The Role of CO₂ Enhanced Oil Recovery in Domestic Oil Production and Reduction of the Nation’s Carbon Intensity

National Association of State Legislators
Los Angeles, California
July 29, 2018

John Harju
Vice President for Strategic Partnerships
Energy & Environmental Research Center
Grand Forks, North Dakota
Oil Is **Still** Largest Supplier of U.S. Energy

Estimated U.S. Energy Consumption in 2017: 97.7 Quads

Source: EER, April 2018. Data is based on EIA/DOE MUR (2015). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, unless otherwise specified. This chart was revised in 2017 to reflect changes made in EIA/EIA to the Energy Information Administration’s energy methodology and reporting. The efficiency of electricity production is estimated as the ratio of retail electricity delivered to the primary energy input into electricity generation. Net Wt Efficiency is estimated at 3% for the residential sector, 4% for the commercial sector, 6% for the transportation sector, and 4% for the industrial sector which was updated in 2017 to reflect DOE’s analysis of manufacturing. Totals may not equal sum of components due to independent rounding. EER-86-41584T
Maturation of Conventional Oil Fields

**Primary Recovery (~20% recovery)**
- Oil is brought to the surface by natural pressure or artificial lift (e.g., pump).
- Can last a few years to several decades.

**Waterflood (~18% recovery)**
- Oftentimes referred to as “secondary recovery.”
- Injection of water for pressure maintenance and to mobilize/displace (e.g., push) oil.
- Typically lasts several decades.

**Enhanced Oil Recovery (EOR) (~17% recovery)**
- Oftentimes referred to as “tertiary recovery.”
- Usually follows waterflood.
- Injected fluid swells, lowers viscosity, solvates, and/or mobilizes additional oil. Fluid is most commonly CO$_2$.
- Typically planned for 20–30 years.

Improved oil recovery (IOR) is a broader term that encompasses all forms of secondary and tertiary recovery.
Secondary Recovery
Waterflood – How It Works

• Water injection repressures the reservoir, thereby reestablishing a drive mechanism.

• A portion of the injected water will be produced with the oil, separated at the surface, and recycled to be used again in the reservoir.

• Waterflooding operations can run for decades.
Tertiary Recovery
CO₂ EOR – How It Works

• CO₂ dissolves in oil, lowers oil viscosity, solvates and/or swells the oil allowing oil to flow more freely.

• CO₂ injection repressures the reservoir, thereby reestablishing a drive mechanism.

• A portion of the injected CO₂ will be produced with the oil and water, separated at the surface, and recycled to be used again in the reservoir.

• Typically 95% of the purchased CO₂ volume is retained in the reservoir (dead end pores and channels).

• The CO₂ retained in the reservoir is considered to be “stored.”
CO₂ produced with oil is recycled and reinjected. Because the process acts as a closed-loop system, effectively all of the supplied/purchased CO₂ will remain in the reservoir at the end of the EOR process.

Over 95% of the CO₂ supplied to an oilfield results in associated storage.
(DOE NETL, 2010; Melzer, 2012; Azzolina and others, 2016)
PROJECTED CO₂, EOR OPERATIONS, AND CO₂ SOURCES: 2020

**Oil production, 2020**
- CO₂-EOR projects: 147
- Oil production, 1,000 b/d: 638

**CO₂ supplies, 2020**
- Number of sources: 30
  - Natural: 6
  - Industrial: 24
- CO₂ supply, MMcf/d: 6.5
  - Natural: 3.4
  - Industrial: 3.1

147 Number of CO₂-EOR projects
- Natural CO₂ source
- Industrial CO₂ source
- CO₂ pipeline
- CO₂ proposed pipeline

Source: Advanced Resources International Inc. based on OGJ EOR/Heavy Oil Survey 2014 and other sources
U.S. CO₂ EOR

• Oil production (2017)
  • 300,000 BOPD from CO₂.

