Energy & Environmental Research Center (EERC)

Lower-Carbon Oil Production via Captured CO_2 EOR and Associated Storage

USEA Webinar:

CO_2 Storage, Optimizing Large-Volume First-Mover Projects By Managing Short- and Long-Term Security and Liabilities

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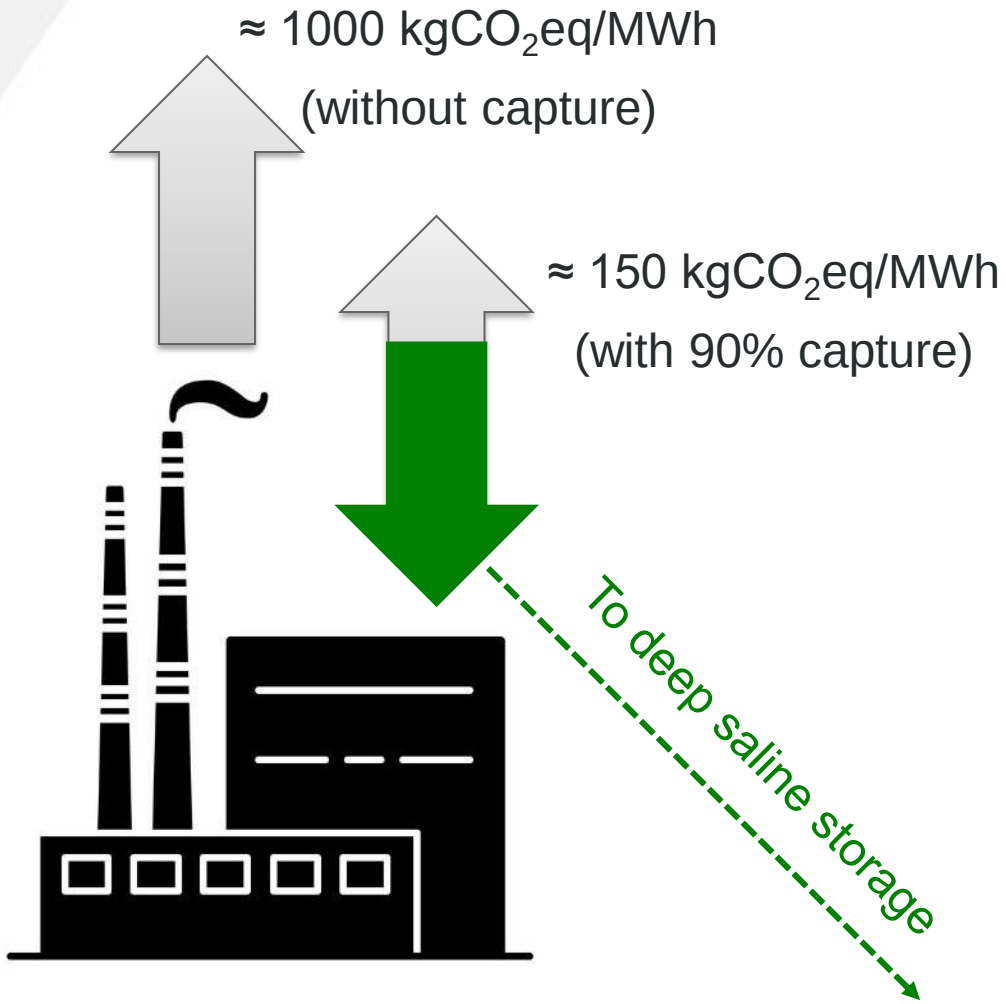
Presentation Outline

- Briefly review terminology used to quantify the carbon intensity of different products.
- Review “dedicated storage” and “associated storage” and what we mean by these two types of CCS/CCUS projects.
- Explain why incremental oil produced via EOR using captured CO_2 from an industrial source has a lower carbon intensity than any other oil in the marketplace.
- Highlight a few caveats and important details about the calculations.

