the pressure front that would be created in non-EOR based storage has been a major area of technical research. Much work has been done to develop and test different modeling and monitoring tools for predicting and confirming the movement of the CO2 plume. Predicting the behavior of the pressure front is required among other things for determining the size of the storage site, the Area of Review surrounding it, and the acquisition of necessary property rights to the subsurface pore space to be used. Monitoring tools are needed to track the actual subsurface movement to confirm the accuracy of the modeling and to detect potential leakage to the surface (which would require some type of remediation and presumably some type of compensation if an economic benefit had been earned at the time of initial injection).

In the case of EOR-based storage over the last forty years, where the purpose of the injections has been the production of oil and the resulting CO2 storage has been incidental to this purpose, there has been no reason to seek to quantify the exact mass of CO2 that remains sequestered at the end of oil production operations. Similarly, there has been no need to monitor subsurface developments following plugging of injection and production wells at the conclusion of EOR operations at a particular site. Because of this lack of measuring and monitoring of EOR-based storage, there are no precise numbers of the mass of CO2 sequestered, nor mechanisms for verifying or confirming the precise CO2 mass involved even though hundreds of millions of tons of CO2 have been sequestered during the course of EOR operations. The absence of documented data from EOR-based injections and storage has meant that much of the published research on geologic storage of CO2 has focused on the limited number of projects around the world in which the injected CO2 mass has in fact been specifically measured (e.g. Sleipner, Weyburn, In Salah, etc.), even though these projects involve the high-risk profile of non-EOR storage and even though the quantities involved are a small fraction of the amounts stored during lower-risk EOR operations in the USA. The widely-discussed Sleipner project, for example, involves non-EOR based storage of less than one million tons per year – equal to approximately 2 percent of ongoing EOR-based storage in the USA. As a result, the published results tend to focus on projects that are quite unrepresentative of the actual experience with EOR-based storage and unrepresentative of the likely storage sites that will receive the vast bulk of CO2 to be captured in the United States from initial deployment of CO2 capture technology.

In view of the role that EOR-based storage will play in any CCS strategy deployed in the USA for emission reduction purposes, it becomes critical to build on the existing environmental regulation of EOR-based storage. The USA EPA has sought to do this in pending rulemaking proceedings expected to be finalized during 2010. EPA's original proposal, however, does not distinguish between geologic sequestration in non-EOR storage operations (with the build up of pressure throughout the injection period) and EOR-based storage (with its lower pressure and consequent lower risk profile). As a result the expected costs of qualifying for the new EPA well classification for geologic sequestration (known as "Class VI") are likely to be prohibitive for EOR-based storage operations. This would foreclose the ability to use EOR-based storage to receive the CO2 to be captured from about three-quarters of the planned commercial scale demonstration projects and could create a potentially insurmountable barrier to rapid deployment of the CCS demonstration projects in the USA.

To address this problem, and in recognition of the fundamental difference in risk profiles, a diverse group of industry and environmental groups developed a revised approach to govern the geologic sequestration that occurs during EOR operations. Known as the "Multi- Stakeholder Discussion group (or "MSD group"), the group developed proposed standards for monitoring and verification of CO2 sequestration in the EOR context that were more extensive than those required today for CO2 injections in EOR operations (or that would be required by EPA for ongoing "business as usual" EOR operations), but less extensive (and less costly) than what might be appropriate for the greater risk profile presented at a non-EOR based storage site. In effect, the approach developed by the MSD group is to create an intermediate classification (proposed as subcategory "IIb" of the existing Class II well classification).[3] The intent is to develop a set of monitoring and verification tools and practices that are tailored to reflect the risk profile presented by EOR-based storage, while also allowing the parties to accurately measure the total mass sequestered and to allow the regulator to confirm these quantities and verify that the CO2 injectate remains sequestered. This measurement, monitoring and verification would be required in order to assign an precise economic value to a specific mass of CO2 sequestered in the context of a CO2 emission-reduction regulation (whether the sequestered CO2 is treated as an offset, as CO2 "not-emitted", or in meeting an emissions performance ceiling under either a tax-based or a market-based capping regime).

At this writing, it is unclear whether this risk-adapted approach for EOR-based CO2 storage will be adopted by the EPA. How the EPA rulemaking eventually addresses this issue is expected to have a major role in whether the current group of CCS demonstration projects planned in the USA proceed to financing and construction or not.