• Projections
  • EIA projections forecast 390,000 BOPD by 2025, assuming current technology and market conditions.
  • DOE estimates a U.S. recoverable resource from CO₂ EOR of up to 137 billion barrels from conventional oil fields.
  • Possibly up to another 100 billion barrels in unconventional tight oil formations.
  • 30 billion metric tons of CO₂ would be needed to produce 100 billion barrels of oil.
    • This equates to 35 years of CO₂ emissions from 140 gigawatts of coal-fired power.
CO$_2$ point sources with emissions greater than 100,000 metric tons/year

Many industrial point sources of anthropogenic CO$_2$ are in proximity to sedimentary basins that contain petroleum fields that are EOR candidates.

Source: NATCARB, 2013
EOR Oil Has a Lower Carbon Intensity


ctl = coal-to-liquids
SCO = synthetic crude oil
Federal Tax Incentives for CO₂ Storage

• Bipartisan Budget Act of 2018 modified 45Q tax credits under the federal tax code.

• Created to incentivize private investment in carbon capture technologies.

• Value of the tax credits depends on the purpose of the CO₂ injection:
  Dedicated storage = injection without resource recovery
  Associated storage = injection into an oil field for the purpose of EOR
Value of 45Q Tax Credits

Associated Storage (qualifying CO₂ EOR projects)
• Present value set at $15.29/metric ton, increasing linearly on an annual basis max. of $35/metric ton in 2026.

Dedicated Storage (injection without resource recovery)
• Present value set at $25.70/metric ton, increasing linearly on an annual basis until max. of $50/metric ton in 2026.

Adjusted for inflation after 2026.

Credits can be claimed by qualified projects that begin construction before January 1, 2024, for a period of 12 years once operations begin.

EERC
Other Key Provisions of Current 45Q Rules

• Participation threshold for nonelectrical industrial facilities is a minimum of 100,000 metric tons annually.
• Participation threshold for electrical industrial facilities is a minimum of 500,000 metric tons annually.
• Credits are attributed to the “emissions source,” although some language attributes the credits to the “owner of the capture technology.”
• Emitters may be able to transfer credits to “operators of dedicated storage or CO₂ EOR sites.”
The CO\textsubscript{2} EOR Value Chain and 45Q Tax Credits

Industrial Source | Capture Technology | Compression | Pipeline/Transportation | Recycle and Processing Facilities | Injection Operation | Energy Consumers

Pore Space Owners | Mineral Owners | Investors/Shareholders

Which links can realize the credits?
Who is responsible for monitoring and reporting?
Permitting, Accounting, Certification, and Reporting...
A CO₂ EOR Project that Spans the North Dakota and Montana Border Using Anthropogenic CO₂ Sourced from a Gas-Processing Facility in Wyoming and a Coal-Fired Power Electric Power Generation Facility in North Dakota
Tax appetite may be limiting.

- Clarification/enhancement of 45Q tax credit portability would better enable innovative business models to realize the incentives and enable financing of new EOR projects.

  Regulation and reporting compatibility is required.

- Flexibility and alignment of required reporting with applicable regulation is necessary for proliferation and use of anthropogenic CO$_2$ for EOR.
Bell Creek CO$_2$ EOR Project

• The Bell Creek oil field is operated by Denbury Onshore LLC, which is conducting a commercial EOR project.

• CO$_2$ is sourced from ConocoPhillips’ Lost Cabin and ExxonMobil’s Shute Creek natural gas-processing plants in Wyoming.

• The EERC is studying the interrelationship between EOR and incidental CO$_2$ storage at a commercial-scale project.
CO₂ Injection

As of December 2017

- Associated CO₂ storage incidental to EOR: ~4.8 million tonnes (source: Denbury)
- Oil produced: ~4.8 million barrels (source: Montana Board of Oil and Gas Database)

Estimated 20–40 MMbbl of oil. J.P. Morgan 2018 Energy Conference - estimated proved plus potential tertiary reserves

CO₂ EOR may result in as much as 15 million tons of associated storage.
“Take Home” Thoughts
Contact Information

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

www.undeerc.org
701.777.5157 (phone)
701.777.5181 (fax)

John Harju
Vice President for Strategic Partnerships
jharju@undeerc.org