SUMMARY: NET GREENHOUSE GAS IMPACT OF STORING CO_2 THROUGH ENHANCED OIL RECOVERY (EOR)

ICO2N commissioned the Pembina Institute, a Canadian environmental think tank, to analyze the greenhouse gas (GHG) impact of storing CO_2 through the process of enhanced oil recovery (EOR). The analysis looked at CO_2 emissions associated with operating an EOR site as well as those associated with the oil that is produced. Stakeholders have differing perspectives on how to view the GHG impact of CO_2-EOR and this work is an attempt to quantify five different scenarios. Using actual operational data, the intent of the study was not to legitimize any one viewpoint but rather to bring quantitative data into the discussion.

The analysis considered the CO_2 emissions of five scenarios representing differing viewpoints; it did not include the upstream activities associated with the capture and transport of CO_2.

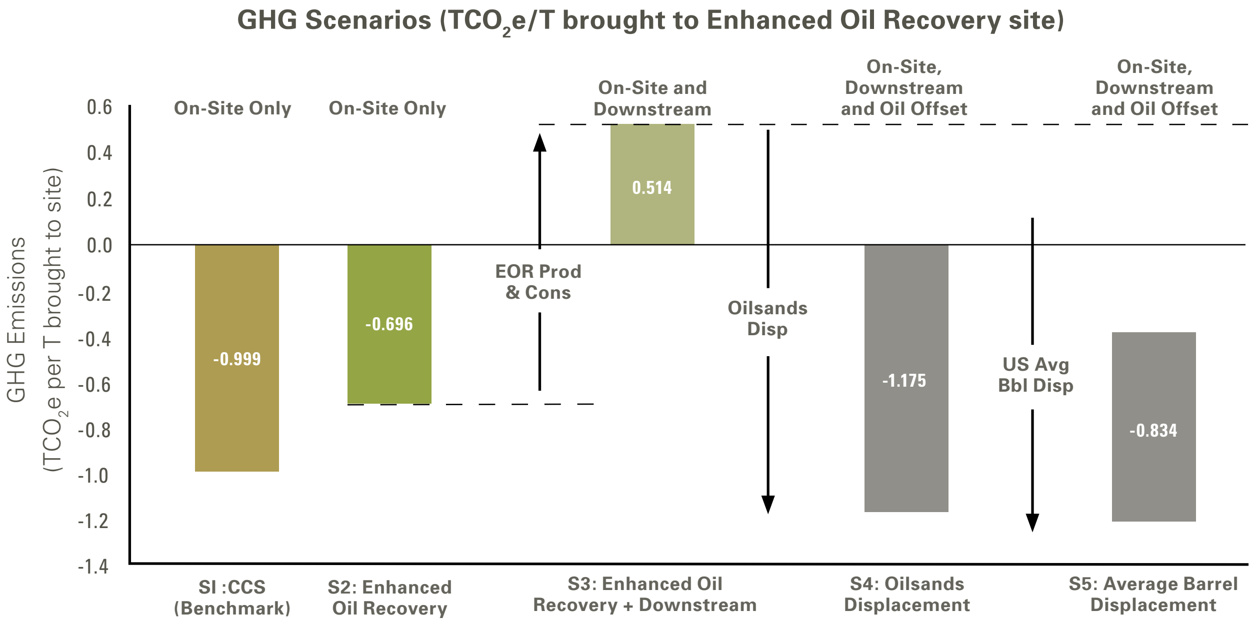
VISUAL REPRESENTATION OF FIVE SCENARIOS

SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5
Geologic Storage carbon capture and storage (CCS)	EOR On-Site	EOR Full Lifetime Emissions	EOR full lifetime emissions with Offsetting (Oilsands Barrel)	EOR full lifetime emissions with Offsetting (Average Barrel)
CO_2 Storage through CCS (baseline)	CO_2 Storage through EOR less EOR operational emissions	CO_2 Storage through EOR less EOR operational emissions	CO_2 Storage through EOR less EOR operational emissions	CO_2 Storage through EOR less EOR operational emissions
		↓ Downstream CO_2 emissions of EOR produced oil	↓ Downstream CO_2 emissions of EOR produced oil	↓ Downstream CO_2 emissions of EOR produced oil
			↓ CO_2 savings from displacement of a barrel of oil from the oilsands	↓ CO_2 savings from displacement of an average barrel of oil

