Certification of Associated CO_2 Storage in EOR Fields

CSA/ANSI ISO 27916:19

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2021 CO_2Conference
December 6-9

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Agenda

- Introduction
- Overview of CSA/ANSI ISO 27916:19
- Application to 45Q
- Major components
  - EOR Complex Description, Qualification, and Construction
  - Containment Assurance & Monitoring within the EOR Complex
  - Well Construction
  - Project Termination
  - Quantification
- Conclusions
- Q&A

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Denbury Overview

A Unique Energy Business

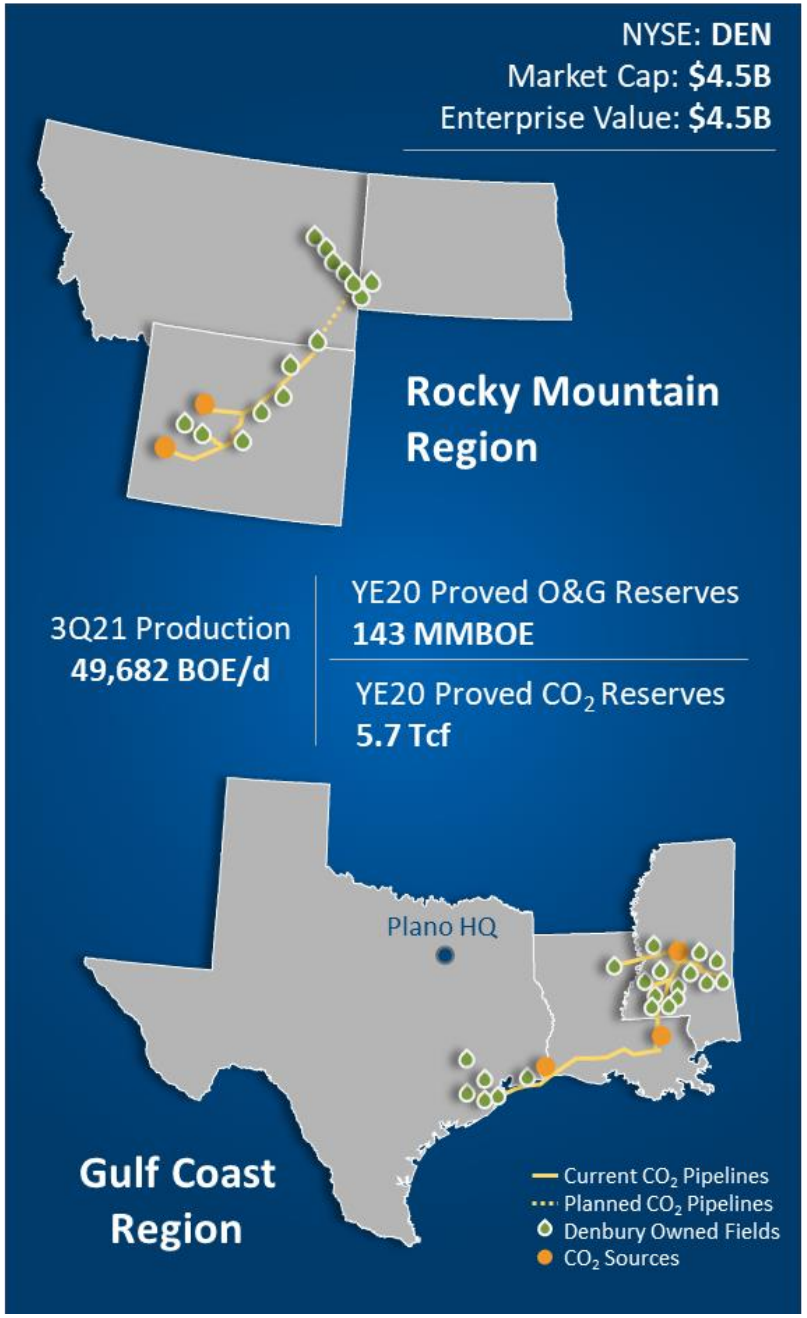
- CO_2 Enhanced Oil Recovery (EOR) is our primary focus
- Low base decline rate and low capital intensity
- CO_2 expertise and assets position Denbury to lead in Carbon Capture, Use and Storage (CCUS)

