



Utilization of Carbon Dioxide for Enhanced Oil Recovery



What is Enhanced Oil Recovery?

Oil fields are found in layers of sedimentary rock buried hundreds to thousands of feet below the surface. The crude oil in porous and permeable rock layers originated from organic material, such as plankton and algae, and was deposited and preserved millions of years ago. Crude oil is typically a fairly viscous fluid that, like carbon dioxide, is less dense than water and subsurface brine and tends to migrate towards the surface. Conventional oil fields are formed when the migrating oil is trapped by impermeable rock layers. Many oil fields have trapped buoyant oil and gas fluids in the subsurface for millions of years. Today, sophisticated techniques have been developed for finding and producing oil fields.

When an oil field is first produced, the natural high pressure in the formation, which is a function of burial depth below the surface, helps to push the oil out of the formation and to the surface. In the early days of oil industry, this sometimes led to the famous “gushers” seen in history books. Typically, native subsurface pressure is great enough to produce roughly 10-30% of the oil in an oil field. Once the pressure is depleted during the natural or “primary” production phase, various techniques are employed to restore a pressure drive in the oil field and reduce the thickness or viscosity of the oil so that additional oil can be recovered. In addition to water flooding, there are 3 major approaches used in enhanced oil recovery (EOR):

- *thermal*- steam is injected to thin the oil and help it flow;
- *chemical*- polymers or surfactants that behave like soap are injected to break up the oil and help release it from the rock surfaces in the pore space; and,
- *gas*- natural gas (a by-product), nitrogen or carbon dioxide is injected to increase reservoir pressure and to help thin the oil so it can flow to the surface.

Figure 1 illustrates how gas – in this case, compressed carbon dioxide which has liquid-like density but gas-like flow properties – is used for EOR. Carbon dioxide and often water are injected into the oil reservoir through an injection well. The carbon dioxide mixes (becomes miscible) with the oil, swelling and decreasing the viscosity of the oil. At the same time, the injected carbon dioxide and water re-establishes high pressure in the oil field, helping to push the oil towards the production well. The resulting oil, carbon dioxide, and water mix is brought to the surface in a closed loop system that allows the operator to separate the carbon dioxide and water for reuse while the oil, and in some cases the related products, are sold into the market. In this process, carbon dioxide displaces oil and some of it remains behind permanently. Because not a lot of surplus carbon dioxide is available in a form that can

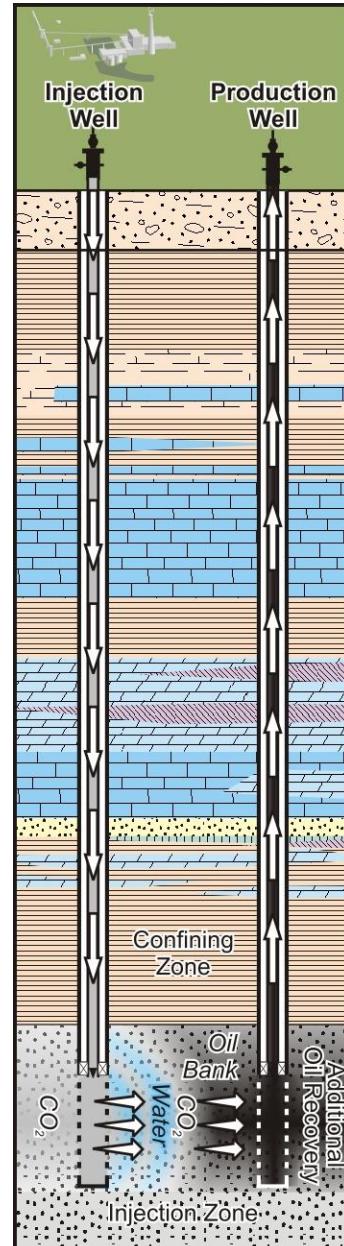


Figure 1. Carbon Dioxide-EOR Illustration

be used for EOR, operators work diligently to recover as much of the carbon dioxide as they can. Despite these efforts, approximately 20-30% of the injected carbon dioxide remains in the ground.

