

CO₂ Enhanced Oil Recovery (EOR) for Capture and Long-term Underground Storage of CO₂

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Potential Value of CO₂ EOR becoming CCS



- The Carbon Capture Project (CCP4) asked ERM to study key issues in transitioning CO₂ EOR to become long-term CCS projects, and we present the study results here today
- In most cases when CO₂ is injected underground for the purpose of Enhanced Oil Recovery (EOR), the CO₂ remains permanently trapped in the underground reservoir
- Thus, CO₂ EOR is a potential candidate for CCS project designation if operators can show that the CO₂ from EOR remains underground in line with CCS monitoring requirements
- CO₂ EOR projects absorb CCS capture cost since CO₂ is used for a commercial purpose
- CO₂ cost included in the EOR project budget = zero capture cost for the transition to CCS
- Removing CO₂ capture cost thanks to EOR greatly improves the financial viability of CCS

Context for CO₂ EOR transitioning to CCS



- The purpose of **Carbon Capture and Storage (CCS)** is to reduce emissions of carbon dioxide (CO₂) to the atmosphere as a **climate change mitigation activity**.
- The IEA says that **CCS may have to contribute as much as 20% of the emissions reductions needed by 2050** in order to limit global warming to well below 2° C.
- **Huge volumes of CO₂ slated for EOR offer major opportunities to mitigate emissions IF the CO₂ used in EOR can also satisfy CCS rules for permanence.**
- **Experience has been gained from 130+ commercial CO₂ EOR operations globally.** Active CO₂ EOR projects exist primarily in the United States and Canada, with further commercial and demonstration projects operating in Asia, Middle-East and the North Sea.
- **Challenge is that CO₂ EOR was not designed for CCS purposes - reservoirs are not monitored for long-term CO₂ retention after the EOR operations cease.**



CO₂ Regs not written to address CCS rules

- The underground reservoir in an EOR project is determined by the location of existing oil and gas production, not selected from the beginning for long-term CO₂ storage
- Regulations for EOR projects anticipate that CO₂ injection will end and wells will be decommissioned, plugged and abandoned after CO₂ EOR operations have ceased
- A separate process is required to evaluate the oil and gas reservoir undergoing EOR to determine its viability for long-term underground storage of CO₂ under CCS rules
- Differences between CO₂ EOR and CCS rules have greater implications for existing CO₂ EOR projects because transition to CCS was not considered in existing EOR – current activities were locked in before CCS requirements were taken into account
- New CO₂ EOR projects can plan for transition to CCS by including site evaluation, monitoring and other requirements in the original project design (i.e., planning for both the CO₂ EOR operating phase and the post-EOR CCS long-term storage phase).



Overview of CCS Regulation and CO₂ EOR

Canada: Fragmented federal/stage approach – Alberta has clear CCS regs, British Columbia policy framework

Europe: Clear existing framework for transition from EOR to CCS using CCS and EU ETS Directives

USA: Framework for transition from EOR (Class II) to CCS (Class VI) wells but focus on water rather than CO₂






















Brazil: CCS mentioned in national CC Policy and integrated assessment studies are underway (economy-wide). Petrobras and Foreign Investment Program testing MMV of Lula EOR/CO₂ Storage Project. No regulatory framework in place.

Australia: Federal and state (Victoria/Barrow Island) legislation for CCS. No discussion of EOR CCS





Key for this Graphic:
Comprehensive CCS-
Specific regulations
Patchwork of CCS
Specific regulations
Partial coverage of CCS
activities
No CCS policy/regulation

Status of CO₂ EOR & CCS Regs in key areas

Table 2. Overview of regulatory status of each country/region

Type of Regulation	USA	Canada			European Union	Australia	Brazil
		Alberta	Saskatchewan	British Columbia			
EOR							
Transition							
CCS							

The indicator key is as follows:

	Regulations/process in place
	Regulations/guidance in development
	Policy discussions under way
	No information available



CCS rules can be adapted for CO₂ EOR

- Fortunately, ERM's study found no existing policies or regulations which explicitly prohibit CO₂ EOR projects from transitioning to become CCS projects
- In fact, US EPA underground injection rules, the EU CCS Directive and IPCC Guidelines for CCS in national GHG inventories all refer to CO₂ EOR as a possible type of CCS
- The main differences that require particular attention from regulators, policy makers and relevant legal authorities for CO₂ EOR projects to be recognized as CCS are:
 1. Storage site evaluation and geological modelling;
 2. Monitoring of the storage site, reporting and verification;
 3. Site closure conditions and post-closure stewardship and liability;
 4. Conformance with national GHG inventory guidelines for CCS.



