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Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

CARBON CAPTURE, UTILIZATION, AND STORAGE

REGIONAL UPDATE FOR THE WILLISTON BASIN

25th Annual CO_2 Conference

Midland, Texas

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REGIONAL POTENTIAL

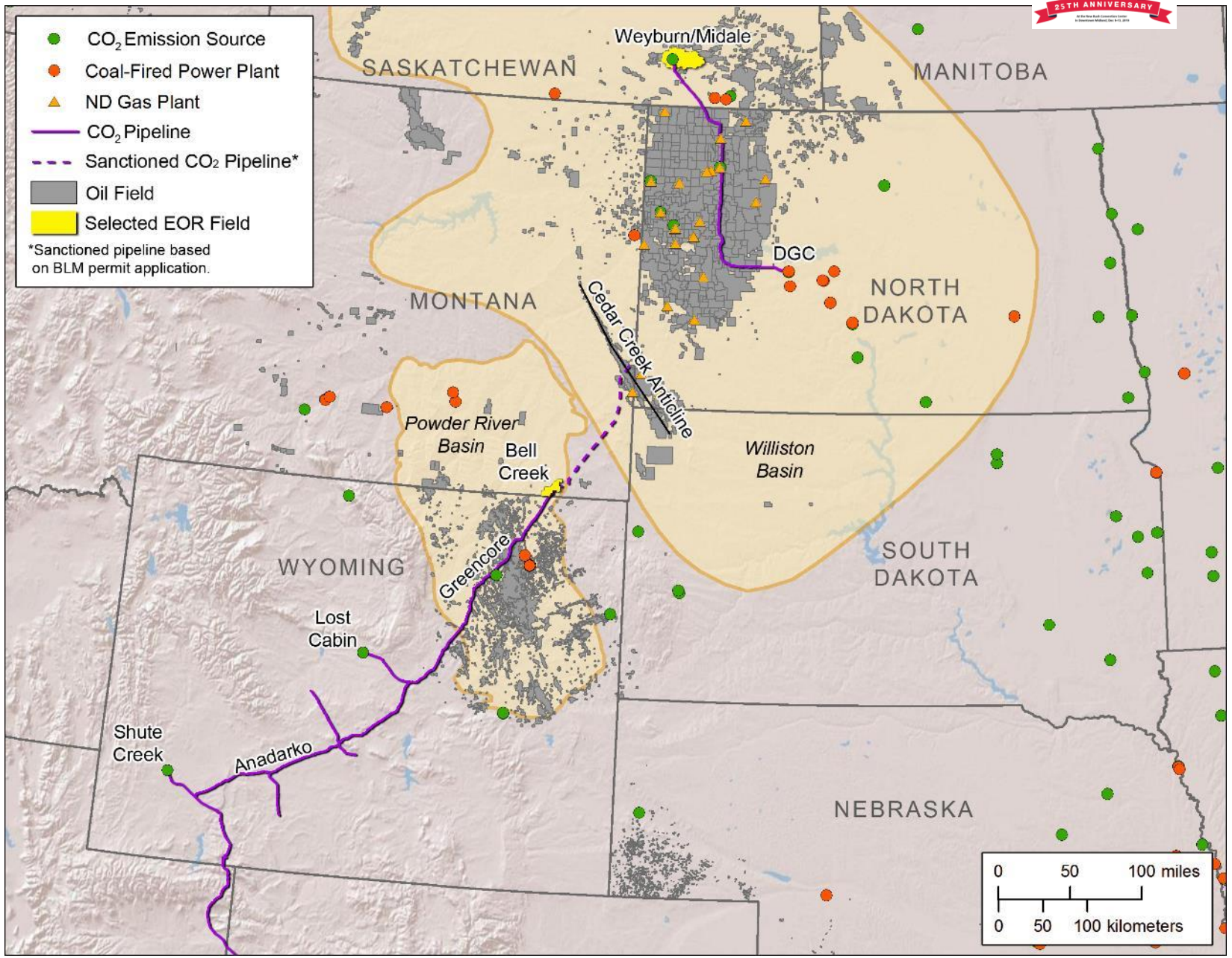
A Prolific Oil-Producing Region in North America

- **Conventional**
- **Unconventional**
- **Stacked horizons**
- **Residual oil zones (ROZs)?**

Abundant Anthropogenic CO_2 Sources Proximal to Enhanced Oil Recovery (EOR) and Storage Opportunities

