



Energy & Environmental Research Center (EERC)

# Lower-Carbon Oil Production via Captured CO<sub>2</sub> EOR and Associated Storage

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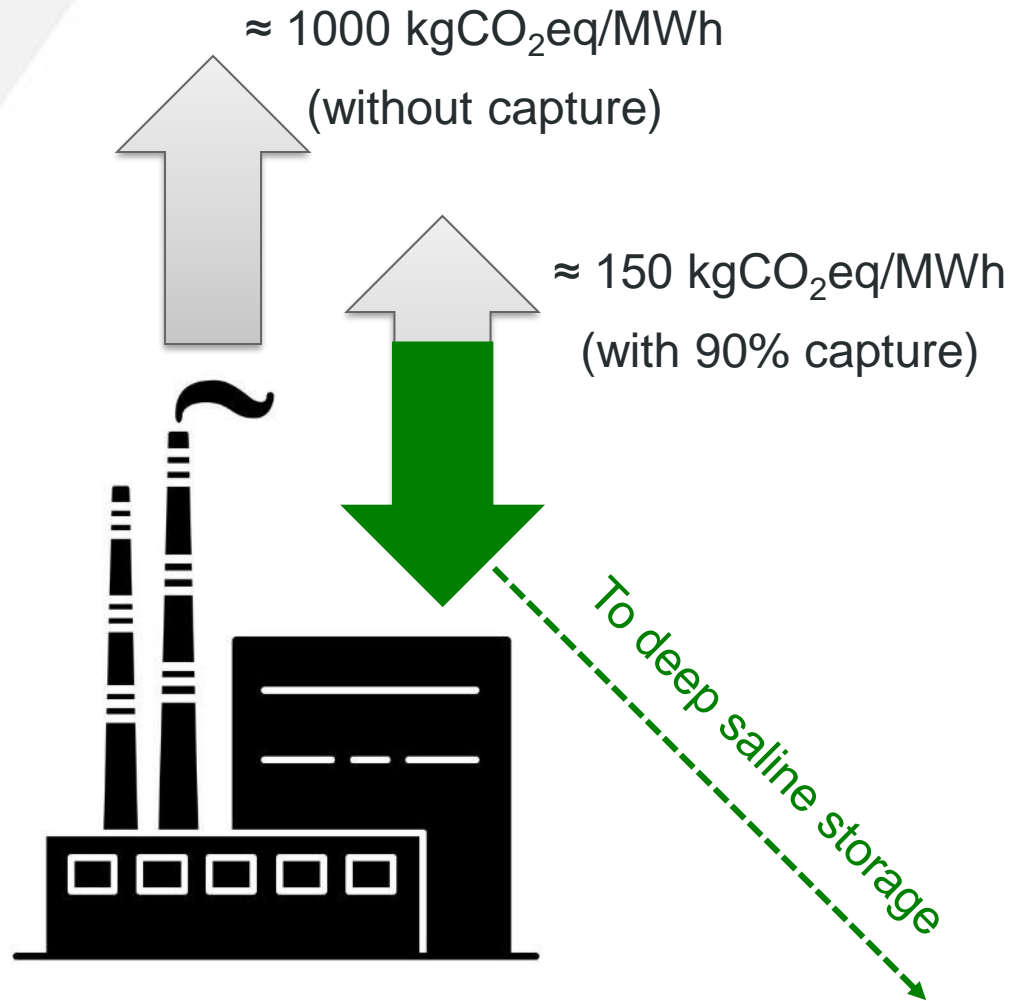
# Presentation Outline

- 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<sub>2</sub> 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