- A potential CO₂ storage site needs to be characterized by three principal requirements:
 - Capacity - whether there is sufficient storage volume and whether it can be accessed;
 - Injectivity - whether suitable reservoir properties exist for sustained injection of CO₂ at economical industrial supply rates; and
 - Integrity - whether the site is secure with negligible risk of unintended migration or leakage.
Well integrity is important throughout the life cycle from drilling to plugging and abandonment.
- Any CO₂ EOR project seeking to transition to a CCS project will have to address the long-term monitoring requirements for CCS storage sites.
- CO₂ EOR/CCS projects will need robust monitoring regimes to:
 - detect leakage,
 - account for losses in the project's over all emissions inventory, and
 - ensure that measures are put in place to stop leaks when detected



- The issue of liability and ownership of CO₂ in a given project over time is important to ensure that effective measures are put in place to ensure viability and accountability.
- Aspects which have been considered by government authorities in the context of a liability framework for CCS include:
 - Management of leakage and permanence
 - Stewardship of the storage site
 - Costs and financial provision(s)
- There is also a need to address the use of the pore space for long-term CO₂ storage purposes beyond decommissioning of oil production after EOR ceases.

- A number of GHG accounting guidelines for CCS have been published in recent years.
- Most of these guidelines address accounting for emissions associated with CO₂ EOR, including the recycle or 'breakthrough' of CO₂ during the production phase.
- The IPCC Guidelines for National GHG Inventories (2006) address the geological storage of CO₂ within emission inventories. CCS projects have requirements to assess the potential for CO₂ to be emitted via leakage pathways, as follows:
 - Properly and thoroughly characterize the geology of the storage site and surrounding strata;
 - Model the injection of CO₂ into the storage reservoir and the future behavior of the storage system;
 - Monitor the storage system; and
 - Use the results of the monitoring to validate and/or update the models of the storage system.



GHG Accounting Guidelines: CCS/EOR-CCS

Date	Organization	Title of Guidance Document	GHG Accounting for EOR Addressed?	Differences in Accounting between CCS and EOR?	Emissions from Increased Oil Production Accounted for?
2015	IEA	Storing CO ₂ through Enhanced Oil Recovery	Yes, indicative only	Only EOR is addressed	Yes, in lifecycle assessment
June 23, 2015	Alberta Government	Quantification Protocol for CO ₂ Capture and Permanent Storage in Deep Saline Aquifers	No, only applies to deep saline aquifer storage	NA	NA
April 2015	American Carbon Registry	Methodology for GHG Emission Reductions from Carbon Capture and Storage Projects, Version 1.0	Yes	None; the same equations are used to account for energy use and CO ₂ losses during recycle operations.	No
January 2015	California Council on Science and Technology	Electricity from Natural Gas with CO ₂ Capture for Enhanced Oil Reduction Emissions Accounting under Cap and Trade and LCFS	No; discussion paper on lifecycle considerations	NA	No
January 2013	ICO2N	Net Greenhouse Gas Impact of Storing CO ₂ Through Enhanced Oil Recovery (EOR)	Yes, high level carbon intensity figures presented	Yes, carbon intensity of CCS versus EOR-CCS are presented	Yes
October 2012	DOE, NETL	Best Practices for Monitoring, Verification and Accounting of CO ₂ Stored in Deep Geologic Formations, Second Edition	No	Monitoring is addressed, but no methodology to determine GHG emission reductions	No
February 2012	Centre for Climate and Energy Solutions	GHG Accounting Framework for Carbon Capture and Storage Project	Yes	CCS in producing formations are addressed separately, but no major differences	No
October 2007	Alberta Environment	Quantification Protocol for Enhanced Oil Recovery (Specified Gas Emitters Regulation)	Yes	Only EOR is addressed	No
December 2006 (adopted December 2011)	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories	Yes	No distinction between CCS and EOR-CCS	No



Findings/Conclusions: CO₂ EOR to CCS (I)

- In sum, ERM's analysis of CO₂ EOR to CCS supported the 2013 CSLF finding that:

“There are no specific technological barriers or challenges per se in transitioning and converting a pure CO₂ EOR operation into a CO₂ storage operation. The main differences between the two types of operations stem from legal, regulatory and economic differences between the two.”
- For CO₂ EOR/CCS to count as progress in meeting national contributions under the Paris Agreement, emissions avoided must be reflected in national GHG inventories.
- Since proponents of CO₂ EOR projects transitioning to a CCS project will presumably be interested in that project receiving national recognition for emissions avoided, it will be necessary to follow the reporting requirements in the CCS provisions found in Chapter 5 of the 2006 IPCC Guidelines for National GHG Inventories.

Findings/Conclusions: CO₂ EOR to CCS (II)

- There is a clear regulatory framework for CO₂ EOR and for CCS in most regions but there are insufficient provisions to allow a CO₂ EOR operator to follow a clear transition pathway for legal and regulatory approval of a CO₂ EOR project to be a CCS project.
- CO₂ EOR projects present a special case with particular circumstances for long-term underground CO₂ storage and provisions unique to this special case may be required.
- Specific guidance or regulation should be provided setting out the specific requirements for new and existing CO₂ EOR projects which may wish to transition to CCS.
- A clear pathway for legal and regulatory approval of CO₂-EOR to become CCS could be elusive until regulatory and legal gaps that have been identified are resolved.
- Given the relatively high costs of CCS today, coupling CCS with CO₂ EOR could provide a critical financial incentive to facilitate development of CCS projects in the near term.



End

