State Staff Information Sharing "Surge" Call Summary

"Enhanced Oil Recovery"

September 2016

The process of enhanced oil recovery (EOR) involves injecting carbon dioxide (CO_2) into depleted oil wells in the subsurface of geologic oil formations. Sometimes the CO_2 is simply stored in the geologic reservoirs. When CO_2 is used in reservoirs where recoverable oil remains, the EOR process fills in the reservoirs, builds pressure and allows for enhanced recovery. Recovering additional oil as a revenue stream can improve the economics of storing CO_2. Both naturally occurring and anthropogenic (originating in human activity, such as captured from a coal plant) carbon dioxide can be used in an EOR project, as we will see in Texas.[1]

"At the depths and temperatures of these fields, supercritical CO2 acts like a fluid."[1]

When natural gas with high levels of carbon dioxide mixes with water, it can cause coercion in pipelines and other facilities.

As part of a DOE-supported technical assistance conversation, twenty State PUC staffers gathered on September 23, 2016, to explore how enhanced oil recovery (EOR) has affected and been affected by regulatory activity. Staffers from the Texas Railroad Commission and the Michigan Public Service Commission led the discussion that is summarized below. The Michigan staffer gave insight into why EOR exists in Michigan and the regulations that interacted with EOR. The Texas staffer discussed regulatory and policy implications in Texas.

Antrim Shale is a major source of natural gas in the northern part of the Michigan Basin.

Michigan has one application of carbon dioxide enhanced oil recovery in the northern Lower Peninsula that has a history that began in the mid-1990's. Some non-regulated affiliates in Michigan installed carbon dioxide stripping plants to reduce carbon dioxide in the Antrim Shale natural gas stream. At first, when Antrim shale production was low, carbon dioxide was vented into the atmosphere. As production increased, units to strip carbon dioxide from the natural gas stream were built. That's when they begun to experiment with EOR at a nearby oil production facility. After gas volume dropped, consolidation of the stripping units began.

Eventually, the non-regulated affiliates sold off the carbon dioxide stripping and EOR equipment to CORE Energy and they have been using the EOR equipment since the early 2000's. Shortly after, about a decade ago, **CORE, the U.S. Department of Energy, and other Michigan companies partnered in a carbon sequestration demonstration**. The

[1] Miles Keogh, "Part II: Technological and Regulatory considerations for Carbon Capture and Storage" in *Coal Generation Technology & Carbon Capture & Storage* (2009), 13-28.

underground carbon site continues to be monitored and according to CORE Energy's website, the project is a successful pilot project.

CORE Energy is not a regulated utility, and therefore their interactions with the PSC are limited. However, they did seek support from the PSC for a legislative change that would grant the PUC authority to site carbon dioxide pipelines similar to their existing authority of natural gas pipelines. Act 16 was amended in 2014 to grant the PSC authority to site CO_2 pipelines. However, only one conversation with CORE took place about developing a carbon dioxide gridline, but the PSC has not processed any applications since the amendment. Other than CORE energy and the affiliates of the demonstration projects, there have been a few EOR proposals but no developments in Michigan.

Percent of oil recovered using various methods

Primary Methods	~10-20% oil is recovered
Secondary Methods (with water)	An additional ~18% of oil is recovered
Tertiary Methods (with CO_2)	An additional ~17% of oil is recovered

Texas has the most experience and the largest volume of CO_2 EOR projects in the world. The first project was in 1972 in west Texas and, until recently, most carbon dioxide came from naturally occurring underground reservoirs. Texas has about 114 commercially active carbon dioxide injection projects which together inject about two bcf of CO_2 and produce over 280 thousand barrels of oil a day. In the US, EOR counts for approximately 6% of onshore oil production, or 350,000 barrels of oil a day. However, expense is a concern since oil without EOR is economical (at $46 a barrel from west Texas).