3.2 Addressing liability issues.

Addressing all the potential liability issues presented by geologic storage of captured CO2 far exceeds the scope of this brief article. It is worthwhile, however, to examine in particular the potential applicability of the Resource Conservation and Recovery Act ("RCRA") 42 U.S.C. §§ 6901-6992k. Under the current law, CO2 injections involve a "fluid" and are permitted by federal environmental legislation (principally, the Safe Drinking Water Act) through Class II well. In the event that CO2 captured from power generating or industrial processes included toxic substances or solid waste, then the injections might also become subject to additional environmental protection schemes, principally including RCRA, which regulates certain solid wastes which are defined in part as "any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations" (and further defined by regulation). In addition, Subtitle C of the act addresses management of solid wastes that are also "hazardous wastes" as there defined). Because Subtitle C establishes a kind of "cradle to grave" regulatory scheme with requirements for generators and transporter – and provides for substantial civil and criminal penalties for violations – its applicability to geologic storage of CO2 would increase costs of CCS significantly.

At present, CO2 used for EOR purposes (stored as an inherent part of the production process) is a valuable commodity that companies may expend hundreds of millions of dollars to acquire and is not a waste. Moreover, as noted above, the Obama Administration's Interagency Task Force on CCS has itself recognized that CO2 is "not toxic" and that the current scarcity of CO2 supply is "an important limiting factor" in EOR oil production.[1] Hence, it is difficult to see how a CO2 stream that does not contain toxic impurities could be viewed as subject to a statute regulating wastes. CO2 is not currently a listed RCRA hazardous waste and the Obama Administration's Interagency Task Force on CCS has observed that from current technical knowledge, CO2 is "unlikely to exhibit the characteristics of ignitability, reactivity, or corrosivity at the point of capture or compression or injection for permanent storage" that would lead to its characterization as a hazardous waste under RCRA.[1]

The EPA itself has taken the approach to date that the status of CO2 under RCRA depends on its composition, stating that it cannot make a categorical determination as to whether injected CO2 is "hazardous" under RCRA:"[4]
[T]he composition of the captured CO2 stream will depend on the source, the flue gas scrubbing technology for removing pollutants, additives, and the CO2 capture technology. In most cases, the captured CO2 will contain some impurities, however, concentrations of impurities are expected to be very low.
Accordingly, so long as the CO2 stream does not contain chemical constituents at levels above the toxicity characteristic concentrations listed by EPA (Table 1 of 40 C.F.R. § 261.24(b)), such a stream "likely would not be subject to Subtitle C requirements as a RCRA hazardous waste".[1]

In any event, RCRA applies at the point at which the waste is generated. CO2 that is captured from industrial or power plant operators could contain impurities that are in fact toxic (e.g. arsenic, mercury, selenium , etc.).[4]. Therefore the issue of whether a particular CO2 stream constitutes a hazardous waste based on the toxicity of particular components would depend on its specific composition and the presence of one of a listed substance at levels that exceed the toxicity characteristic concentrations stated in the EPA's regulations. At present, the question of managing undesirable substances that might be introduced into a CO2 stream captured during an industrial process can be managed by prohibiting the introduction of any solid wastes or hazardous substances into the pipeline. If such a contractual requirement in an offtake agreement requiring the CO2 supplier to completely remove all such substances from the CO2 stream before tendering the CO2 stream for delivery is too expensive for the capturing entity to meet, then the transaction will not be consummated and geologic sequestration will not be an available option for emissions reduction.

EPA is planning to issue a proposed rule during 2010-2011 that would specifically examine and address the potential applicability of RCRA in the context of CCS operations. One option believed to be under consideration is the development of a "conditional exemption" from RCRA intended to facilitate implementation of CCS. Such rulemaking is likely to be of considerable importance in determining the viability of geologic sequestration as a CO2 emissions reduction tool.

Another major liability issue is the question of dealing with long-term liability. In some respects, this issue is less important that it might initially appear because under the existing legal and regulatory framework, the EOR operator already bears the liability for CO2 injections. The real issue is not so much liability as the question of trying to ensure the continued existence of some institution responsible for continuing monitoring and remediation activities after the close of EOR operations (which may continue for decades) and the availability of adequate funding for these activities. Various options are available, a number of which are discussed in the White House CCS Task Force Report (at pp. 109-118).