Why Use Carbon Dioxide for Enhanced Oil Recovery?

Carbon dioxide has unique properties and is highly effective at freeing otherwise stranded oil from depleted oil fields. Today, there are more than 114 active commercial carbon dioxide injection projects involving EOR in the United States. Combined, they inject more than 2 billion cubic feet of carbon dioxide and produce more than 280,000 barrels of oil per day (see April 19, 2010 Oil and Gas Journal). For comparison, the total undeveloped US domestic oil resources still in the ground total more than 1 trillion barrels (160 km³), most of it remaining unrecoverable. By most estimates, EOR can help to recover an additional 50-60% of the original oil in place. DOE estimates that if the EOR potential were to be fully realized, State and local treasuries would gain \$280 billion in revenues from future royalties, severance taxes, and state income taxes on oil production, aside from other economic benefits. Further developing this potential would depend on the availability of commercial carbon dioxide in large volumes, which could be made possible by widespread use of carbon capture and storage.

What does it mean for the MRCSP?

Use of carbon dioxide, captured at industrial emission sites, for EOR could increase domestic oil production while making it more economically attractive for industry to reduce carbon dioxide emissions. Executed together, the synergy of EOR and Carbon Capture and Storage are referred to as Carbon Capture, Utilization, and Storage or CCUS. The ultimate goal of CCUS technology development is to accelerate deployment of viable options for reducing carbon dioxide emissions related to large point sources while increasing domestic oil production. The Midwest Regional Carbon Sequestration Partnership (MRCSP) region contains some of the largest historic oil-and-gas producing areas in the conterminous United States (Figure 2). The MRCSP estimates that potentially 8,500 million metric tons of carbon dioxide could be stored within our region alone – or approximately ten years worth of emissions from our region. Using carbon dioxide for EOR could lead to the production of an additional 1.2 billion barrels of oil that would otherwise be stranded in the ground.

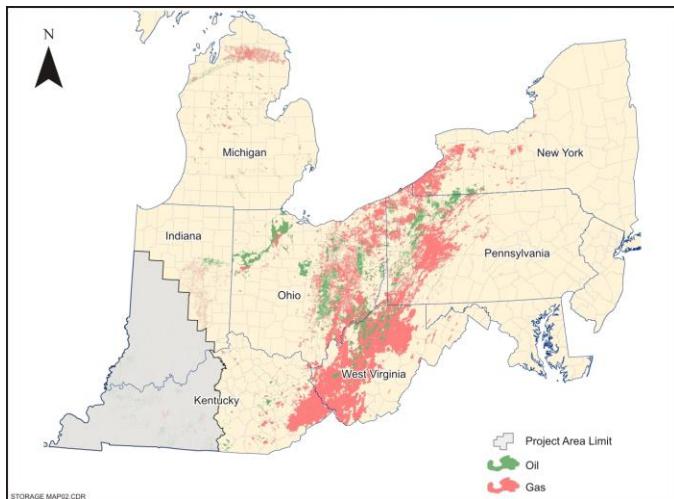


Figure 2.
Oil and gas fields map for the MRCSP region

Existing EOR operations also offer opportunities to research carbon storage technologies while providing valuable information about optimizing the recovery of additional oil. Experienced gained will help develop more efficient ways to monitor carbon dioxide injection both to assure safety but also to make the best use of resources. MRCSP will also further refine the understanding of the oil bearing formations by continuing with its geological characterization work throughout the region.

For More Information or to Provide Input

If you have questions or want more information, please contact T.R. Massey, Battelle, at 614-424-5544 (masseytr@battelle.org). Information on overall MRCSP activities is available on the Web at www.mrcsp.org. The Web site includes detailed information about MRCSP small-scale tests, as well as information about global climate change, carbon storage and the overall activities of the MRCSP.