Terminology Overview

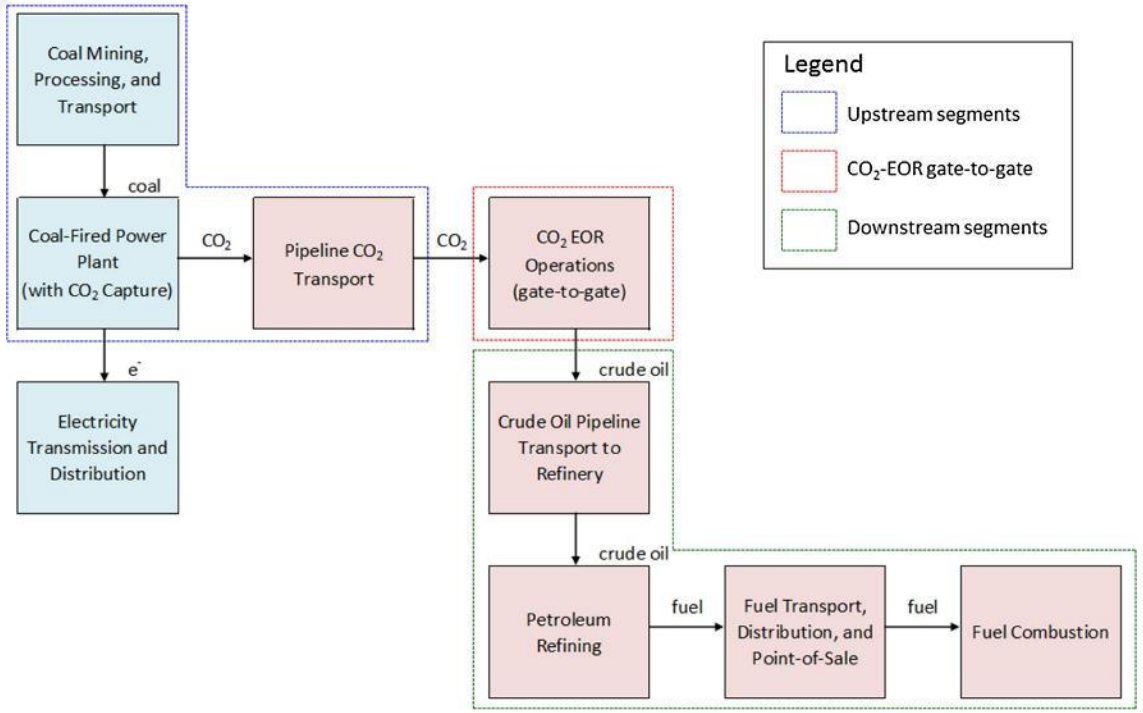
- We commonly measure and track three greenhouse gases (GHGs):
  - Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)
- We express these three GHGs as "CO_2-equivalents" (CO_2eq) by multiplying the mass of each gas by its 100-year global warming potential:
  - (CO_2 x 1) + (CH_4 x 36) + (N_2O x 298) = CO_2eq
- The "carbon intensity" (CI) value of a product is the mass of CO_2eq per unit of product, e.g.,
  - $kgCO_2eq$/MWh electricity or $kgCO_2eq$/barrel oil
- Sometimes the CI value is expressed on an "energetics basis" (or other variants), e.g.,
  - gCOeq/MJ combusted gasoline

Dedicated Storage Math is (Relatively) Easy



- "Dedicated storage" – CO_2 captured from an industrial source and permanently stored in a deep saline formation.
- Example:
  - A coal-fired power plant used to emit ~1000 $kgCO_2e/MWh$
  - We install a capture system running at 90% capture efficiency
  - Small additional coal mining, processing, and transport emissions.
  - Net emissions reduction of ~85%.

Associated Storage Math Gets Complicated



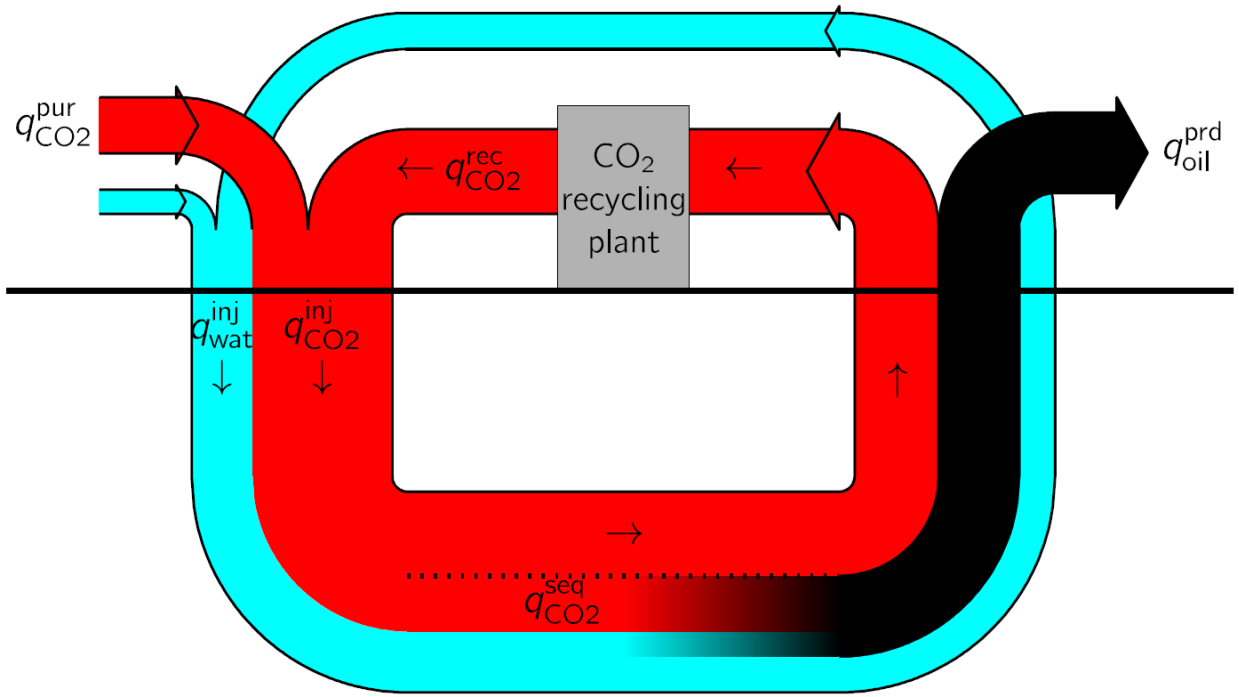
System boundaries for life cycle CO_2 emissions with CO_2-EOR.