Industry Leader in Reducing CO_2 Emissions

- Annually injecting ~3 million tons of industrial sourced CO_2 into our reservoirs
- Potential to reach full carbon neutrality this decade with CCUS, including downstream Scope 3 emissions

Strategically Advantaged Operations

- Vertically integrated CO_2 supply and distribution network with > 1,000 miles of CO_2 pipelines
- Cost structure largely independent from industry
- Asset base diversity mitigates single basin risk

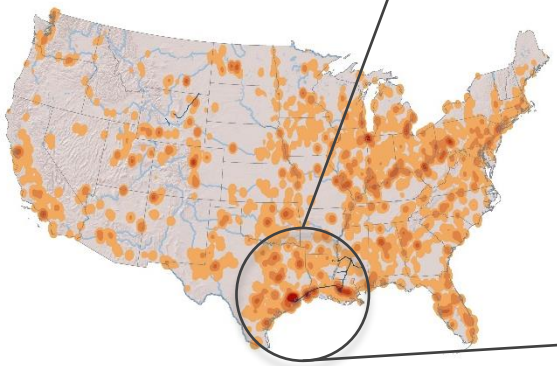


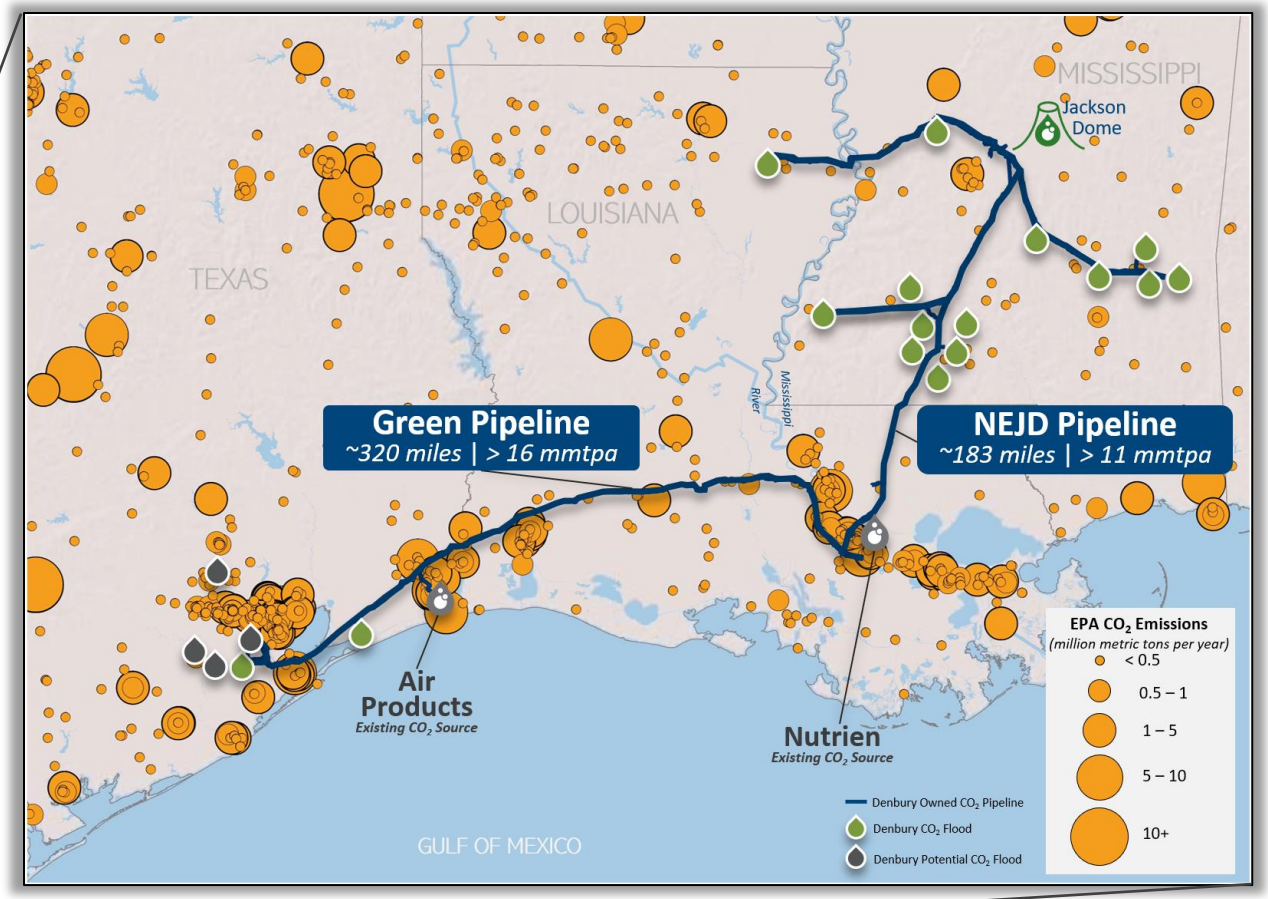
What is the challenge?

