The Energy & Environmental Research Center's Economic Case for CCUS: Reducing Capture Costs and Increasing Demand for Commodity CO_2

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Energy & Environmental Research Center

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The International Center for Applied Energy Technology®

THE UNIVERSITY OF NORTH DAKOTA

Presentation Outline

- Economic case for carbon capture, utilization, and storage (CCUS):
  - EERC Carbon Management Program
  - PCO$_2$C (Partnership for CO$_2$ Capture)
  - PCOR (Plains CO$_2$ Reduction) Partnership
  - Enhanced oil recovery (EOR) potential
  - Vision for the future of CCUS

Carbon Management at the EERC

- PCOR Partnership
- PCO_2C
- Gasification, warm-gas cleanup, and precombustion carbon capture

Development of Focus Areas for CO_2 Capture Implementation in Coal-Fired Power Plants

- Scale-up
- Energy penalty
  - 20% to 30% less power output
- Cost
  - Current costs are $40 to $80 per ton of CO_2 (80% increase in cost of electricity [COE]).
  - Very capital intensive ($1500 to $2000/kW).
- Contaminants
- Resource availability and sector readiness
  - Supply of solvents or sorbents will be limited.
  - Manufacture of air separation units and other large equipment will be a handcuff to implementation.
- Regulatory framework
  - Lots of unknowns and liability issues.

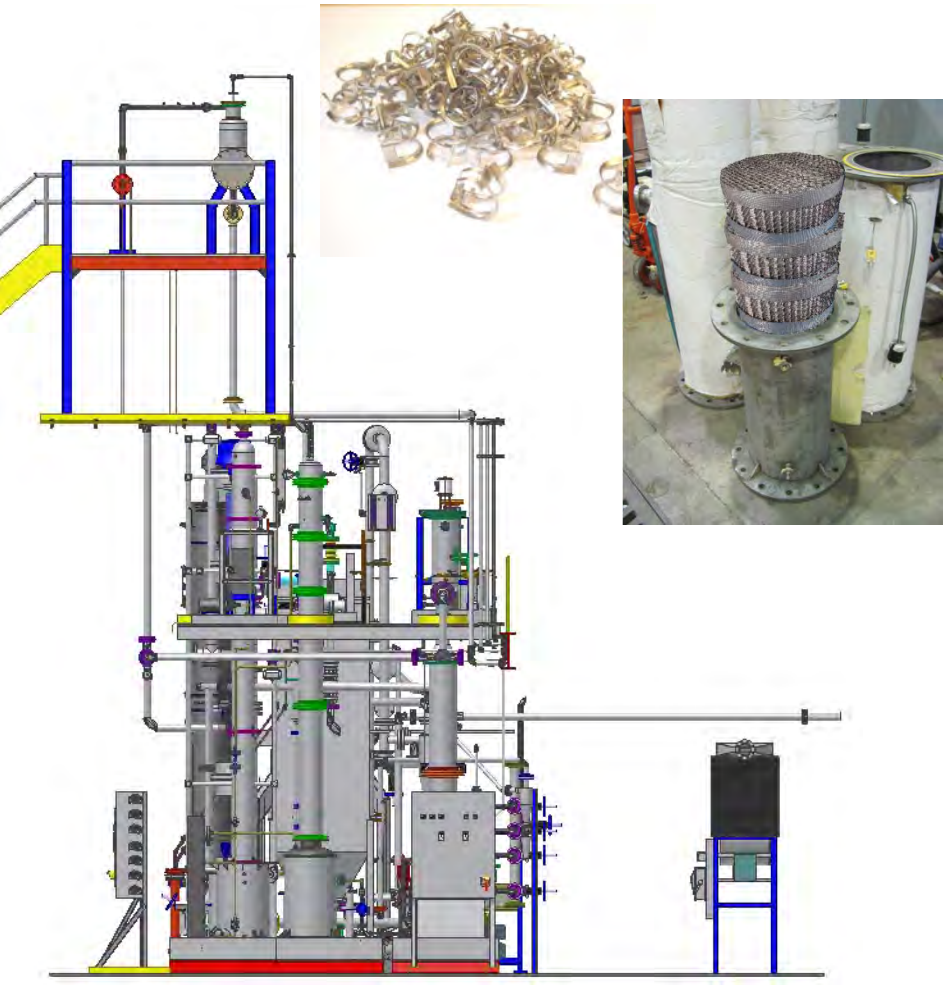
PCO_2C Phase III Sponsors

Combined Combustion Facilities

- Two “sister” pilot-scale units
- 550,000 (single) to 1.1 million Btu/hr (combined)
- 60 to 130 scfm (single) or 260 scfm (combined) flue gas
- Air- or O_2-fired
- Multifuel capability (coal, biomass, gas, liquid fuel, sludge, and municipal solid waste)

- Features
  - Air preheater and heat exchangers
  - Adjustable-swirl burner
  - Deposition section
  - Numerous ports
  - Selective catalytic reduction (SCR) reactor
  - Baghouse
  - Electrostatic precipitator
  - Sulfur scrubber
- Testing of fuels and additives
  - Fouling and slagging
  - Corrosion
  - Hg
  - NO_x
  - SO_x
  - CO_2 capture
  - Particulates
  - Heat flux
  - Infrared flame characterization

CO_2 Capture System



- Three 10-inch-diameter packed columns.
  - Two absorbers and one stripper that are designed for maximum flexibility.
  - Able to evaluate different solvents by adjusting the column height.
  - Absorber columns are operated in series.
  - Packing type (both random and structured) can easily be changed.
- Water wash column used to monitor solvent slip.
- Very highly instrumented to allow for tight control and accurate, precise measurement of parameters.
- Can process up to 160 scfm of flue gas.

Testing During Phases I and II

- Monoethanolamine (MEA) (30 wt%)
- Hitachi H3-1
- Methyldiethanolamine (MDEA)–piperazine
- Huntsman advanced solvent
- Huntsman solvent additive
- Baker Hughes additives
- Cansolv next-generation solvent
- ION Engineering solvent
- National Energy Technology Laboratory solid sorbent
- C-Quest sorbent
- Neumann Systems Group