- "Associated storage" – CO_2 captured from an industrial source, utilized for EOR, and stored in the reservoir incidental to the CO_2-EOR process.
- Co-products (two or more products in the system, e.g., electricity and oil) complicate the GHG accounting.
- However, detailed studies have shown that the net result is an incremental oil with a lower carbon intensity than other crude oils.

>95% of the Purchased CO_2 is Stored in the Reservoir

Within the Footprint of the EOR Project

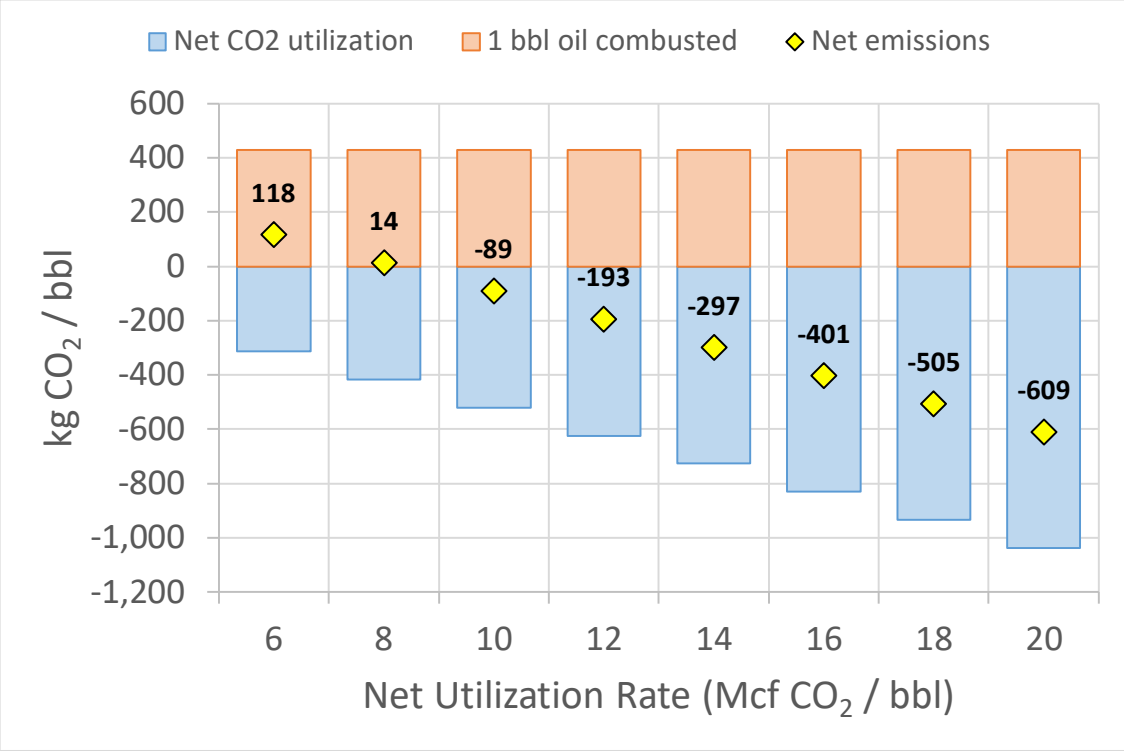
Upstream CO_2-generating processes



Downstream CO_2-generating processes

Adapted from: *van 't Veld, K., Mason, C.F., and Leach, A. (2013) The economics of CO_2 sequestration through enhanced oil recovery. Energy Procedia, 37:6909-6919.*

