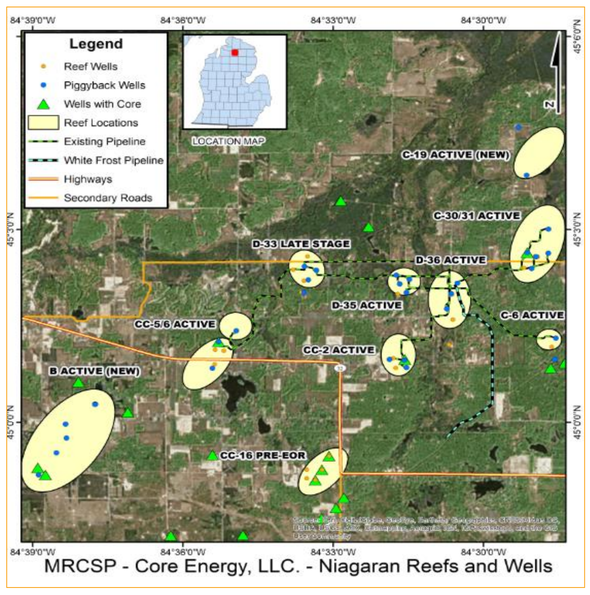
Measurement and Accounting for net CO_2 Injection in a CO_2-EOR Complex

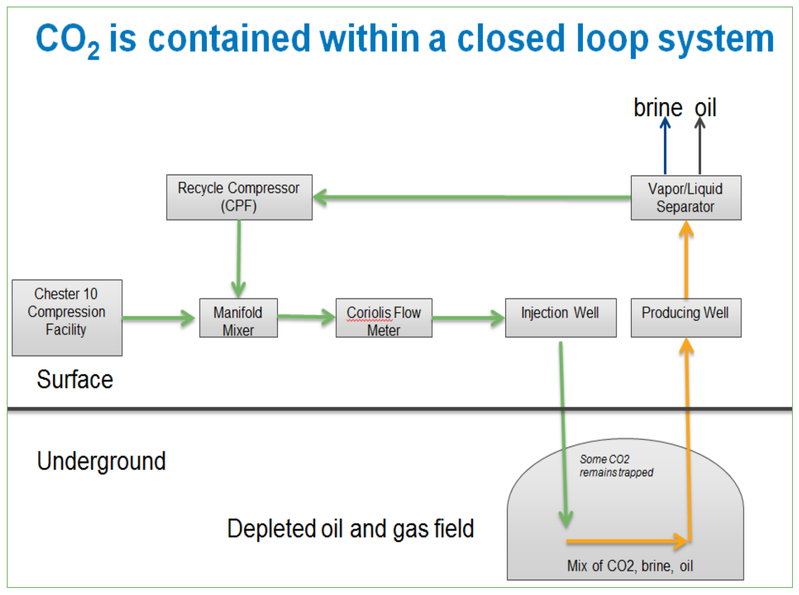
Sanjay R. Mawalkar (sanjay@battelle.org), Neeraj Gupta, Matt Place, Ashwin Pasumarti, and Andrew Burchwell, Battelle, 505 King Ave., Columbus, Ohio 43201; Rick Pardini, Core Energy LLC.