CO_2 Emissions

~2.6 billion tons/year from stationary sources in the U.S.

~230 million tons/year (~10% of total U.S.) within 30 miles of DEN Gulf Coast Infrastructure





Source: National Petroleum Council (NPC) 2019 Report, Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of Carbon Capture, Use and Storage and 2019 EPA Greenhouse Gas Reporting Program data.

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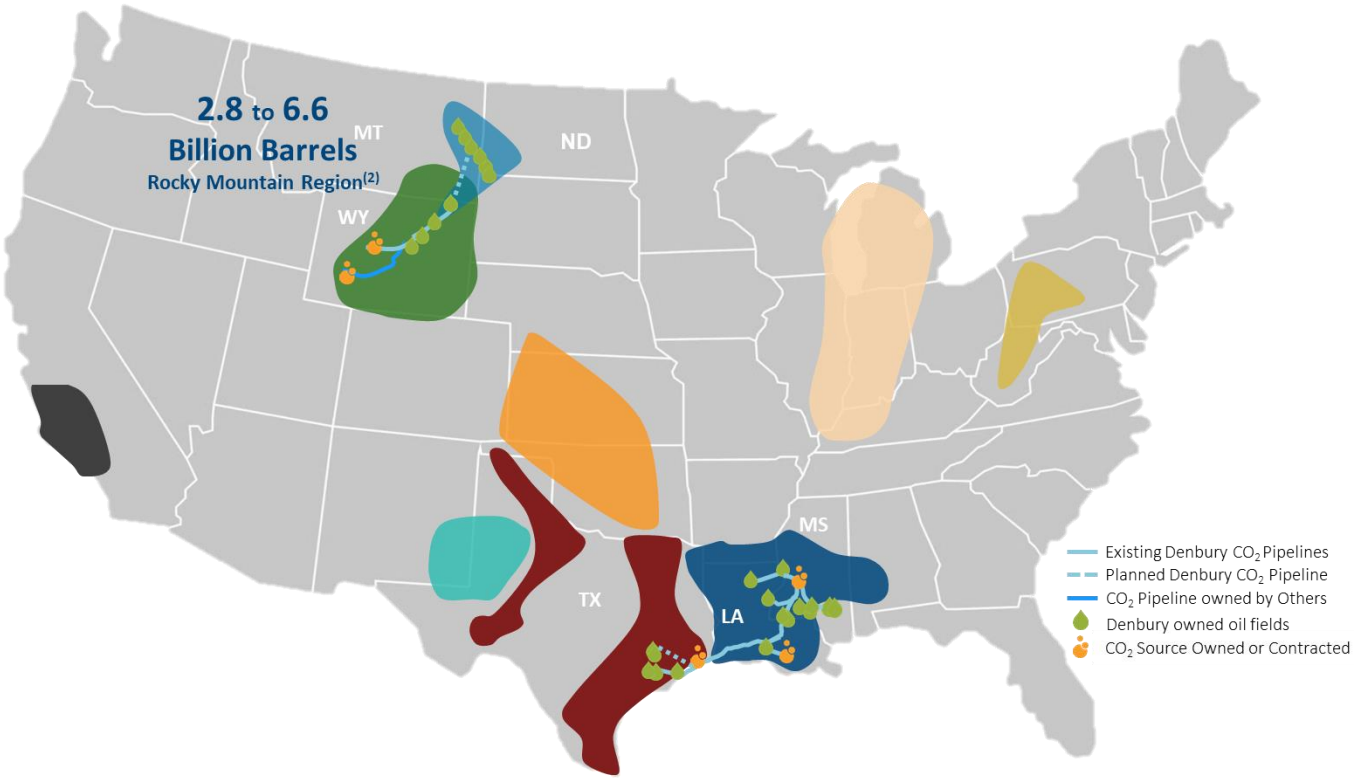
Significant CO_2 EOR Potential in the U.S.