Some combination of existing state and federal law and commercial practices is likely to evolve over time as the potentially applicable legal rules imposing environmental liability are clarified. The key point, however, is that the policy decisions regarding the imposition of environmental liabilities must precede the policy choices regarding managing the liabilities thereby imposed. It is thus premature to attempt to craft federal liability limits, indemnification programs, bonding programs, etc. until the governments (both state and federal) define what liabilities there are to be managed.

4. THE REGULATION OF CO2 PIPELINE TRANSPORT

The present CO2 pipeline infrastructure in the United States comprises approximately 3,600 miles of pipeline. CO2 pipelines are generally subject to federal and state regulation to ensure safe operation. At the federal level, the Federal Pipeline and Hazardous Materials Safety Administration (PHMSA) within the Department of Transportation establishes and enforces standards designed to ensure proper design and safe operation of CO2 pipelines transporting supercritical CO2 fluid. CO2 is not classified as a hazardous liquid by the DOT, but "for administrative convenience", the agency included the regulations governing CO2 pipelines within the section of the regulations that do address hazardous liquids (49 C.F.R. pt. 195). To date the safety record of the industry has been excellent, with only 12 total accidents reported between 1986 and 2008, none of which resulted in human injuries or fatalities.[7]

There is no federal economic regulation of CO2 pipelines. As is the case with oil pipelines (but not natural gas pipelines), there is no federal siting program and no ability to obtain a federal grant of eminent domain power to acquire private property for pipeline right of way purposes. At the state level, however, there are varying laws, some of which allow the use of an eminent domain power for the acquisition of CO2 pipeline right of way under varying terms and conditions.

One of the key regulatory issues currently being discussed with whether the existing framework for CO2 pipeline regulation will be adequate to support the widespread commercial deployment of CCS technology. In reviewing those issues, it is important to understand the operational and commercial dynamics of CO2 pipelines for receiving captured CO2 from power plants or other large industrial sources.

There are several distinctive features of CO2 pipeline development that have important implications for potential regulatory regimes:

- Small number of very large supply sources. Major power plants that capture CO2 will produce large supply sources relative to pipeline capacity. For example, a new 650 MW power plant might capture up to 4 million metric tons per year or more. It would take just 5 such capture sources to fill a large, 30 inch, pipeline with the capability of transporting 20 million tons per year. To take a natural gas analogy, it would be like constructing a major new natural gas pipeline for the sole purpose of receiving the output of just five huge wells for a 20 or 30 year term. In sum, each supply source will account for a considerable proportion of the total throughput capacity to be constructed. Hence, a CO2 pipeline will be very different from both oil and natural gas pipelines. In the case of oil pipelines, the commodity can be stored onsite awaiting transportation and there are alternatives to pipeline transport (truck, barge, etc.), although the alternatives may be more expensive and less desirable. In the case of natural gas pipelines, each well or supply source constitutes a small portion of the overall throughput, such that new wells or supply laterals can be attached or wells plugged and laterals abandoned as the supply situation changes.
- Power plant and industrial capture sources will need a dedicated, reliable output offtake service that is assured 24 hours a day, every day of the year. These contractual assurances will need to be provided before financing for the plant can be obtained (and may also be a condition of obtaining a federal contribution to funding as a demonstration plant). Absent such assurances, the project is unlikely to be obtain financing and will not be constructed.
- The market for the CO2 will be a limited number of EOR injection sites where very large quantities of CO2 are required. In combination with the small number of supply sources, this means that the pipeline grid will be a "few-to-few" network, involving a relatively small number of major CO2 supply points and a relatively small number of EOR injection and storage delivery points. Parties at both ends of the pipeline will need long-term assurances of firm, reliable and flexible service.
- These contractual assurances must be negotiated and committed to before either the capture source or the pipeline can be financed, much less constructed. It is hard to conceive how the developer of a non-existent pipeline could exercise any market power, extract unjust or unreasonable rates, or impose unjust terms or

> conditions from the developer of a non-existent capture facility. Both parties will need to negotiate the agreements prior to either of the physical facilities being built. Under such circumstances it is difficult to identify a source of monopoly power or undue market power that would justify regulatory intervention.

