

How America Can Dramatically Ramp Up the Production of Domestic Oil and Simultaneously Sequester Large Volumes of CO₂

By: A. James Mayer

Enhanced oil recovery using CO₂ injection and sequestration offers the potential to vastly expand domestic crude oil reserves and production, while simultaneously providing one significant positive answer to CO₂ emissions. Carbon dioxide Enhanced Oil Recovery (CO₂ EOR) is a value added sequestration solution that is proven and commercial. Injection of CO₂ into mature oil fields for EOR is being actively practiced and has been safely and successfully utilized for 35 years. In fact, CO₂ EOR was growing in the U.S. even before the crude oil price run-up at a time when oil was selling for \$20 per barrel. This technique now accounts for about 4% of U.S. crude oil production.

Leading experts estimate that CO₂ EOR has the potential to increase domestic oil production by as much as 50%, adding 2-3 million green barrels of domestic oil production by about 2030. This translates to production of 730 million to 1.0 billion barrels of "green oil" each year while simultaneous sequestering between 240 and 400 million tons of CO₂ annually (and possibly more). The domestic CO₂ EOR resource base is immense. Ultimately recoverable oil reserves are estimated at up to 100 billion barrels; more than double America's proved conventional oil reserves of between 21 and 31 billion barrels.

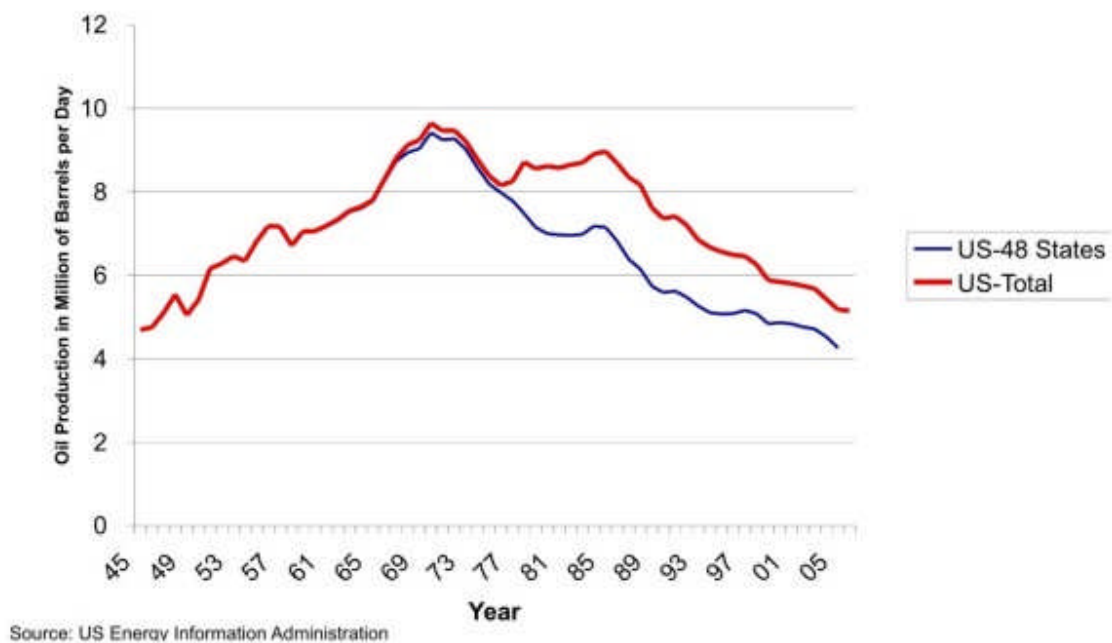
The U.S. clean/green coal program can be markedly advanced through the aggressive development of CO₂ EOR. Large percentages of high purity carbon dioxide can be inexpensively captured from new coal gasification plants at low cost and sold into the EOR markets, providing an additional revenue stream and improving the economics of coal gasification projects to make needed clean electricity, fuels and chemicals. "Green Oil" produced from man-made CO₂ is generally believed to have an excellent fit in a national "Clean Energy Portfolio."

There are already about 3,600 miles of CO₂ pipelines operating in the U.S. These pipelines carry carbon dioxide from naturally occurring underground reservoirs, natural gas processing facilities, ammonia manufacturing plants, and a large coal gasification project to

some U.S. oil fields for use in EOR projects. Rapid expansion of this pipeline network is crucial to realizing the full potential of CO₂ EOR.