33-83 Billion Barrels of Technically Recoverable Oil[1,2]	
Permian	9-21
East & Central Texas	6-15
Mid-Continent	6-13
California	3-7
South East Gulf Coast	3-7
Rockies	2-6
Other	0-5
Michigan/Illinois	2-4
Williston	1-3
Appalachia	1-2



1) Source: 2013 DOE NETL Next Gen EOR.
2) Total estimated recoveries on a gross basis utilizing CO2 EOR.

Associated CO_2 Storage Potential
10-40 billion MT

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CSA/ANSI ISO 27916:19

- Full Title: *Carbon dioxide capture, transportation and geologic storage – Carbon dioxide storage using enhanced oil recovery (CO_2-EOR)*
- Published Oct 2019
- Adopted by both Canadian Standards Association (CSA) and American National Standards Institute (ANSI)
- "…applies to quantifying and documenting the total CO_2 that is stored in association with CO_2-EOR." (emphasis added)
- Contemplates both natural and anthropogenic sources used in a CO_2-EOR project

CSA/ANSI ISO 27916:19

- Key Terminology (just a few of the 23 defined terms)
  - Associated storage
  - Containment assurance
  - EOR Complex
  - Leakage & Leakage pathway
  - Loss
  - Quantification period
  - Termination

CSA/ANSI ISO 27916:19

1.3.1 Inclusions

a) safe, long-term containment of CO_2 within the EOR complex;
b) CO_2 leakage from the EOR complex through leakage pathways; and
c) on-site CO_2-EOR project loss of CO_2 from wells, equipment or other facilities

1.3.2 Exclusions

a) lifecycle emissions, including but not limited to CO_2 emissions from capture or transportation of CO_2, on-site emissions from combustion or power generation, and CO_2 emissions resulting from the combustion of produced hydrocarbons;
b) storage of CO_2 above ground;
c) buffer and seasonal storage of CO_2 below ground (similar to natural gas storage);
d) any technique or product that does not involve injection of CO_2 into the subsurface; and
e) emissions of any GHGs other than CO_2

ISO → 45Q Tax Credit

- Section 45Q provides for tax credit for CO_2 storage ($/tonne):

Storage	2021	2026	Future?
EOR	$22.68	$35	$60
Dedicated storage	$34.81	$50	$85

- IRS 45Q guidance in January 2021 recognized ISO certification in addition to Subpart RR opt-in for CO_2-EOR
- IRS Tax Form 8933 amended to report ISO elements
- Requires 3rd party certification for an EOR Operations Management Plan and annual storage certifications

What are the components of an Operations Management Plan?

EOR Complex Definition	Containment Assurance	Well Construction	Quantification	Project Termination
• Geologic Characterization • Facilities Definition • Well Counts and Vintages	• Discussion of key initial and operational containment risks • Monitoring program including methods and implementation	• New well construction • Well interventions • Continued operation	• Principles and data process	• Termination plan including requirements and assurance of containment

An Operations Management Plan includes all the components already needed to design, implement and manage a CO_2 flood.