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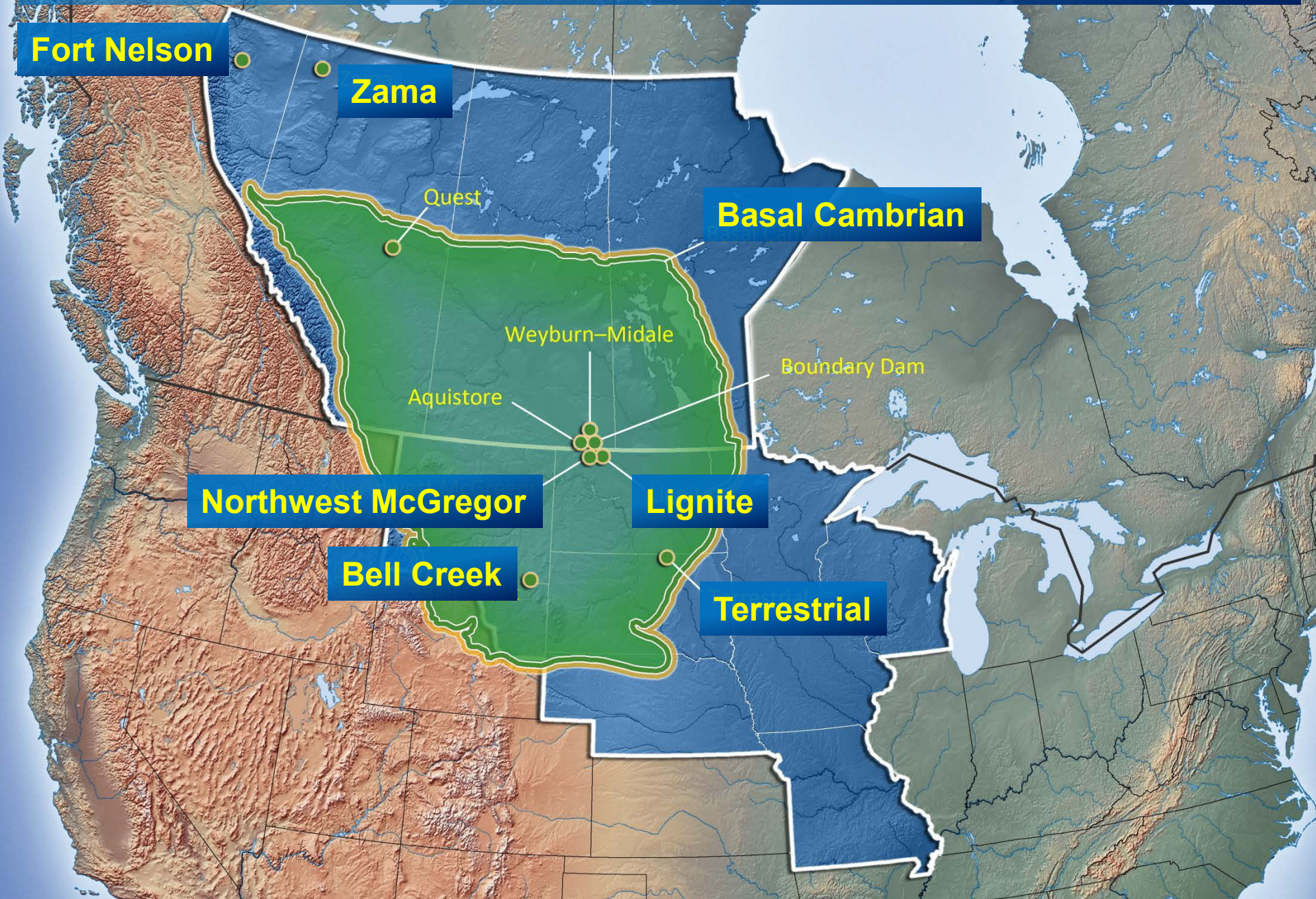
Economic Analysis – Tracking the Potential to Reduce Capture Costs

	U.S. Department of Energy (DOE) Report		EERC Case 10 Models – Using Pilot-Scale Data for Advanced Solvents			
	Case 9 No Capture	Case 10 With Capture	MEA	ION	Huntsman	Cansolv
Gross Output, MW	582.6	672.7	660.3	623.8	646.0	641.7
Net Output, MW	550	550	550	550	550	550
Potential COE, $2011/MWh	82	142	129	112	123	119
Potential CO_2 Capture Cost, $2011/ton	-	59	46	34	42	39

Potential costs projected here are based on pilot-scale testing. Technologies must be verified through further pilot-scale evaluation, scale-up demonstrations, and long-term operation with a variety of coals and plant configurations.