Background: Crude oil production has been declining in the U.S. since its peak in the early 1970s (see Figure 1 below). Current production is about 5.2 million barrels per day, excluding natural gas condensates and other liquid by-products. Leading experts estimate that an additional 2-3 million daily barrels per day of American crude can be produced using CO₂ EOR, representing the potential to increase domestic oil output by as much as 50%. As an indicator, CO₂ EOR has already stimulated rising oil production levels in Mississippi and Wyoming, where adequate, low cost sources of CO₂ have been available to support growth. Unfortunately, there are CO₂ shortages in most U.S. oil basins that constrain the growth of CO₂ EOR.

Figure 1: US Oil Production Has Been Declining Since 1970



In terms of resource base, the U.S. CO₂ EOR prize is tremendous, with technically recoverable reserves estimated to be as much as 88 billion additional barrels of oil ultimately recoverable from declining oil fields (see the Department of Energy fact sheet at http://www.fe.doe.gov/programs/oilgas/eor/Ten_Basin-Oriented_CO2-EOR_Assessments.html). Economically recoverable CO₂ EOR reserves are estimated to be about half that today, or approximately 40-50 billion barrels still a tremendous domestic energy, environmental and economic development prize.

Experts are currently assessing another exciting CO₂ EOR target a new class of virgin oil resources being referred to as residual oil zones or transition zones. Residual oil zones ("ROZs") are untapped oil-bearing geologic units beneath some main pay zones from which the easy oil has been displaced by natural underground water movement over the geological past (a process analogous to oil industry water flooding). CO₂ injection into ROZs is a promising method to mobilize enough of the remaining oil to justify development of a number of these formations. Several major commercial ROZ projects are already underway in the U.S.

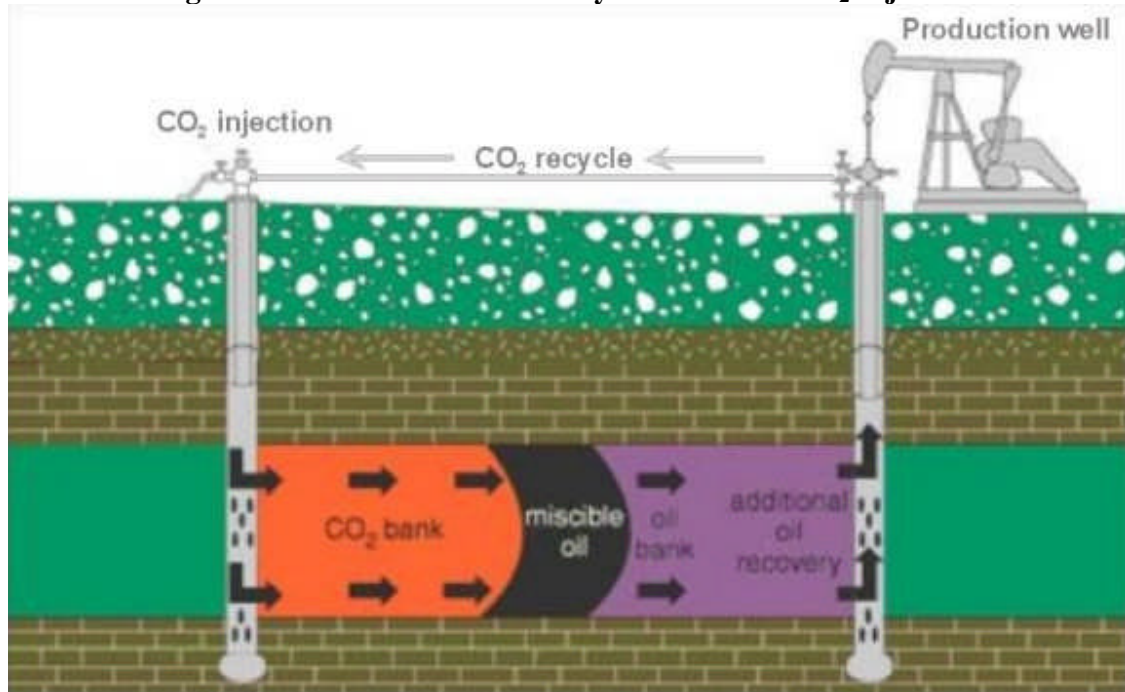
Although somewhat difficult to quantify at this early stage, ROZ resources are believed to be in the billions of barrels, offering the potential to significantly increase the 88 billion barrel CO₂ EOR reserve estimate previously noted (see the DOE fact sheet for more details at http://fossil.energy.gov/programs/oilgas/publications/eor_co2/E - ROZ PROJECT FACT SHEET.pdf). Several very significant commercial residual oil zone projects are in production in the U.S., including an operation at the Hess Seminole Field and one at Occidental Petroleum's Wasson field both in west Texas. Other fields with substantial ROZ resources await CO₂ availability for exploitation.