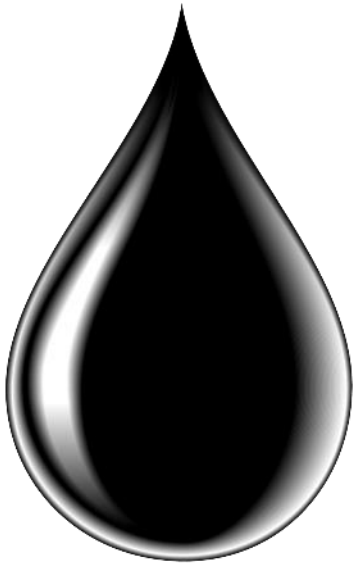
Growing CO_2 Transportation Network

Massive CO_2 Storage Potential in Deep Saline Formations

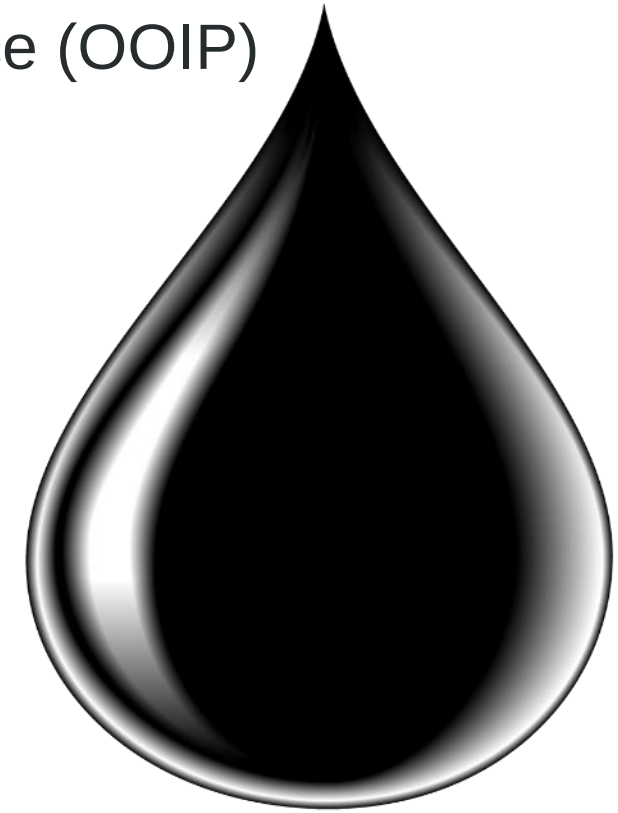


BAKKEN EOR SIZE OF THE PRIZE

Original Oil in Place (OOIP) Estimates



300 Bbbl
(Flannery and Kraus, 2006)



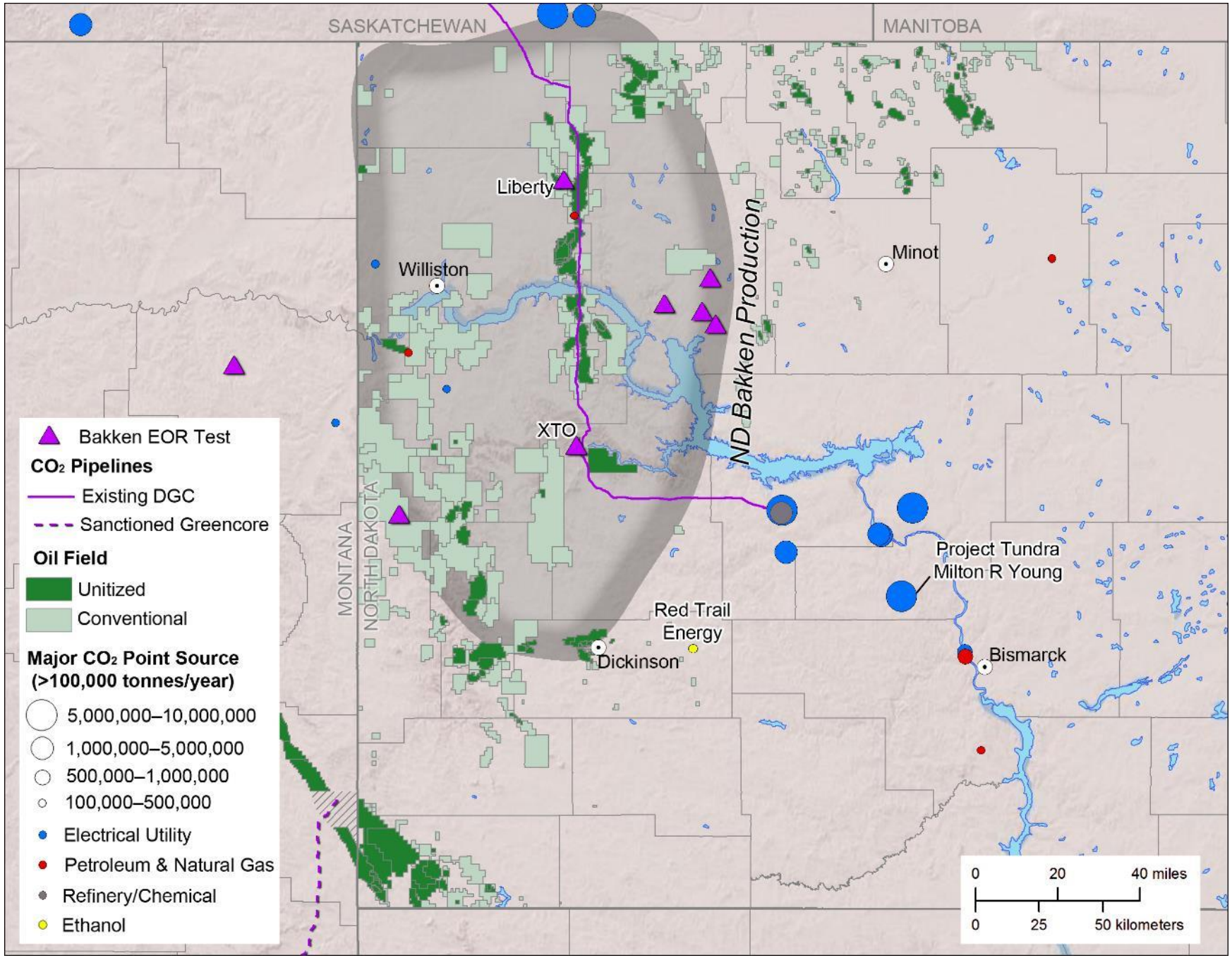
900 Bbbl
(Continental Resources, 2011)