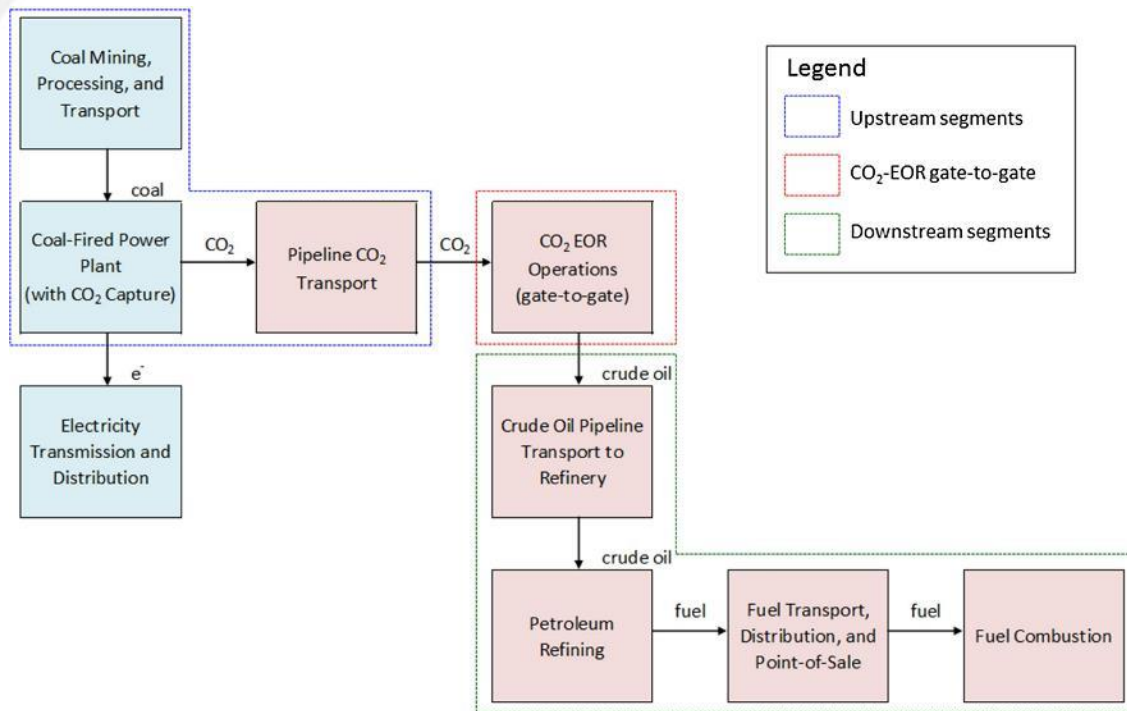
- We commonly measure and track three greenhouse gases (GHGs):
  - Carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O)
- We express these three GHGs as “CO<sub>2</sub>-equivalents” (CO<sub>2</sub>eq) by multiplying the mass of each gas by its 100-year global warming potential:
  - ( CO<sub>2</sub> x 1 ) + ( CH<sub>4</sub> x 36 ) + ( N<sub>2</sub>O x 298 ) = CO<sub>2</sub>eq
- The “carbon intensity” (CI) value of a product is the mass of CO<sub>2</sub>eq per unit of product, e.g.,
  - kgCO<sub>2</sub>eq/MWh electricity or kgCO<sub>2</sub>eq/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<sub>2</sub> captured from an industrial source and permanently stored in a deep saline formation.
- Example:
  - A coal-fired power plant used to emit ~1000 kgCO<sub>2</sub>e/MWh
  - We install a capture system running at 90% capture efficiency
  - Small additional coal mining, processing, and transport emissions.
  - **Net emissions reduction of ~85%.**

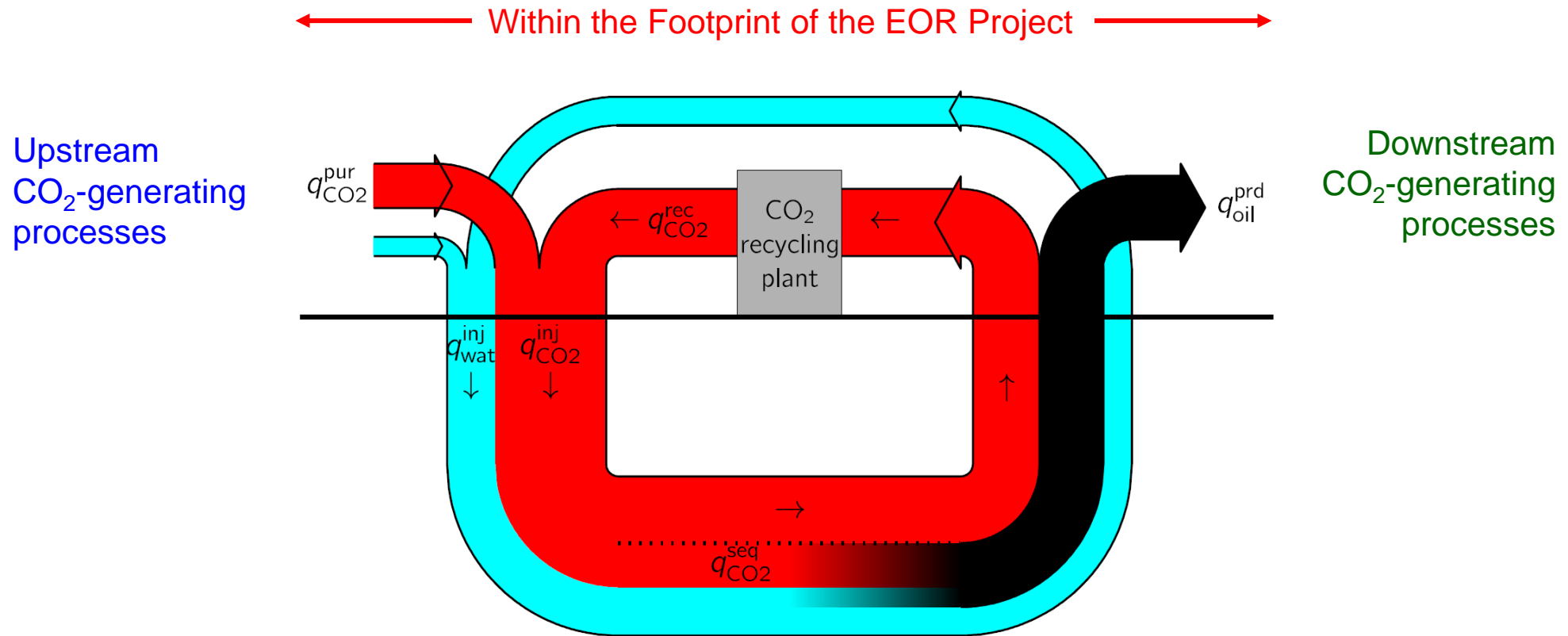
# Associated Storage Math Gets Complicated