For comparative purposes, ANWR represents approximately 10.4 billion barrels of technically recoverable oil, with an estimated maximum production potential of about 1.4 million barrels per day. In contrast, U.S. CO₂ EOR offers the potential to add 2-3 million barrels of production per day and 50 to 100 billion barrels of oil reserves to our base, representing about two to three times the daily production potential of ANWR and 5 to 10 times the oil reserves. All this while creating very large markets and sequestration sinks for billions of tons of CO₂.

Figure 2, below, is a simplified diagram of the CO₂ EOR process. In commercial operations carbon dioxide is transported under pressure to a project area by pipeline in what the industry refers to as the CO₂ "dense phase." The compressed CO₂ is then sent underground into a targeted oil saturated geologic "zone" through injector wells. There the CO₂ acts as a solvent reducing the oil viscosity and surface tension, and freeing some of the oil to be "swept" to production wells. A CO₂ injection well is typically surrounded by a number of production wells organized in a "pattern." Any CO₂ produced with the oil is contained, separated, and recycled back for re-injection. The CO₂ that is not recycled is effectively trapped within the formation in

dead-end pores and channels. When the EOR project is complete all wells are plugged with cement and the CO₂ is permanently sequestered underground.

Figure 2: Enhanced Oil Recovery Process with CO₂ Injection



In current practices, the amount of CO₂ injected to mobilize oil is carefully controlled due to the cost of the CO₂. The yield of a "CO₂ flooding" project typically varies from two to four barrels of oil produced from every ton of CO₂ purchased. CO₂ EOR has not seen wider application because of the high project capital costs, historically low oil prices, and limited supplies of low cost, pure CO₂. But in today's high oil price environment, the main constraint is a shortage of CO₂. Enhanced oil recovery operators are currently paying between \$10 and \$30 per ton for CO₂, when they can find it. The market is there. The challenge is to provide incentives for more CO₂ generators to capture their carbon dioxide streams, and developers to build CO₂ pipelines from CO₂ sources to the oil fields that need it.

Other emerging carbon dioxide application/sequestration technologies are also worth mentioning. These include the enhanced production of natural gas, coalbed methane, and agricultural products (including algae for fuel production) with CO₂. These and other technologies promise to create additional markets for CO₂ but require (and deserve) more

research and development efforts to reach commercial viability. In contrast, CO₂ Enhanced Oil Recovery is already commercial.