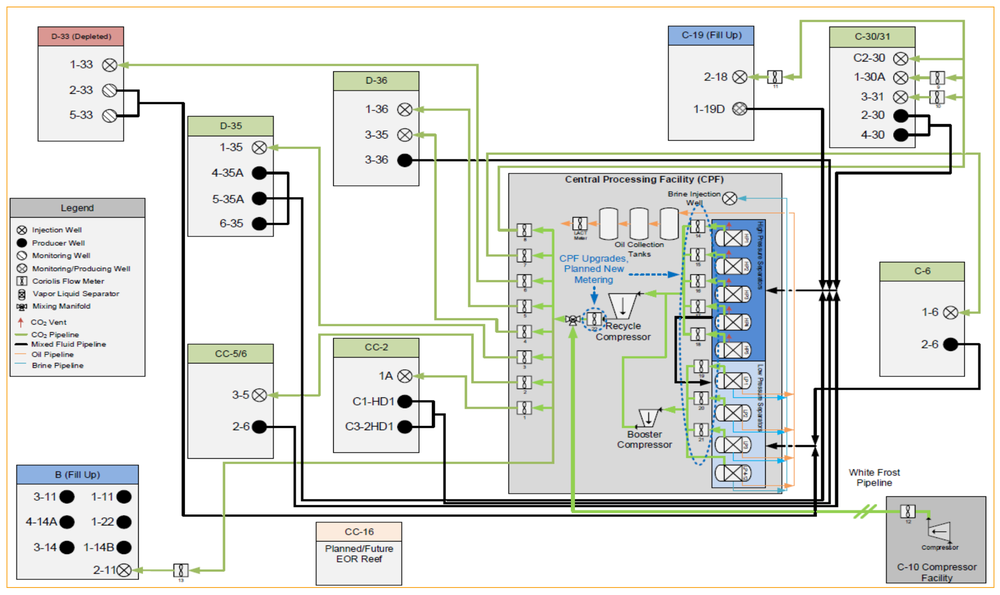
ABSTRACT

The Midwest Regional Carbon Sequestration Partnership (MRCSP) is currently conducting their Phase III (large-scale) CO_2 injection test in conjunction with EOR in a series of Silurian-age (Niagaran) pinnacle reefs in northern Michigan. Approximately 800 pinnacle reefs have been identified in the northern reef trend. MRCSP is monitoring nine of these reefs, which are at various stages of active EOR operations. Pure CO_2 is sourced from a natural gas processing facility (C-10) and co-mingled with recycle gas produced from all the EOR reefs at a central processing facility (CPF) and re-injected back into the reefs as part of a closed-circuit production/injection loop. This poster presents the accounting methodology of CO_2, flow & pressure monitoring systems, and long-term performance trends for the individual reefs and collectively for the reef system.



MRCSP - Core Energy, LLC. - Niagaran Reefs and Wells



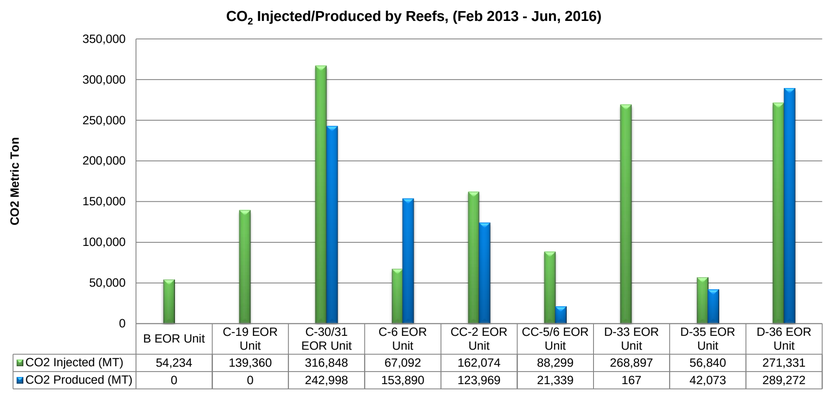


- EOR reefs located in Northern Michigan in Otsego County, near Gaylord, MI.
- 9 existing Niagaran reefs at various stages of EOR (CO_2 Flood, Active EOR, Late Stage).
- New reef (CC-16) to be added to MRCSP project.
- Pure CO_2 sourced from gas processing facility 16km to south.

- EOR reefs are inter-connected at a CPF facility where production parameters are continuously monitored and recorded.
- Brine recovered from oil production is sent to a disposal well.
- EOR reefs contain negligible quantity of hydrocarbon gas; thus, recycle gas is mostly (~95% by mass) CO_2.
- ~ 1200 MT of CO_2 is injected into various reefs daily, with equal quantities of pure CO_2 from C-10 facility and recycled gas.

- Fluid-separation via 5 High Pressure (HP) and 12 Low Pressure (LP) Separators.
- Reefs operating at high-pressures (~400 psi) are first separated from recycle gas in HP Separators. Remaining oil/water stream and produced stream from low-pressure reefs is sent to LP Separators for separating recycle gas from oil and water.
- MRCSP plans to upgrade instrumentation with the latest flow measurement technologies (Coriolis, Vortex, Orifice flow meters) and data acquisition at the CPF. This will improve accuracy of fluid stream measurements and accounting of injected/recycled CO_2.