PCOR Partnership

PCOR Partnership Field-Based Projects

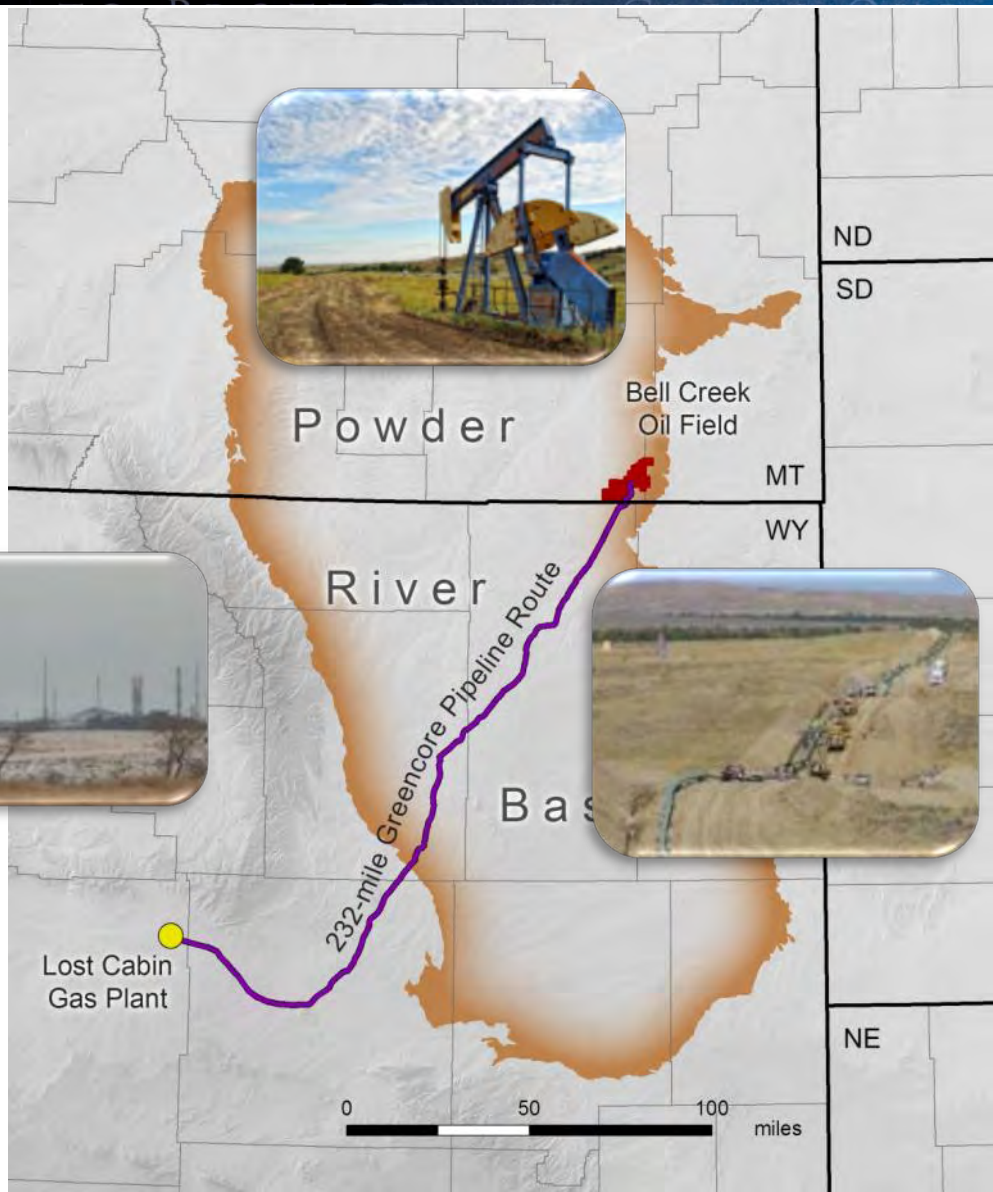


PCOR Partnership Objectives

- Safely and permanently achieve CO_2 storage on a commercial scale in conjunction with EOR.
- Demonstrate that oil-bearing formations are viable sinks with significant storage capacity to help meet near-term CO_2 storage objectives.
- Establish monitoring, verification, and accounting (MVA) methods to safely and effectively monitor commercial-scale simultaneous CO_2 EOR and CO_2 storage projects.
- Utilize the commercial practices as the backbone of the MVA strategy and augment with additional cost-effective techniques.
- Share lessons learned for the benefit of similar projects across the region.
- Establish a relationship between the CO_2 EOR process and long-term storage of CO_2.

Bell Creek CO_2 EOR and Incidental Storage Study

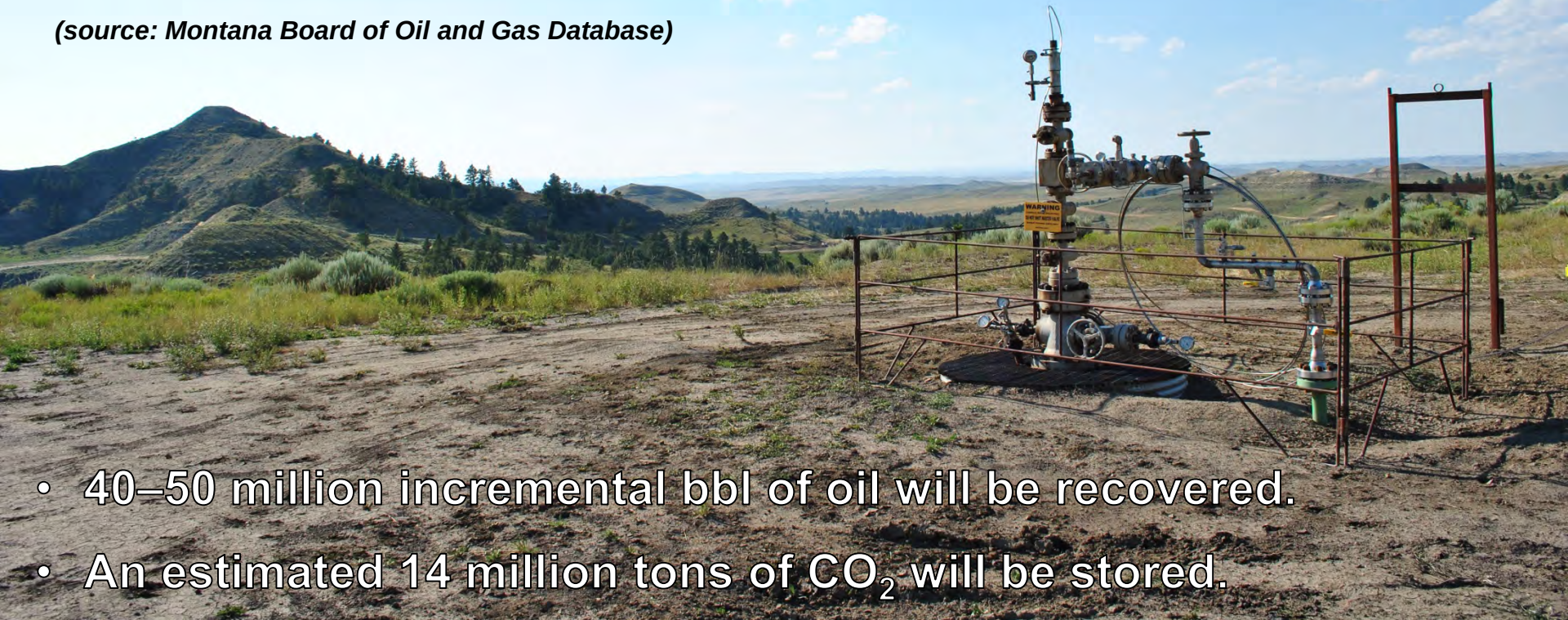
- The Bell Creek oil field is operated by Denbury Onshore LLC.
- CO_2 is sourced from ConocoPhillips' Lost Cabin natural gas-processing plant.



CO_2 Injection Has Begun!!!

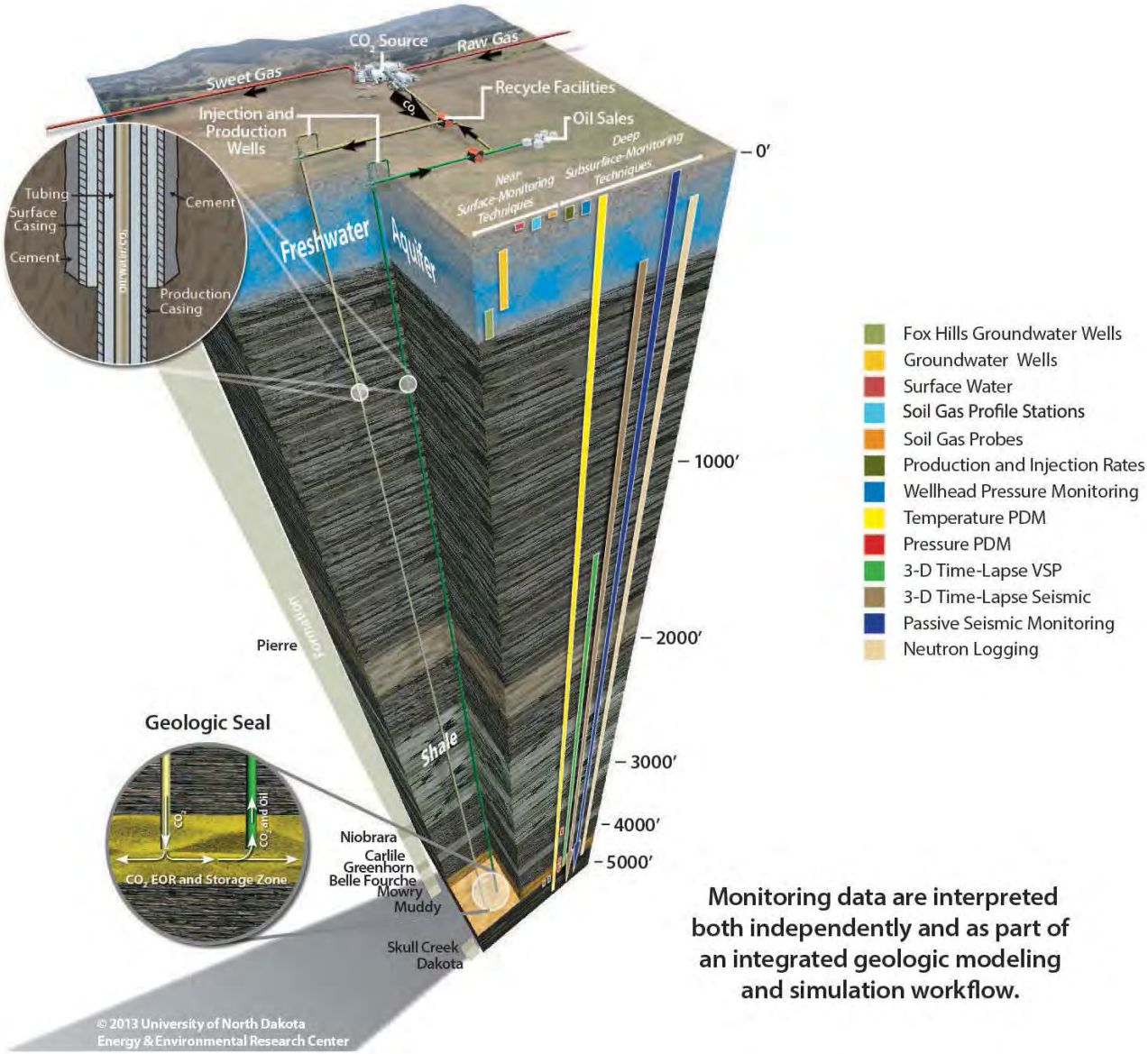
- Pipeline completed November 2012
- Pipeline filled February/March 2013
- First injection May 2013
- Facilities commissioned August 2013
- Approximately 360,000 metric tons injected as of December 31, 2013