In effect, the CO2 pipelines will be special purpose or “dedicated” pipelines, with each one designed, planned, financed and constructed to serve a small defined set of contracted facilities for many, many years (and perhaps for “life-of-facility” type terms. In short, market dominance issues are unlikely to arise (except perhaps in limited and unusual circumstance) because the contracts for service are entered into prior to the pipeline's construction and are indeed essential to its initial financing. In the latter case, it may well be the pipeline developer that is more vulnerable to exploitation or economic power exercised by the potential CO2 capture source, not the other way round. Potential market power issues could perhaps arise of course at the expiration of the contracts that initially supported the pipeline construction or expansion (e.g. some time after the year 2035 or 2040). At that point in time, a pipeline would be in place and depending on (a great many other) circumstances at that time, the pipeline operator might be in a position to exercise significant market power.

These underlying realities will apply whether the pipeline is privately owned or whether it is government-owned and operated as a non-profit public service. Hence, if a regulatory framework were adopted that was intended to ensure open and non-discriminatory access to offtake service, it must recognize that the pipeline will have been designed and constructed to serve the specific contracted capture sources and there is likely to be only quite modest ability to accommodate CO2 from other capture sources developed subsequently. The practice of “prorationing” or reducing service to pre-existing customers or shippers to make room for new customers – a practice typically used in federal “common carriage” regulation of oil pipelines, for example – is simply incompatible with these underlying operational requirements because the unpredictability of service levels under this regulatory approach would fail to meet the fundamental requirement of customers for firm dedicated offtake service. In effect, the adoption of regulatory rules that would require prorationing of capacity or force the pipeline to diminish service to contracted customers to make room for subsequent project would jeopardize the viability of all capture projects.

The European Union’s CCS Directive recognizes this constraint when it specifically provides that “[t]ransport network operators and operators of [CO2] storage sites may refuse access on the grounds of lack of capacity.” [8]

In sum, there is no apparent need to implement economic regulation of CO2 pipelines today or in the foreseeable future. The question of potential regulation of CO2 pipelines could appropriately be revisited after the successful deployment of commercial scale carbon capture facilities.

5. ACQUIRING PORE SPACE FOR CO2 STORAGE.

The legal regime in the USA regarding subsurface rights to inject and store CO2 is unlike the law in most of the world (including in other common law regimes that are descended from British law). In the United States, the subsurface generally belongs to the surface owner and may be conveyed separately from the surface (i.e. “separation of the mineral estate”) whereas in most of the world the subsurface rights belong to the sovereign. This legal regime applies whether the injection is for EOR-based or non-EOR based storage. This area of the law is thus a specialized subset of real property law that, while critically important to the deployment of CCS technology in the United States, [9] is of little interest and little consequence in other jurisdictions of the world and therefore not addressed here.

6. TRANSPOSITION OF THE EU’S CCS DIRECTIVE AND THE AMERICAN EOR EXPERIENCE.

The European Union’s CCS Directive was adopted in April of 2009 and entered into force in June of 2009. The Member States have until June 25, 2011 to transpose the Directive into binding national law. To assist in the overall implementation process, the EU has published four draft “Guidance Documents” addressing four aspects of geologic storage (storage life-cycle risk management framework; site characterization, CO2 stream composition, monitoring and corrective measures; criteria for transferring responsibility a Competent Authority; and financial security and financial contribution).[10] Public comments were received over the course of the summer of 2010 and final guidelines (which represent staff-level positions and are not officially binding) are expected to be published before the end of 2010.

The absence of an EOR industry in Europe over the last several decades means that EU Member States are likely to look more to oil or natural gas frameworks as models for geologic storage. The absence of a European EOR industry further suggests that there is less familiarity with CO2 injections generally and that this may help explain the greater level of public opposition. For example, projects in Germany to inject quantities of CO2 that appear very modest by American standards triggered very powerful public opposition that has ultimately led to delays in adopting a CCS law to transpose the EU Directive.

It is even possible that the American experience with CO2 injections in EOR operations over the last forty years -- and the search for more new sources of CO2 supply to aid in oil production -- may mean that geologic sequestration of power plant of emissions of CO2 in the United States proceed far more rapidly than in the European Union, even in the absence of federal limitations on CO2 emissions.

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