ACCOUNTING FOR PRODUCTION PARAMETERS AND CO_2 MATERIAL BALANCE

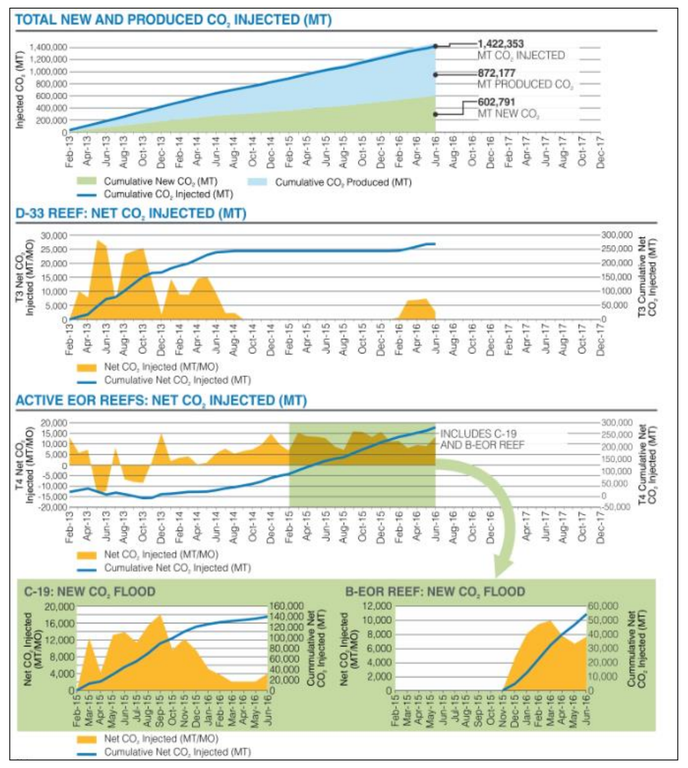


	B EOR Unit	C-19 EOR Unit	C-30/31 EOR Unit	C-6 EOR Unit	CC-2 EOR Unit	CC-5/6 EOR Unit	D-33 EOR Unit	D-35 EOR Unit	D-36 EOR Unit
CO2 Injected (MT)	54,234	139,360	316,848	67,092	162,074	88,299	268,897	56,840	271,331
CO2 Produced (MT)	0	0	242,998	153,890	123,969	21,339	167	42,073	289,272

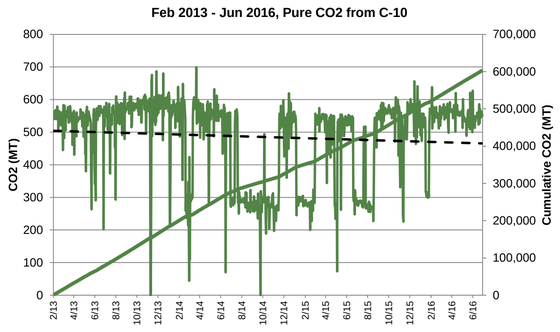
Battelle continuously monitors production parameters, including CO_2 injected, CO_2 produced, Oil, and Brine from various active EOR reefs. Production numbers from EOR operations are routinely updated in monthly and quarterly reports to DOE and other stakeholders. Among the parameters tracked include:

- Daily pure CO_2 availability from the gas processing plant
- Daily production of recycle CO_2 gas from active EOR reefs
- Daily injected quantity of pure + recycle CO_2 in all EOR reefs
- Vented gas
- Production of oil and brine
- CO_2 composition, tubing/casing pressures, compressor station parameters, etc.

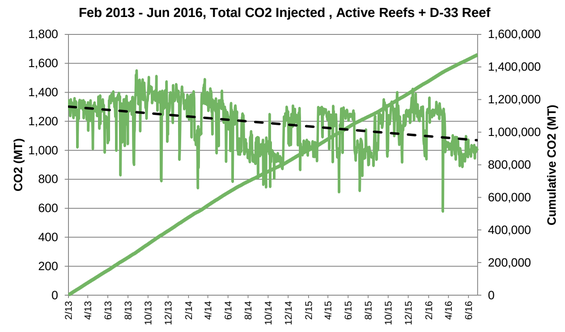
Relational databases in MS Access and SQL Server are used for tracking daily production numbers. These databases have mass-balance queries for identifying reporting errors.