(source: Montana Board of Oil and Gas Database)



- 40–50 million incremental bbl of oil will be recovered.
- An estimated 14 million tons of CO_2 will be stored.

Path Forward – Operational Monitoring



Monitoring data are interpreted both independently and as part of an integrated geologic modeling and simulation workflow.

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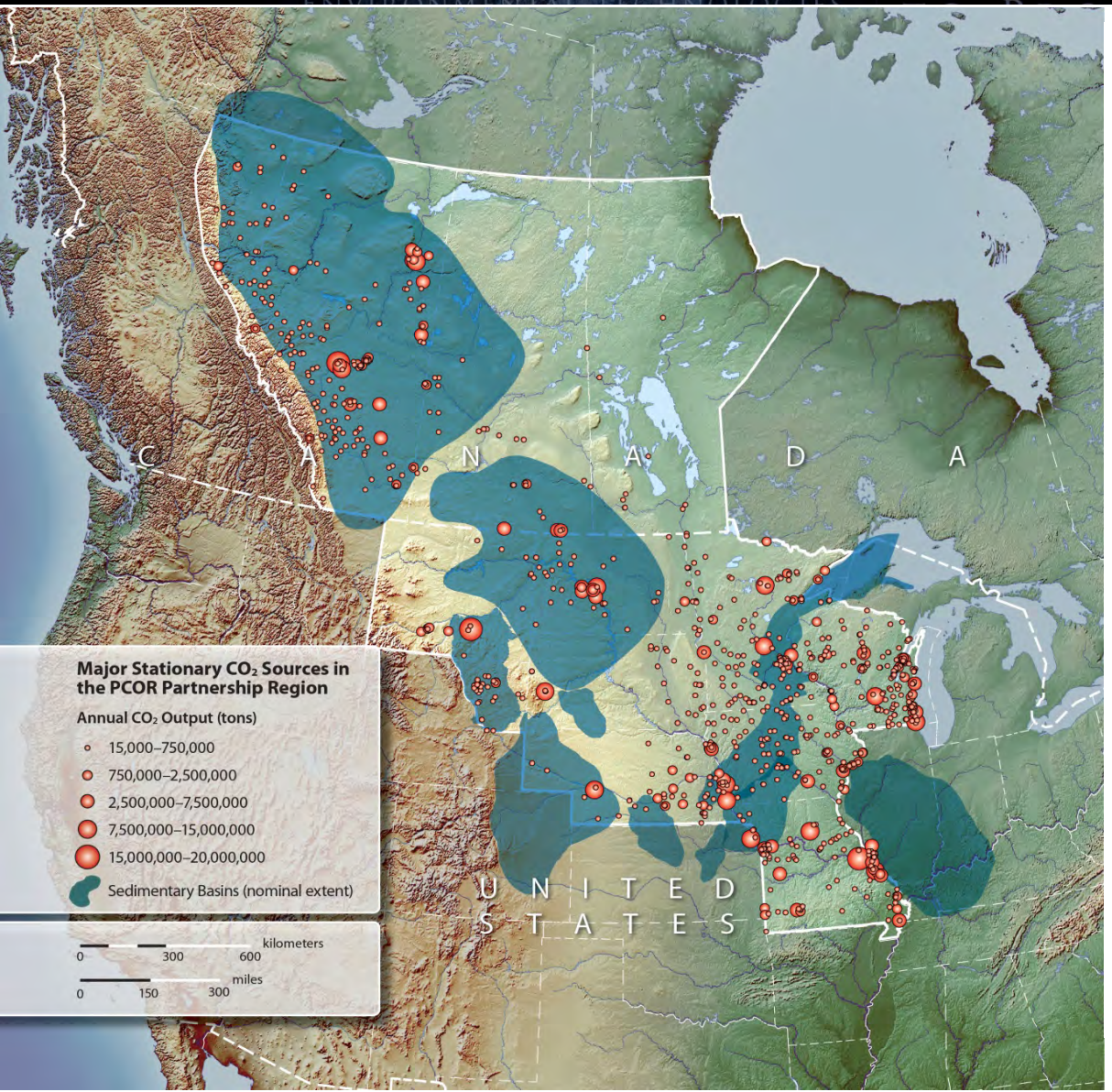
PCOR Partnership Region



- Developing an understanding of the magnitude, distribution, and variability of the region's major stationary CO_2 sources.
- Characterizing potential geologic sinks and infrastructure within the region.
- Estimating regional CO_2 storage resource.
- Performing targeted area and formation-level studies.
- Providing context for extrapolating the results of the large-scale demonstrations.