The Texas Severance Tax Incentive is 4.6% of the market value of each barrel of oil produced. It is established by the legislature, the Railroad Commission implements, and the State Controller oversees the assessment and collection of the tax.

Ownership Texas has experienced issues and resolutions associated with CO_2 storage including service and subservice property rights, pooling possibilities, and unitization. For example, it is voluntary to unitize a field for oil production, but you must unitize a field to do EOR, unless you own the whole field. The state owns any stored carbon dioxide and it is regulated by the Railroad Commission. The Railroad Commission would also regulate any carbon dioxide withdraw from those stored sites as well. Operators have additional responsibilities. There have also been some legal issues around the criteria to being considered a common carrier and the rights that come along with that status such as eminent domain.

Jurisdiction There are many state bodies that have jurisdiction over parts of the EOR and/or the sequestration process. The Railroad Commission regulates both conservation and environmental protections associated with oil and gas. The Texas Commission of Environmental Quality has jurisdiction over other environmental issues. Now the RRC has jurisdiction over the CO_2 EOR and sequestration and CO_2 in a currently or formerly producing hydro-carbon producing reservoir and the reservoirs below and above that. There are provisions for long term storage as well. The Oversight and Safety division of the Railroad Commission also oversees pipelines, which includes CO_2 pipelines.

Incentives There are also economic incentives in Texas, particularly anthropogenic CO_2. There is a severance tax on crude oil, but using CO_2 grants a 50% reduction in that severance tax, and if it is anthropogenic CO_2 then the tax is lowered by another 50%, to 25% of the original severance tax. The Railroad Commission must approve a measurement, monitoring and verification program for stored anthropogenic CO_2 and Texas has only approved one so far. The approved process was phased so that costs and the verification process can be controlled. Not all states have severance taxes.

Texas is trying to remove barriers to capture, transport, store, and sequester CO_2 particularly for power generation facilities, as well as those that ultimately sequester provided that they can prove that 99% of the CO_2 will remain sequestered for 1,000 years (an expensive monitoring requirement).

Older wells from the early 1900's may not have been completed or plugged properly and therefore must be examined more carefully with respect to CO_2 injections and sequestration for the possibility of CO_2 escaping and protection of groundwater. Retrofits or other corrosion protections may be needed for the well or pipelines. Some older wells have older paperwork that might not have been well done.

Seismicity The public is generally concerned with four areas: (1) hydraulic fracking, (2) extraction, (3) enhanced recovery, and (4) wastewater disposal. One of the reasons that there has appeared to be a spike in seismic activity is the recording of seismicity itself: the US Array has more monitors which thus pick up lower seismicity, hence some were led to believe that there were more earthquakes.

Seismometers measure the movement of the earth and attempt to detect the location and depth of an seismic activity epicenter. Currently, the resolutions of the seismic monitors are not very sharp and at times indicate that the epicenter of seismic activity is ten miles long! The more monitors you have, the better the resolution, the more likely it is to detect lower levels of seismic activity, and the more likely it is to locate the problem.

Texas has amended at least two rules that deal with oil and seismicity. First the disposal rule requires applicants to indicate if there has been seismic activity 100 square miles around the site. If so, then they would have to provide information on how they would not include risk factors that induce seismic activity. Sixty applications were filed and 20 were approved with special conditions that might include seismic monitoring, volume limits or other types of conditions to mitigate risk. Additionally, the Texas Railroad Commission amended a rule to grant authority to shut in wells that are suspected to induce seismic activity.

The state does have some information on faults. Not all faults are known, but also, not all faults are suitable for creating seismic activity. The Texas legislature has developed a four million dollar grant to their state geologists to improve their seismic monitoring, the TexNet Seismic Monitoring Program. Leasing the sites for the monitors can be complex as well. First, the location must be away from human activity to lower the risk of interface devaluing the quality of the data. Second, the state must lease the space for the monitors to sit at least twenty feet underground. Texas also has mobile monitors for when activity is more extreme. The monitoring site is clearly marked.