System boundaries for life cycle CO<sub>2</sub> emissions with CO<sub>2</sub>-EOR.

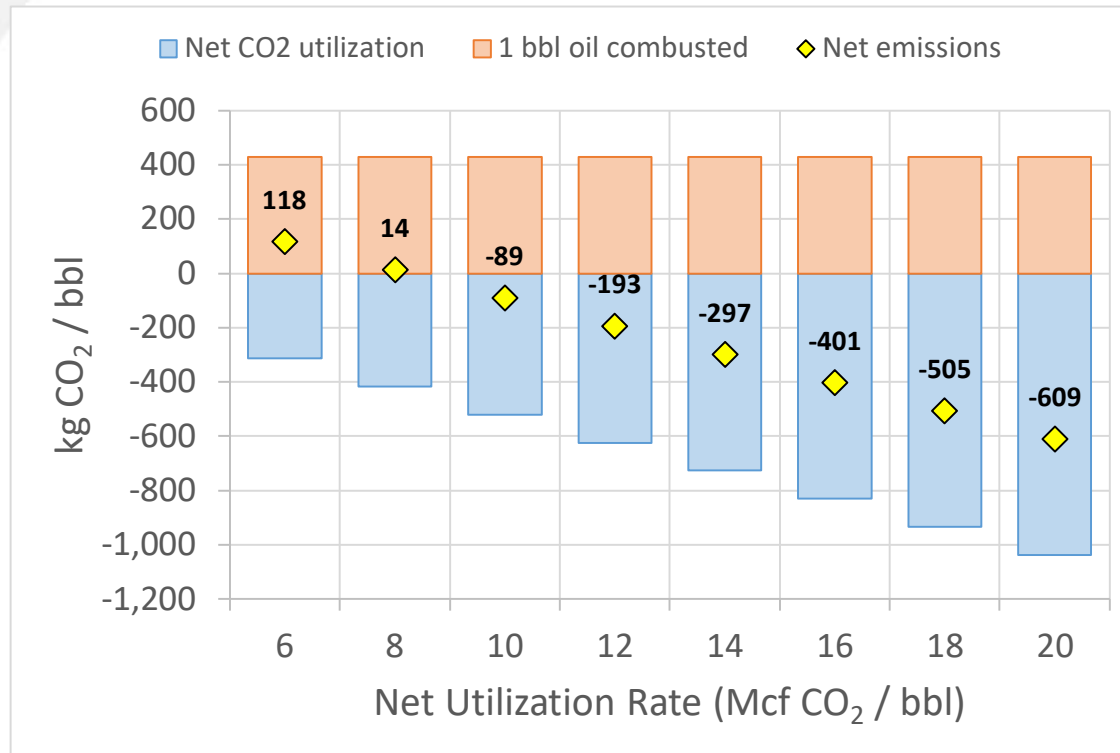
- “Associated storage” – CO<sub>2</sub> captured from an industrial source, utilized for EOR, and stored in the reservoir incidental to the CO<sub>2</sub>-EOR process.
- Co-products (two or more products in the system, e.g., electricity and oil) complicate the GHG accounting.
- However, detailed studies have shown that the net result is an incremental oil with a lower carbon intensity than other crude oils.