PCOR Partnership Regional Characterization

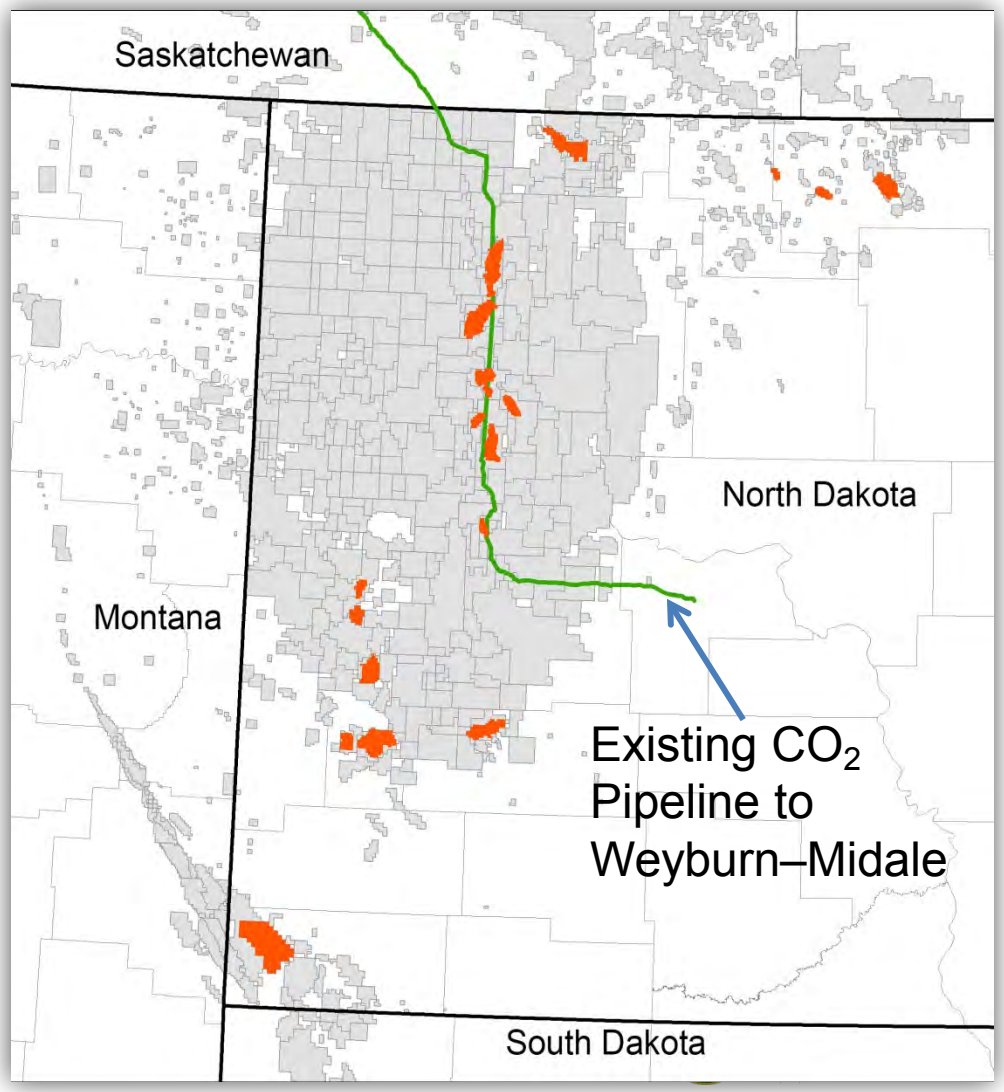
Objective: Characterize sources, geologic and terrestrial sinks, and infrastructure within the PCOR Partnership region in an effort to optimize source–sink opportunities within the region.

Data Types

- **Sources**
  - Size, location, type
- **Sinks**
  - Geologic properties, thickness, type (e.g., saline formation, oil field)
- **EOR**
  - Oil recovery potential
- **CO_2 storage capacity estimates**
  - Saline formations and hydrocarbon reservoirs

Significant Non-Bakken North Dakota Fields/Pools Await CO_2 EOR

- Nearly 130 million tons of CO_2 is needed for the top 22 candidate fields in North Dakota.



BAKKEN PETROLEUM SYSTEM

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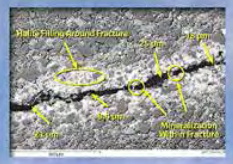


Bakken Optimization Program

- Site logistics
- Waste Management
- Hydrocarbon Utilization
- Water Management
- Process Optimization and Systems Analysis

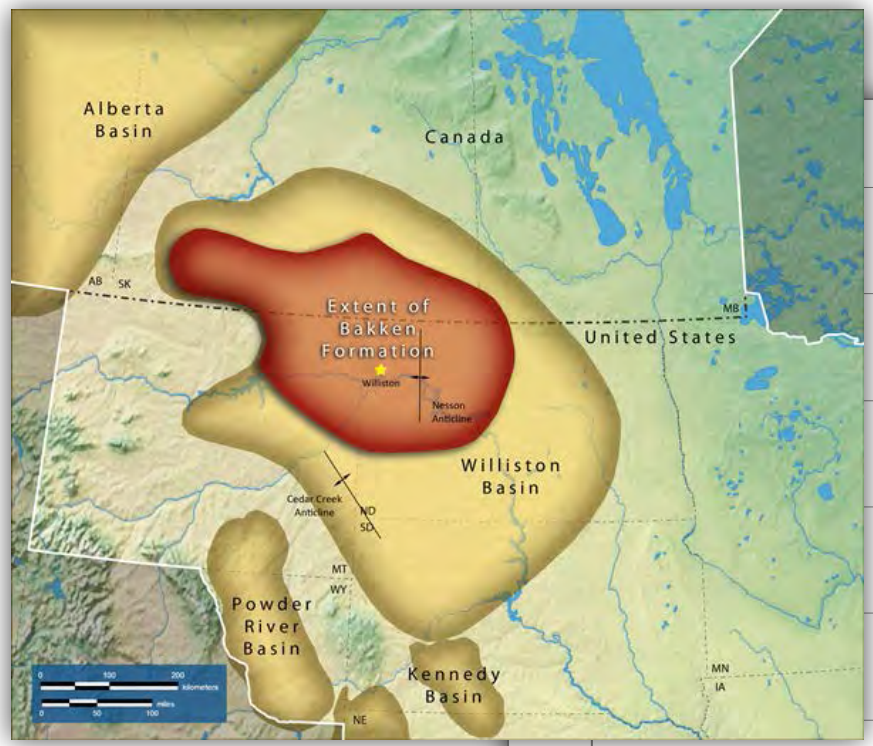
Continental Resources — America's Oil Champion
Marathon Oil
WHITING
OASIS PETROLEUM
Nuverra Environmental Solutions
Bakken Production Optimization Program