The analysis established the following high level conclusions:

- The GHG impact of CO_2-EOR varies greatly depending on perspective and by project.
- When assuming oil produced through the EOR process fully displaces competing sources of crude oil, EOR has a GHG benefit.
- The ratio of CO_2 injected to barrels of oil produced has a large impact on the overall GHG benefit of CO_2-EOR.
- On a lifecycle GHG intensity basis oil produced from EOR falls in between comparative North American sources of oil.

The following graph demonstrates the conclusions of this analysis by showing the GHG impact of the five scenarios outlined above.

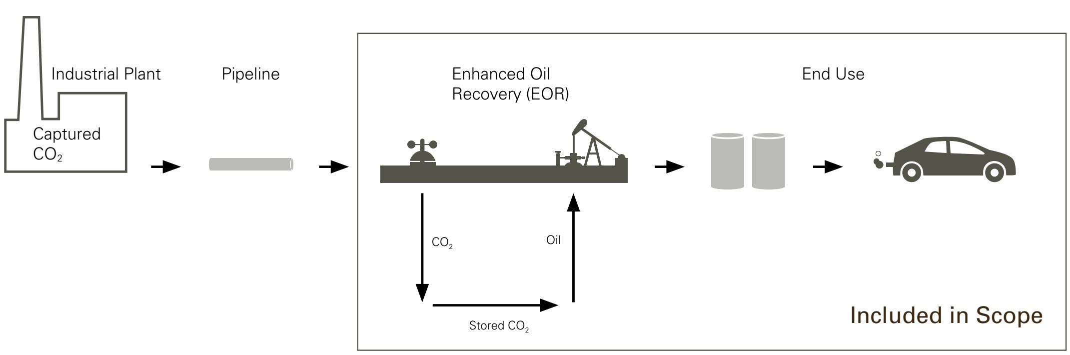


When downstream production of EOR is taken into account there is a 0.5 tonne increase in emissions for every tonne of CO_2 brought to site. However, when assuming full displacement of competing sources of crude oil (Scenarios 4 and 5 – S4 and S5 in the graph), storing CO_2 through EOR has a net GHG benefit of 1.175 TCO_2e reduced for an oil sands barrel and 0.834 TCO_2e for an average barrel.

ANALYSIS METHODOLOGY

The analysis was separated into three steps (described below) and sensitivities were used to analyze the potential variance of the results. The analysis did not consider upstream emissions associated with producing CO_2 and starts when a tonne of CO_2 arrives on site. A Canadian EOR site with an oil productivity of 1:1 barrel of oil produced per tonne of CO_2 injected was used as the base case. The scenarios that were run include higher productivity rates of 3 and 5 barrels produced per tonne of CO_2 injected and different performance and recycle ratios. These sensitivities and additional variables are identified in detail in the full report.