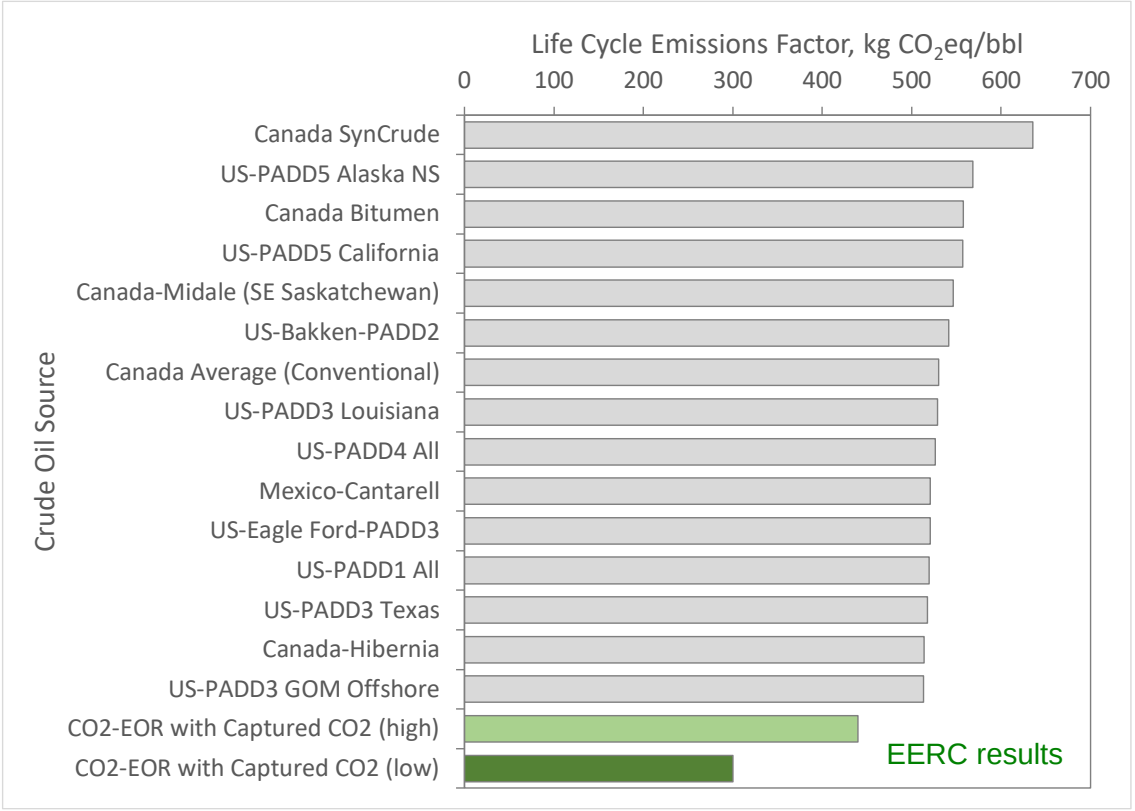
Start Simple: Just the Oil and the Net Utilization



- Historically, operators have tried to minimize net CO_2 utilization rates to improve the efficiency (and profitability) of CO_2-EOR.
- 6-10 Mcf/bbl (312-519 kg/bbl)
- 1 bbl oil combusted emits 430 kg/bbl
- Therefore, ~8.3 Mcf/bbl is the “break-even” point for oil combustion.
- Higher net CO_2 utilization rates >10Mcf/bbl further reduce the net emissions.

Expand the System to Include Up- and Downstream

- We must include:
  - Upstream emissions from the CO_2 capture source and
  - Downstream emissions from crude oil transport, refining, transport of refined fuels to point-of-sale, and fuel combustion.
- However, even with all these additions, the associated storage wins out and the incremental oil has a lower CI value.



Adapted from: *Cooney, G., Jamieson, M., Marriott, J., Bergerson, J., Brandt, A., and Skone, T.J., 2017, Updating the U.S. life cycle GHG petroleum baseline to 2014 with projections to 2040 using open-source engineering-based models: Environ. Sci. Technol., v. 51, p. 977–987.*

Caveats and Other Considerations

- Every system is site-specific and has unique aspects to the GHG accounting.
- The upstream CO_2 source plays a large role in the final carbon intensity.
- The CO_2 capture rate (at the source) and net CO_2 utilization rate (of the EOR site) are generally the two most important variables to consider.
- As the share of the U.S. domestic crude production includes a larger proportion of incremental oil from captured CO_2-EOR, the overall carbon intensity of petroleum products – gasoline, diesel fuel, heating oil, and jet fuel – will decrease.

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