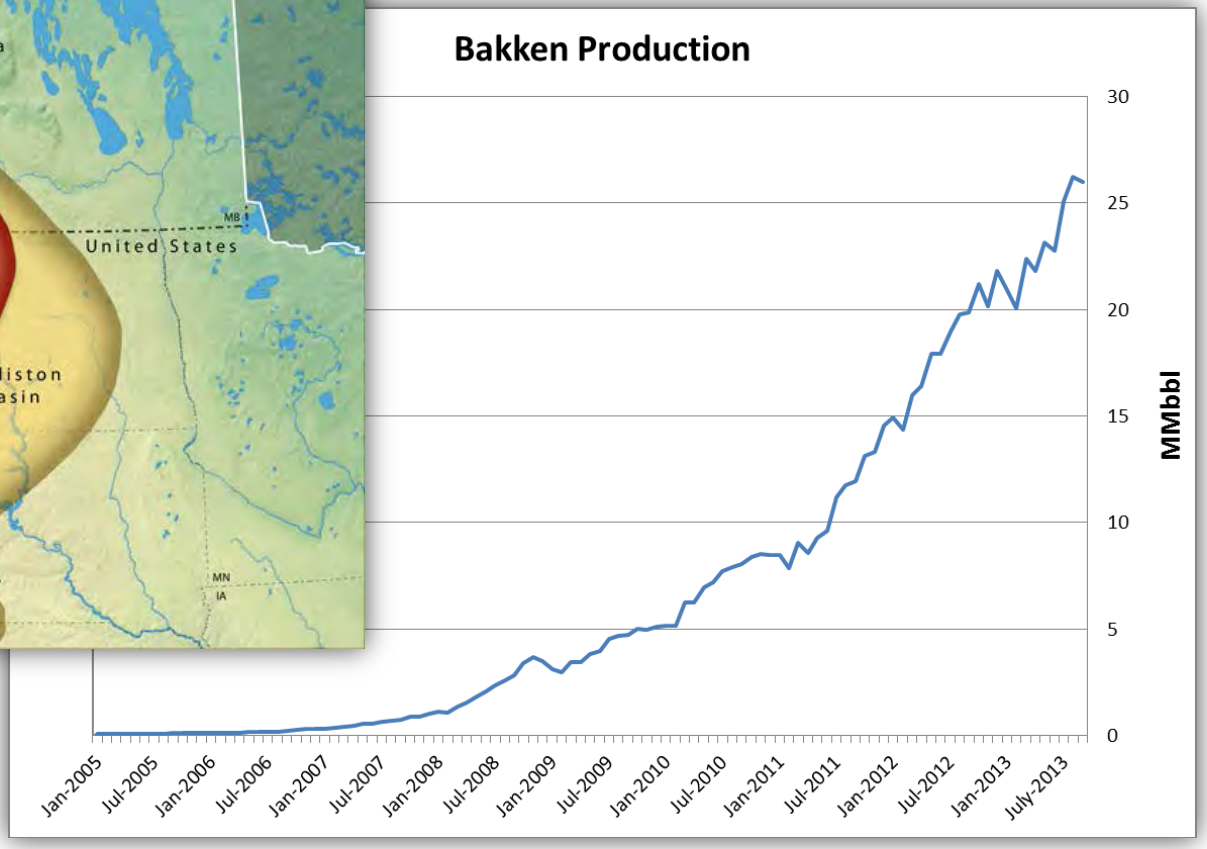
Bakken CO_2 Enhanced Oil Recovery and Storage Project

- Resource Maximization
- Innovative Reservoir Characterization
- Fracture Characterization and Modeling

NETL
Continental Resources — America's Oil Champion
Marathon Oil
TAQA

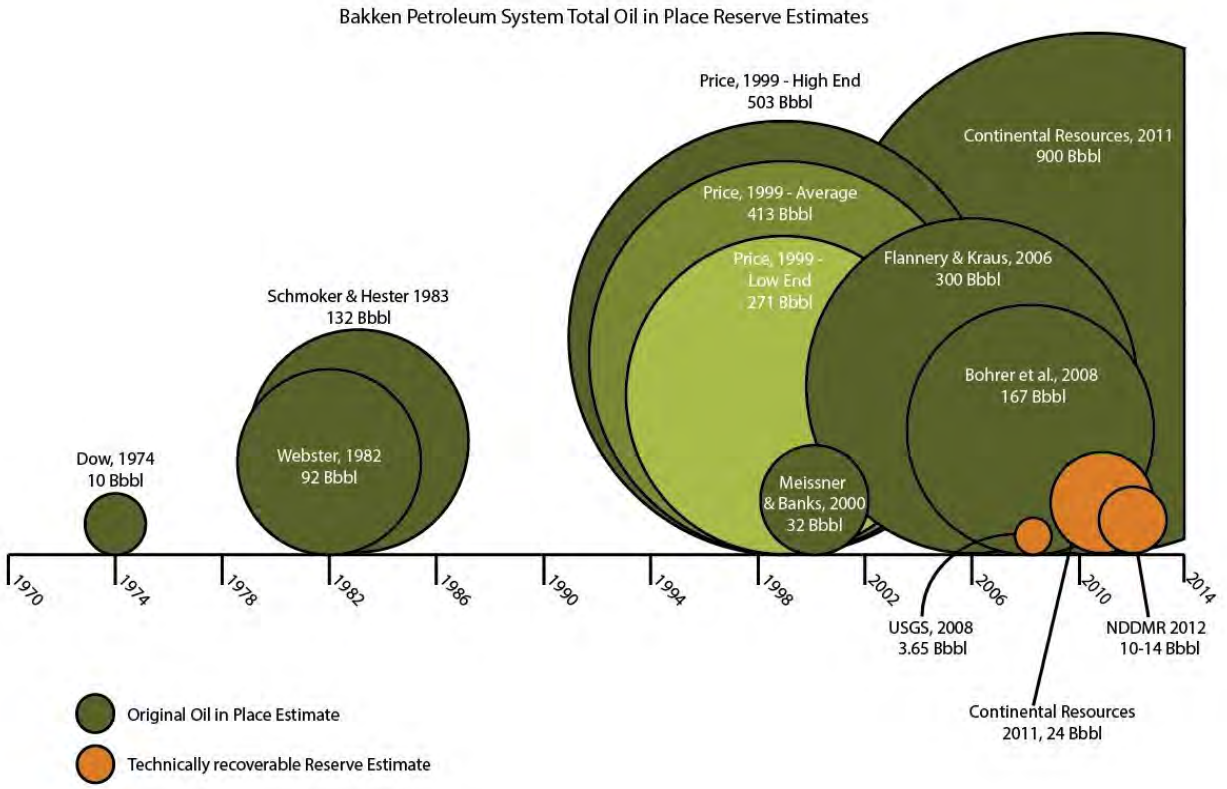
Bakken Extent and Productivity





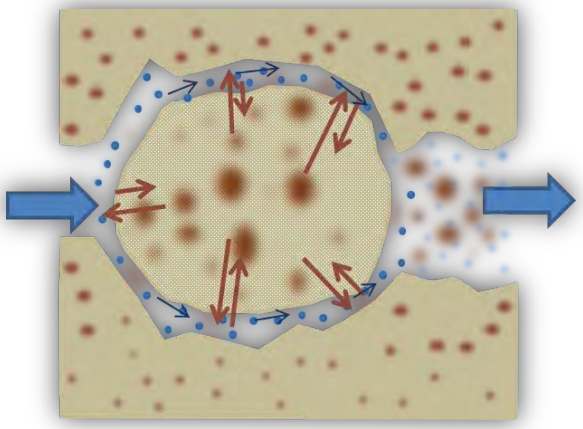
How Do We Get More Oil Out of the Bakken?