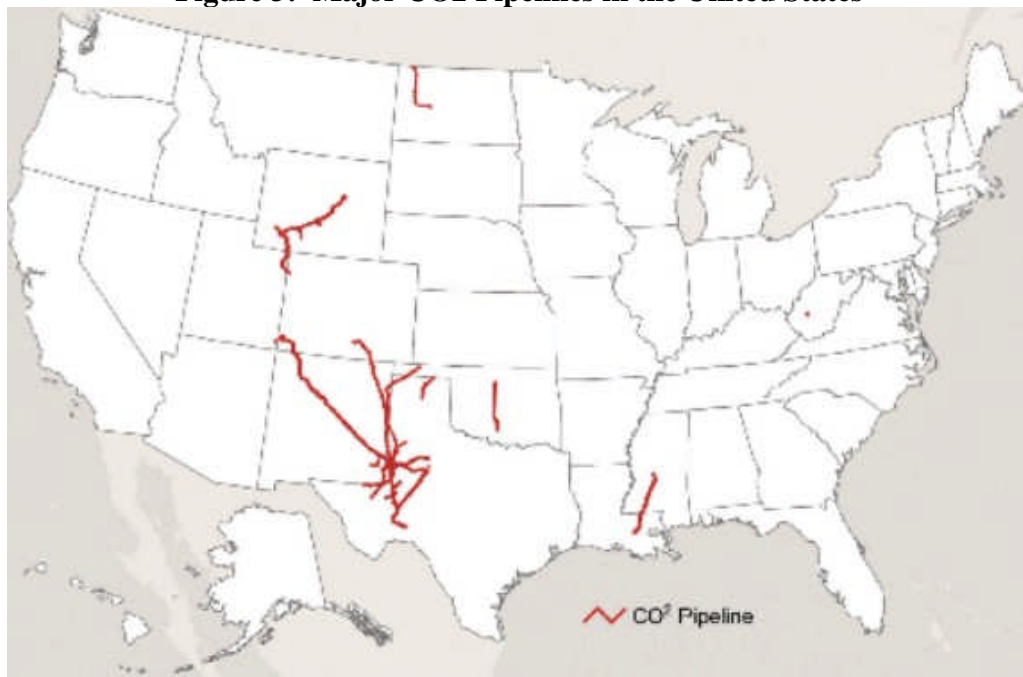
Choosing a sensible, market-driven approach to CO₂ emissions limits will best advance U.S. national security and promote economic prosperity. Rapid expansion of Enhanced Oil Recovery provides an excellent foundation, followed by the development of other productive uses of CO₂, to enhance natural gas, algae growth for biofuels, etc. The alternative, mandated emissions caps and the focus on the passive, costly sequestration of CO₂ in deep saline formations will increase the price of U.S. energy products and thus impose a significant burden on our economy and our society.

Carbon dioxide occurs naturally in the subsurface and it is no stranger to geologists who attempt to understand fluid migration and subsurface accumulations. The fact that CO₂ can be trapped in subsurface formations for geologic times is known and accepted; and we will undoubtedly find more of these locations. Oil and gas "traps" are considered by recognized petroleum engineers and geologists to be excellent final resting places for CO₂. These traps have already demonstrated the ability to hold oil and gas safely underground for hundreds of millions of years.

Government programs to advance CO₂ EOR should include strong incentives to build CO₂ pipelines. Expanding the current CO₂ pipeline network (see Figure 3 below) will be necessary to transport this valuable gas from emissions sources to targeted oil fields where it can be utilized to produce "Green Oil." Also, the work currently being done by the U.S. EPA to further regulate underground injection of CO₂ should be carefully monitored to ensure that unnecessary burdens are not placed on CO₂ EOR that prevent or slow the rapid expansion of this important value added energy and environmental activity.

The CO₂ EOR story is begging to be introduced to the American people and to many in industry and political leadership positions. Increasing awareness of the economic, energy security, and environmental benefits offered by CO₂ EOR and other CCS programs may well be the most important action that can be taken to advance the cause of American energy independence.

Figure 3: Major CO₂ Pipelines in the United States



Source: U.S. Dept. of Transportation, National Pipeline Mapping System

America can create millions of jobs through aggressive efforts to produce more low cost, clean electricity, heat, and liquid and gaseous fuels from our complete portfolio of fossil and renewable domestic energy resources. A comprehensive energy development program will also decrease the trade and budget deficits, provide affordable energy to American families and businesses, and restore economic vitality, opportunity, and prosperity. Increased energy efficiencies and sensible conservation have roles to play as well. Trying to pick winners will limit America's options and choices and restrict supply availability, causing a rise in energy prices. Such selective development will unnecessarily restrict economic growth and ensure continued dependence on foreign oil. Enhanced Oil Recovery using CO₂ injection and sequestration can and should play a big role in America's energy future.

© A. James Mayer

Article posed online at: <http://www.americanenergysecurity.com/AJM-Article-CO2-EOR-5-20-09.htm>

***About the Author:** A. James Mayer has a broad entrepreneurial background in energy spanning three decades. As president of A. J. Mayer International, LLC, he remains active in energy consulting, with a current focus on gasification, biomass, coal, alternative fuels and chemicals, and CO₂ solutions. Jim currently divides his time between consulting and the expansion of his own alternative energy resource, project, and technology development firm. He has an MBA from the Wharton School.*

Contact: Email: JamesMayer@AmericanEnergySecurity.com <> Off Tel: 717-359-0014

Subscribe to the American Energy Security Newsletter: www.AmericanEnergySecurity.com