Technically Recoverable Reserve Estimates (primary recovery)

7.4 Bbbl
(USGS, 2013)

24 Bbbl
(Continental Resource, 2011)

Business as usual gets about 15 billion barrels.



ENORMOUS OPPORTUNITY

86 conventional <u>unitized</u> fields:

- **280 million to 630 million bbl of incremental oil**
- **47 million to 283 million metric tons of CO_2 needed**

200+ conventional fields

- **>1 Bbbl of incremental oil**
- **>358 million metric tons of CO_2 needed**

Conventional + Bakken Petroleum System:

- **4 Bbbl–7.6 Bbbl of incremental oil**
- **2 Btons–3.8 Btons of CO_2 needed**

…or more

INCENTIVES

West Coast LCFS

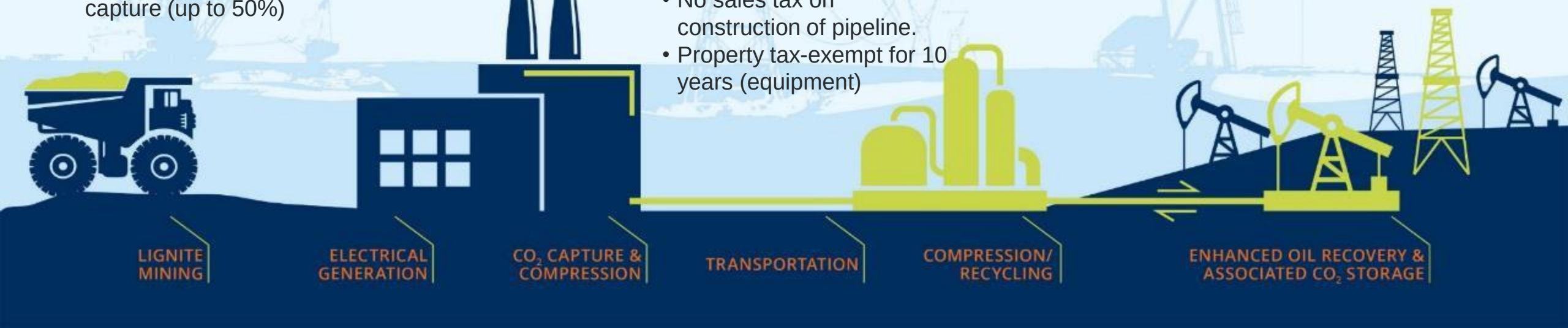
- Credits trading for $136 to $192 per ton.
- Stacked with 45Q