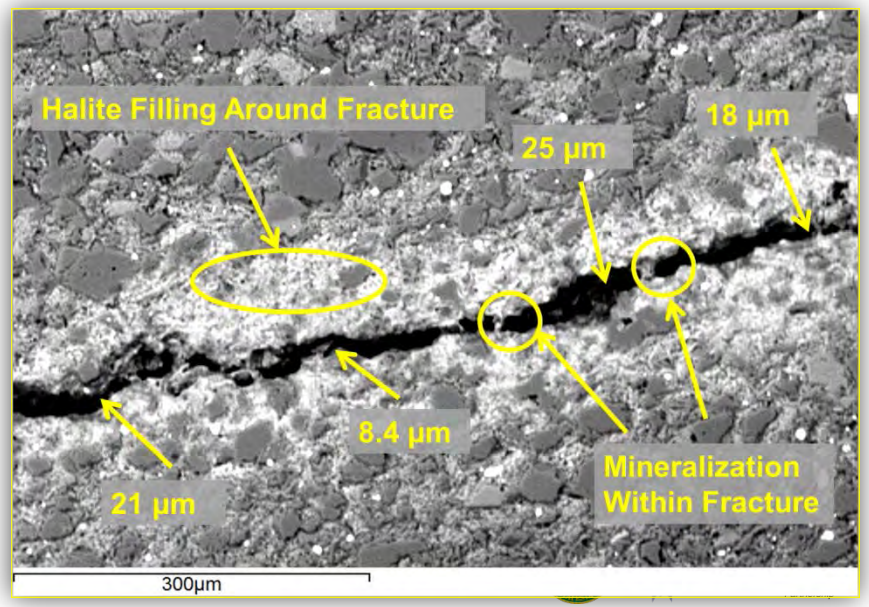
- The more we understand about the Bakken petroleum system, the more oil we recognize in it.
- Currently, only a 3%–10% recovery factor.
- Small improvements in recovery could yield over a billion barrels of oil.
- **Can CO_2 be a game changer in the Bakken?**



Bakken CO_2 EOR Project

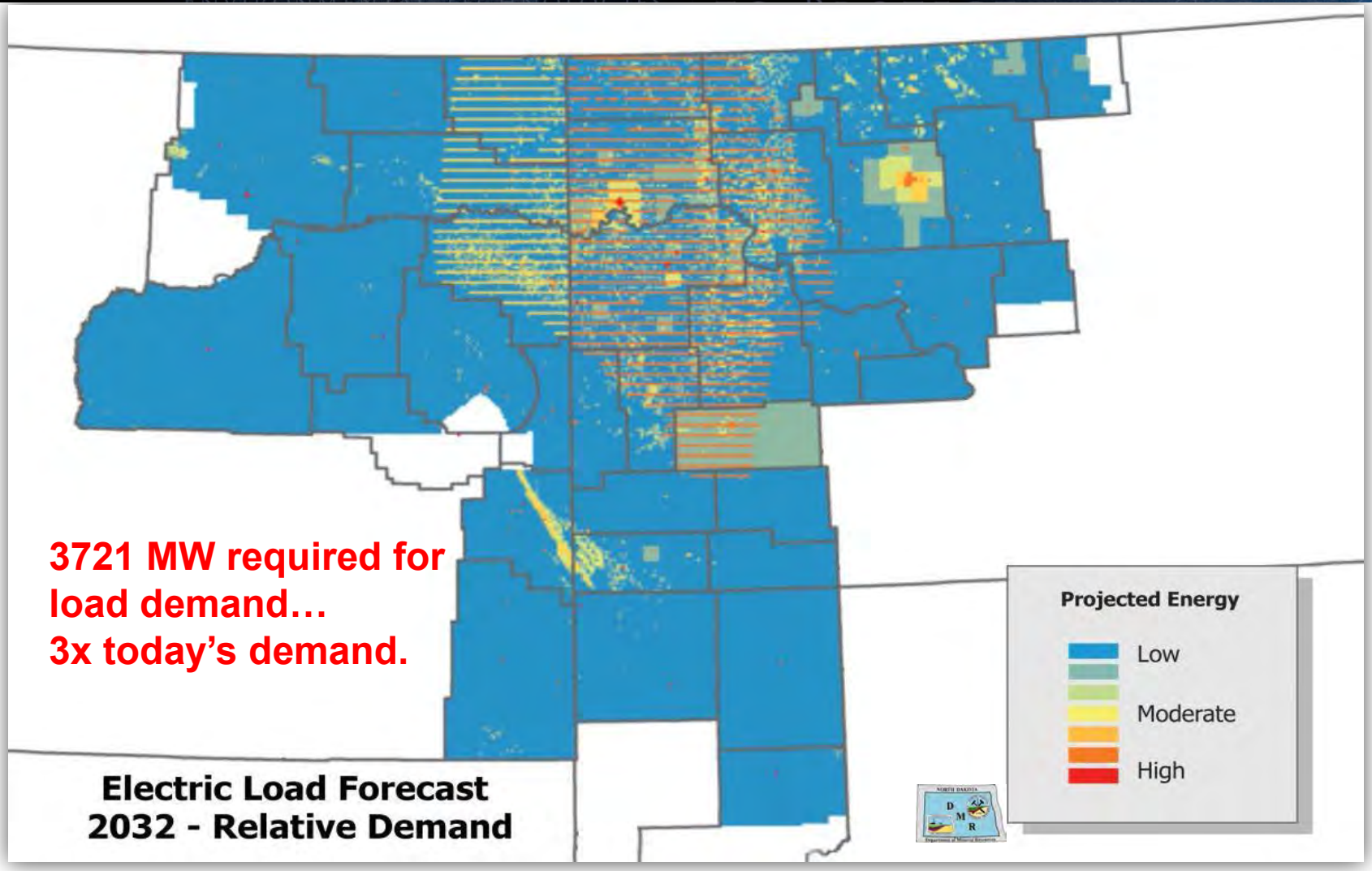
- Analysis of core and microfractures
- Petrophysical modeling
- Numerical simulation





Theme Session 3: "CO_2 Flooding Case Histories" (Fri., Dec. 13: 8:45 a.m.)