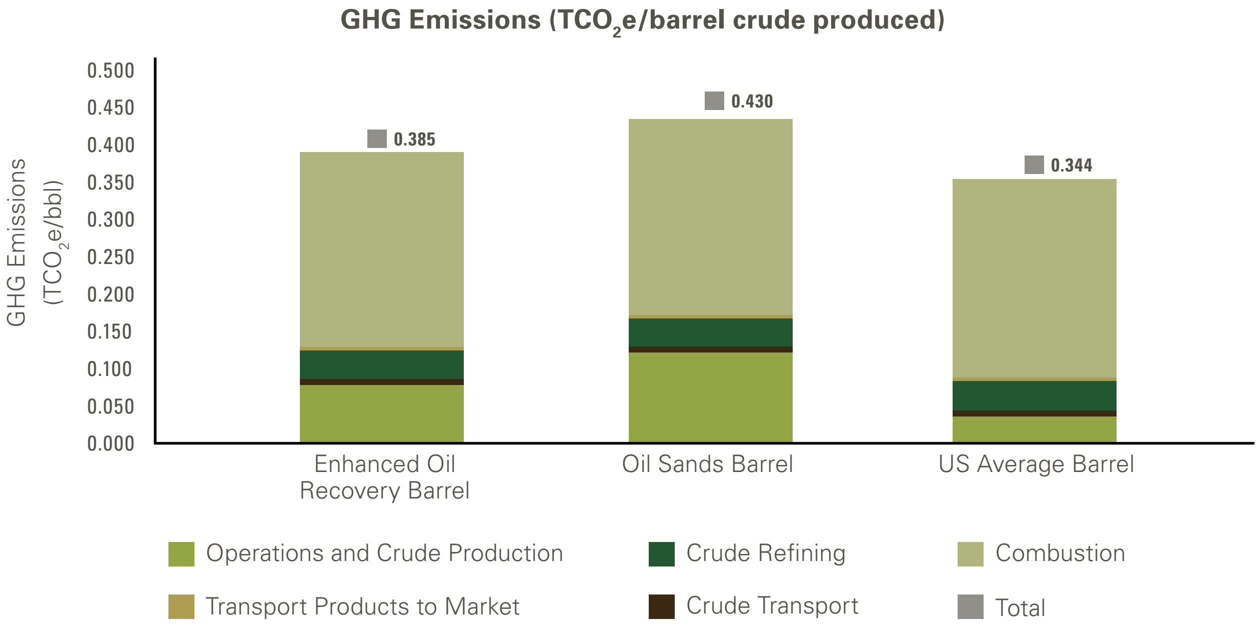
VISUAL REPRESENTATION OF ANALYSIS SCOPE



Step 1 of the analysis: net CO_2 storage: geologic storage vs. EOR

This step compared the emissions associated with operating a CO_2-EOR project to those of a pure geologic carbon capture and storage (CCS) operation to highlight the specific on-site differences in CO_2 stored and released at site. This analysis of the on-site storage and emissions included all CO_2 emitted through the operation of the EOR site for the purpose of producing oil, but excludes all downstream emissions associated with the oil produced through EOR.

In the geologic storage scenario, 0.999 tonne (T) CO2e of every 1 TCO_2e brought to site is stored in the reservoir. The CO_2-EOR scenario has a net (i.e. due to on-site GHG emissions) on-site storage of 0.696 TCO_2e per 1 TCO_2e brought to site.



GHG Emissions per Crude Oil Source

Step 2 of the analysis: per barrel GHG emissions of various crude sources

This step analyzed the comparative GHG emissions associated with producing, processing, refining and combusting a barrel of crude oil produced from the CO_2-EOR operation, from an oil sands operation and from the average conventionally produced barrel in North America. CO_2 storage in the EOR reservoir was not considered in this step as only production associated CO_2 emissions were looked at. The following graph demonstrates their relative GHG intensity outside of any CO_2 storage activities.

The per-barrel emission intensity for EOR produced oil including the emissions associated with downstream activities is 11.5% better than an equivalent amount of oil sourced from an oilsands operation and 10.8% higher than an average barrel of oil. The main difference in GHG intensity is a result of the difference in GHG intensity of extraction methods.

Step 3 of the analysis: assessing GHG impact of CO_2 storage through EOR from various viewpoints

This final step brought together the analytical data of steps 1 and 2 to assess the net CO_2 impact associated with CO_2-EOR for each of the scenarios. The results are in the conclusion graph on page 1.

THE MAIN CONCLUSION OF THE ANALYSIS: THE IMPACT OF STORING CO_2 THROUGH EOR VARIES GREATLY DEPENDING ON PERSPECTIVE

None of the scenarios on how to view the impact of storing CO_2 through EOR are absolute or correct in isolation. One cannot simply assume that a barrel of oil produced through EOR will not displace another barrel on the market, while at the same time market dynamics are extremely complex and it is highly unlikely a full barrel would be displaced. Value judgments on whether or not different factors should be included when assessing the CO_2 storage potential of EOR will lead to greatly diverging conclusions. It is likely that some market offsetting will occur, particularly in the short term, however this analysis did not attempt to arrive at an absolute conclusion. We hope this report will help to put numbers to the various perspectives on viewing EOR and aid further constructive dialogue on this subject.

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