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Defining the EOR Complex

- Geologic characterization mimics unitization documents already required for regulatory bodies
- Should emphasize the zones of interest, juxtaposition across faults and the nature of the trap
- Also includes information on the surface facilities including process flow and metering

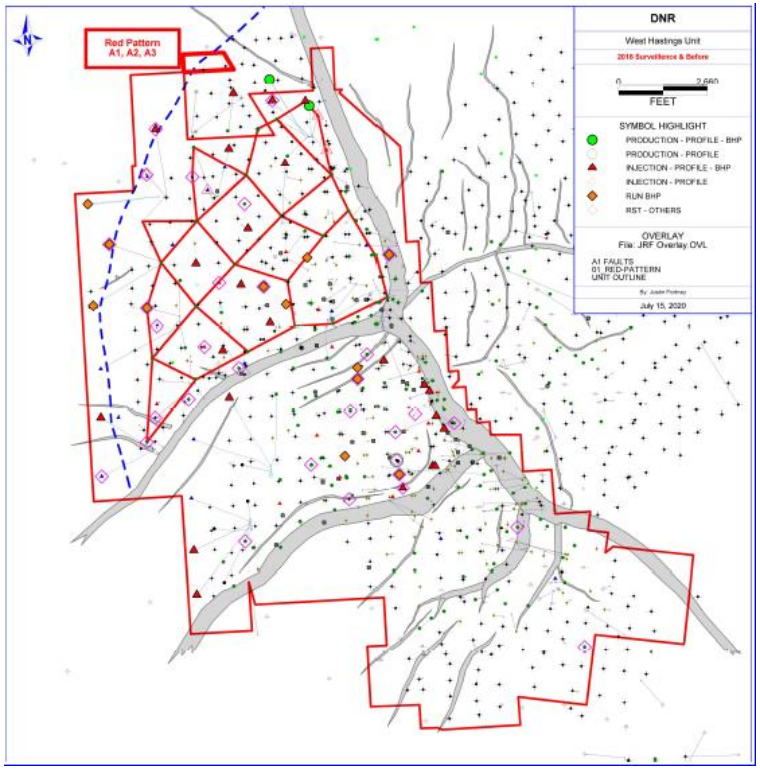
Containment Assurance Framing

- Assessment of the potential pathways for leakage of stored CO_2 outside of the EOR complex.
- Potential pathways:
  - Existing wellbores
  - Faults and fractures
  - Natural and induced seismicity
  - Pipeline/surface equipment
  - Lateral migration
  - Drilling through the EOR complex
  - Diffuse leakage through the seal
  - Other unique pathways by field
- Discussion of each potential leakage pathway includes comments around characterization work that limits the likelihood of occurrence

Monitoring Program Definition and Implementation

Monitoring program should address potential leakage pathways from containment discussion

- Monitoring Methods
  - Cased hole logs – injection/production profiles, bottomhole pressure surveys
  - Continuous monitoring
    - Downhole pressure/temperature gauges
    - Monitoring well in zone or shallow zone
  - Surface monitoring
  - Seismic surveys
- Program Implementation
  - Vertical and areal implementation in line with assuring containment



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Well Construction

- Well construction and intervention standards within oil and gas operations are highly regulated by a combination of jurisdictional agencies and groups including the state regulatory agency, NACE and API standards
- New Well Construction
- Well Intervention
  - Liner installations, sidetracks, etc.
- Well Operation
  - MITs, corrosion protection program

Project Termination

- CO_2 containment will be assured by monitoring fluid movement as the project reaches termination. Absence of fluid movement indicates low likelihood of leakage.

- When does termination occur?
  - Termination is when all the following occur: cessation of CO_2 injection, cessation of hydrocarbon production from the reservoir, and the plugging and abandonment of active wells.

- What are the requirements and plans for termination?
  - Operations management plan will be used until project is completed
  - Field will be abandoned following regulatory guidelines

- Post termination

Quantification

$$m_{\text{stored}} = m_{\text{input}} - m_{\text{loss operations}} - m_{\text{loss EOR complex}}$$

- Simply put → subtract losses from inputs
- Requires completeness & precludes double-counting
- Accounts for “native CO_2”
- Accounts for CO_2 produced and transferred offsite
- Expressed in mass or volumetric units

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Quantification

- **m_{input}**
  - Total CO_2 received at custody meter
  - Native CO_2 documented
  - Allocations may be accomplished via contract

- **$m_{loss\ operations}$**
  - Leakage from EOR facilities
  - Loss from venting/flaring
  - Loss due to entrainment in produced fluids
  - Loss due to transfer out of the project

- **$m_{loss\ EOR\ complex}$**
  - ISO Plan describes procedures to detect and characterize
  - Leakage quantified and documented as loss