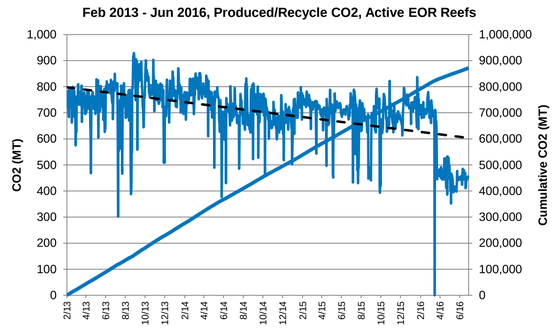
Feb 2013 - Jun 2016, Pure CO2 from C-10



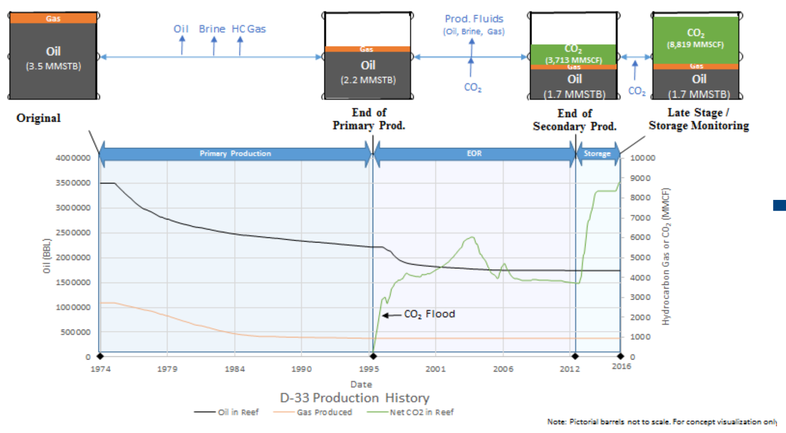
Feb 2013 - Jun 2016, Total CO2 Injected , Active Reefs + D-33 Reef



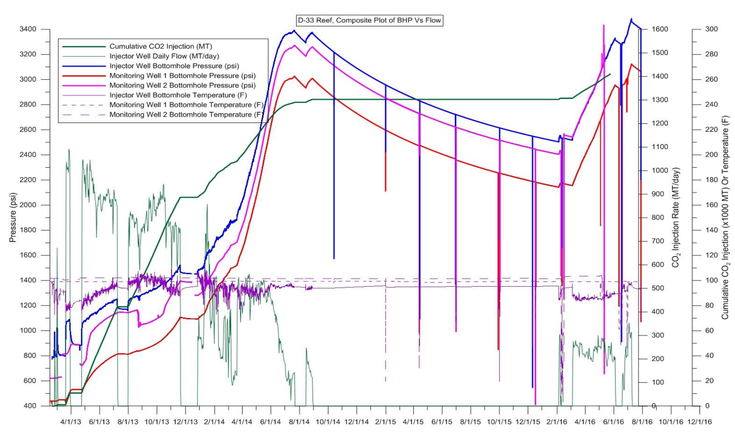
Feb 2013 - Jun 2016, Produced/Recycle CO2, Active EOR Reefs



INDIVIDUAL REEF PRESSURE MONITORING AND PERFORMANCE BENCHMARKS



Life-Cycle of a Late Stage D-33 EOR Reef using Material Balance Approach

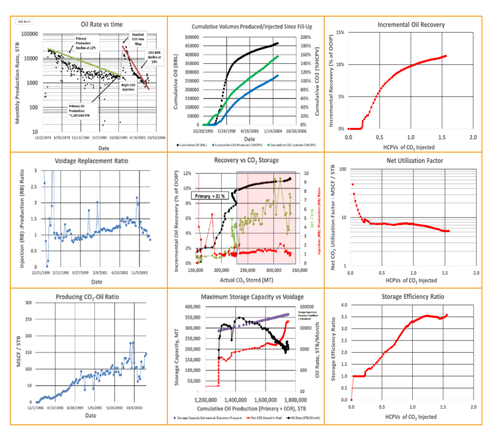


Bottomhole Pressure, Temperature and Flow Monitoring

OOIP estimates when combined with material balance of production fluids during various phases of EOR allows us to compute EOR performance benchmarks. These are further modified by monitoring pressure history and reservoir conditions during CO_2 injection.

Acknowledgement

MRCSP is led by Battelle and supported by U.S. DOE-NETL under Cooperative Agreement No. DE-FC26-0NT42589 with co-funding from several other partners. Core Energy, LLC and its staff are acknowledged for providing access and field implementation support for the large-scale test. Significant contributions were also provided by Kathy Dungey and Joe Coppersmith at Core Energy.



9-Panel Dashboard of Performance Benchmarks