45Q Tax Credits

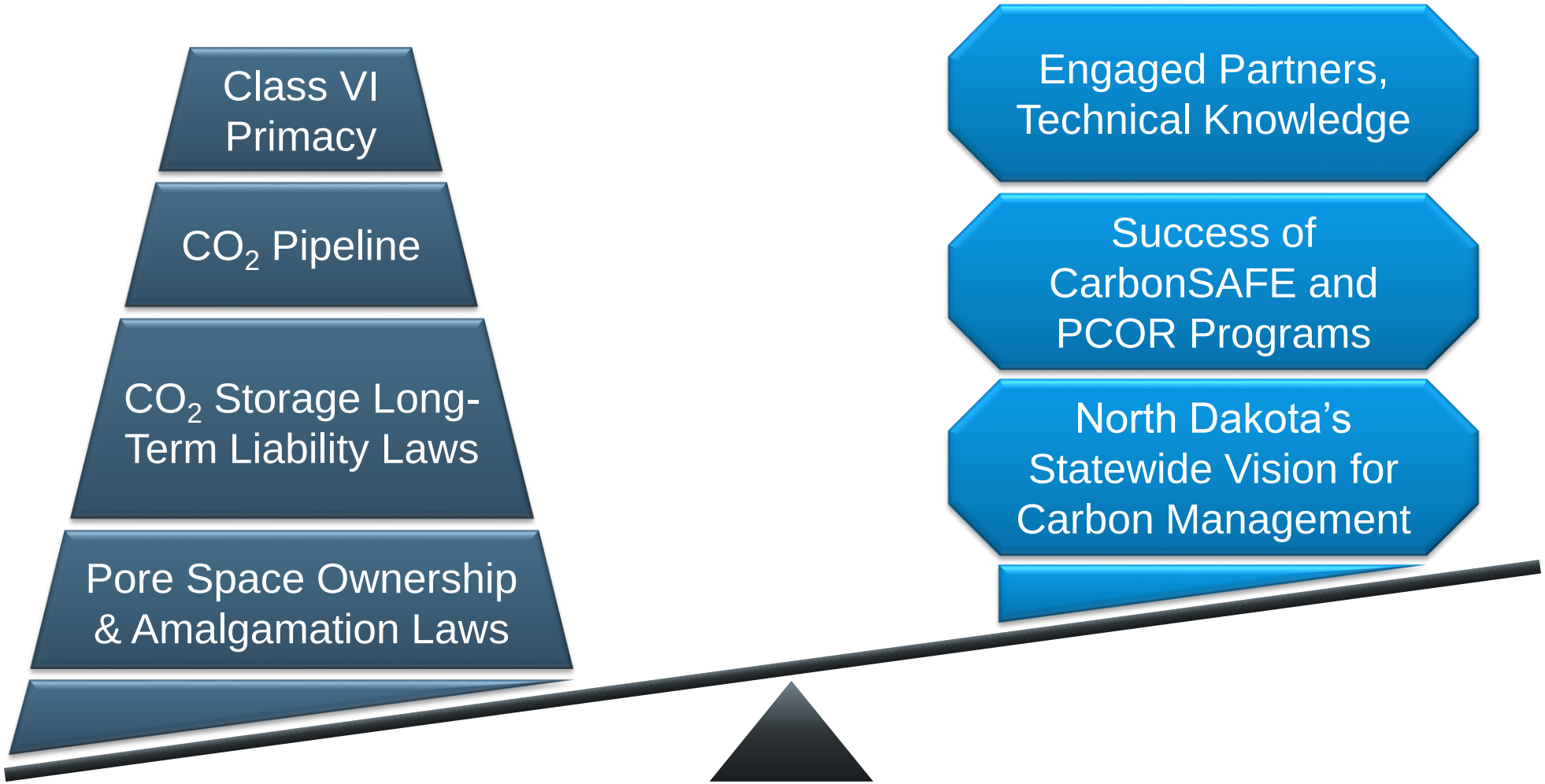
- Projects beginning construction before January 1, 2024, can claim credits for 12 years after operations begin.
- Tax credits claimed by the taxpayer capturing the emissions or transferred to operators of CO_2 EOR) projects.
- Tax credit for CO_2 stored in a qualified EOR project is $15.29/tonne; increases annually to $35/tonne in 2026.
- Tax credit for CO_2 stored in a saline formation is $25.70/tonne; increases annually to $50/tonne in 2026.