# >95% of the Purchased CO<sub>2</sub> is Stored in the Reservoir



*Adapted from: van 't Veld, K., Mason, C.F., and Leach, A. (2013) The economics of CO<sub>2</sub> sequestration through enhanced oil recovery. Energy Procedia, 37:6909-6919.*

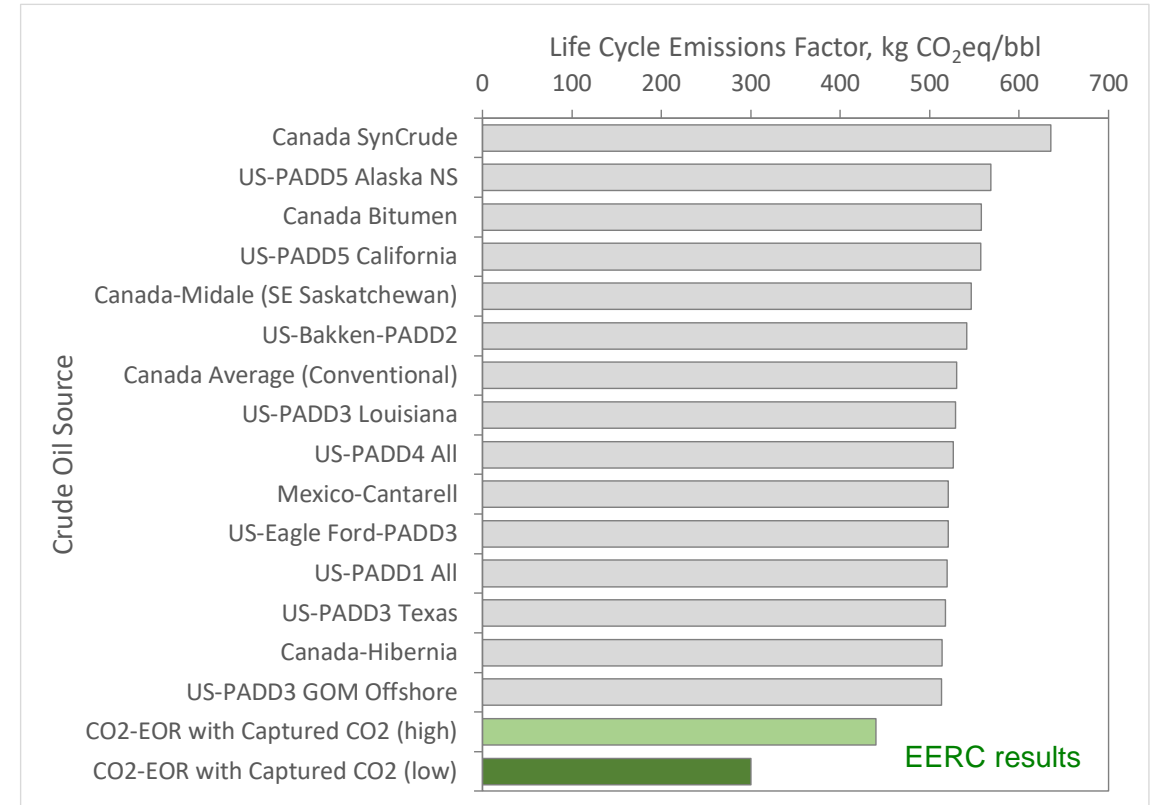
# Start Simple: Just the Oil and the Net Utilization



- Historically, operators have tried to minimize net CO<sub>2</sub> utilization rates to improve the efficiency (and profitability) of CO<sub>2</sub>-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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> source plays a large role in the final carbon intensity.
- The CO<sub>2</sub> capture rate (at the source) and net CO<sub>2</sub> 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<sub>2</sub>-EOR, the overall carbon intensity of petroleum products – gasoline, diesel fuel, heating oil, and jet fuel – will decrease.



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A wide-angle photograph of a university campus at sunset. The sun is low on the horizon, casting a warm glow over the scene. In the foreground, there are large trees with some yellowing leaves. In the background, there are several large, multi-story brick buildings and a parking lot filled with cars.

**THANK YOU**

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