Western North Dakota Power



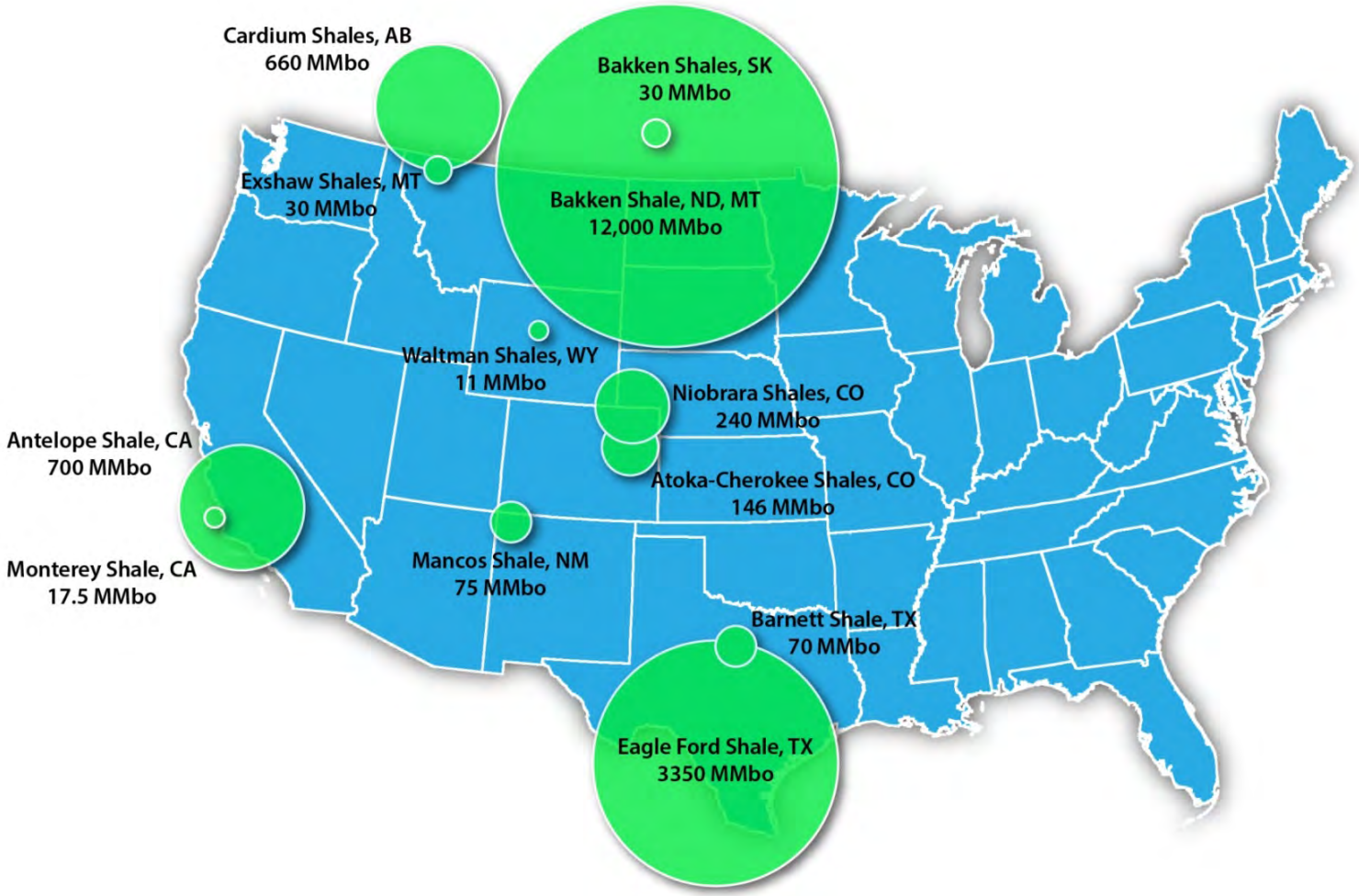
Bakken CO_2 Demand for North Dakota – A 30,000-ft View

- Based on the following:
  - Traditional evaluation techniques
  - North Dakota Industrial Commission original oil in place estimates
  - 4% incremental recovery
  - Net utilization of 5000 and 8000 ft^3/bbl
- 2 to 3.2 billion tons of CO_2 needed.
- North Dakota currently produces ~33 million tons CO_2/year.

Energy Polygeneration Industrial Complex (EPIC)

Leveraging today's abundant resources and economic vitality into tomorrow's innovative technology and prosperity.

How Many More Bakkens Are Out There?



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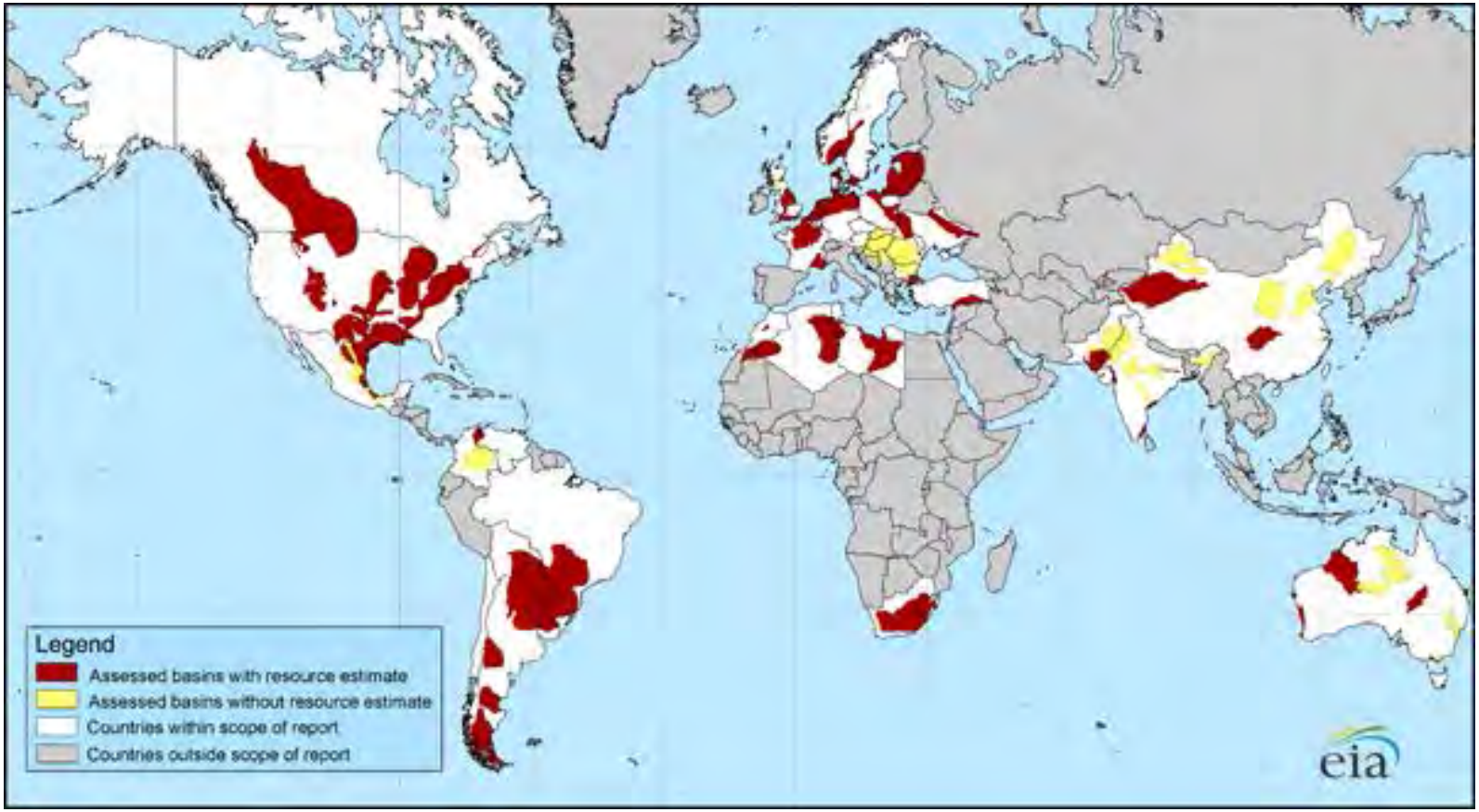

Source: U.S. Energy Information Administration (EIA).


Thank you!

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