Quantification

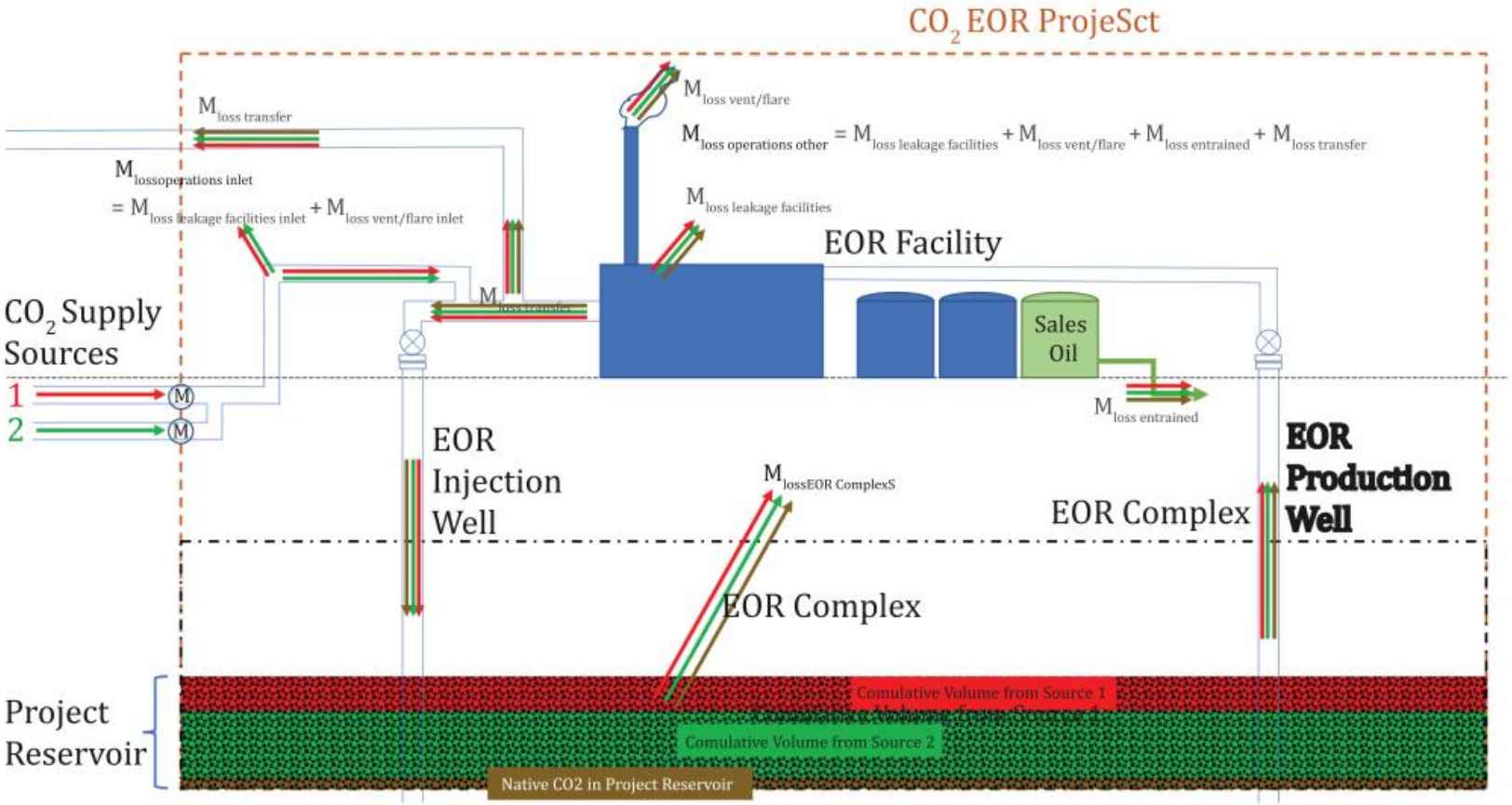

Figure B.1 — Illustration of CO_2 allocations and loss variables

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Conclusion/Final Thoughts

- Much of what the ISO Plan requires is standard practices for EOR operations.
- This is something our industry is well suited to accomplish.
- It is important that we do it right.