North Dakota CCUS Incentives

- Coal conversion tax: tax reduction with CO_2 capture (up to 50%)
- No sales tax on capture-related infrastructure
- No sales tax on CO_2 sold for EOR
- No sales tax on construction of pipeline.
- Property tax-exempt for 10 years (equipment)
- No sales tax on CO_2 EOR infrastructure
- 0% extraction tax for 20 years for tertiary incremental recovery
- Production tax still applies



NORTH DAKOTA'S LEVERAGE



RED TRAIL ENERGY, LLC

North Dakota Ethanol Production

Reduced Carbon Intensity of North Dakota Ethanol Production Through Geologic CO_2 Storage

Incentive Programs

- Low-carbon fuel standard (LCFS) programs (~$200/tonne)
- 45Q ($50/tonne)

Image Credit: Red Trail Energy

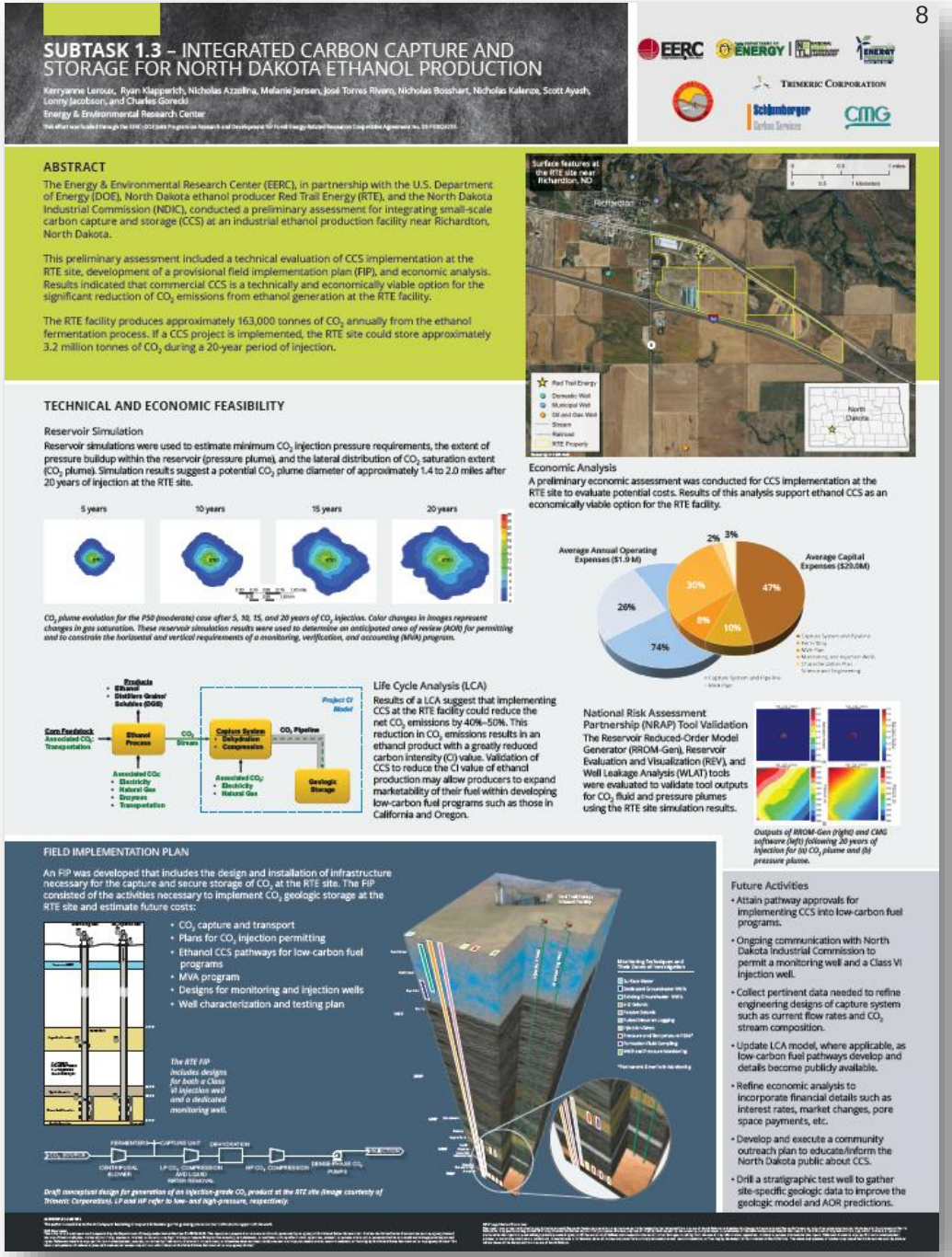


Image Credit: Energy & Environmental Research Center

RED TRAIL ENERGY, LLC

North Dakota Ethanol Production

- Carbon capture
  - 180,000 tons of CO_2 per year from fermentation
  - Nearly pure CO_2 stream
- Carbon storage
  - Broom Creek Formation
  - 6400 ft directly below Red Trail Energy facility, ~300 ft thick

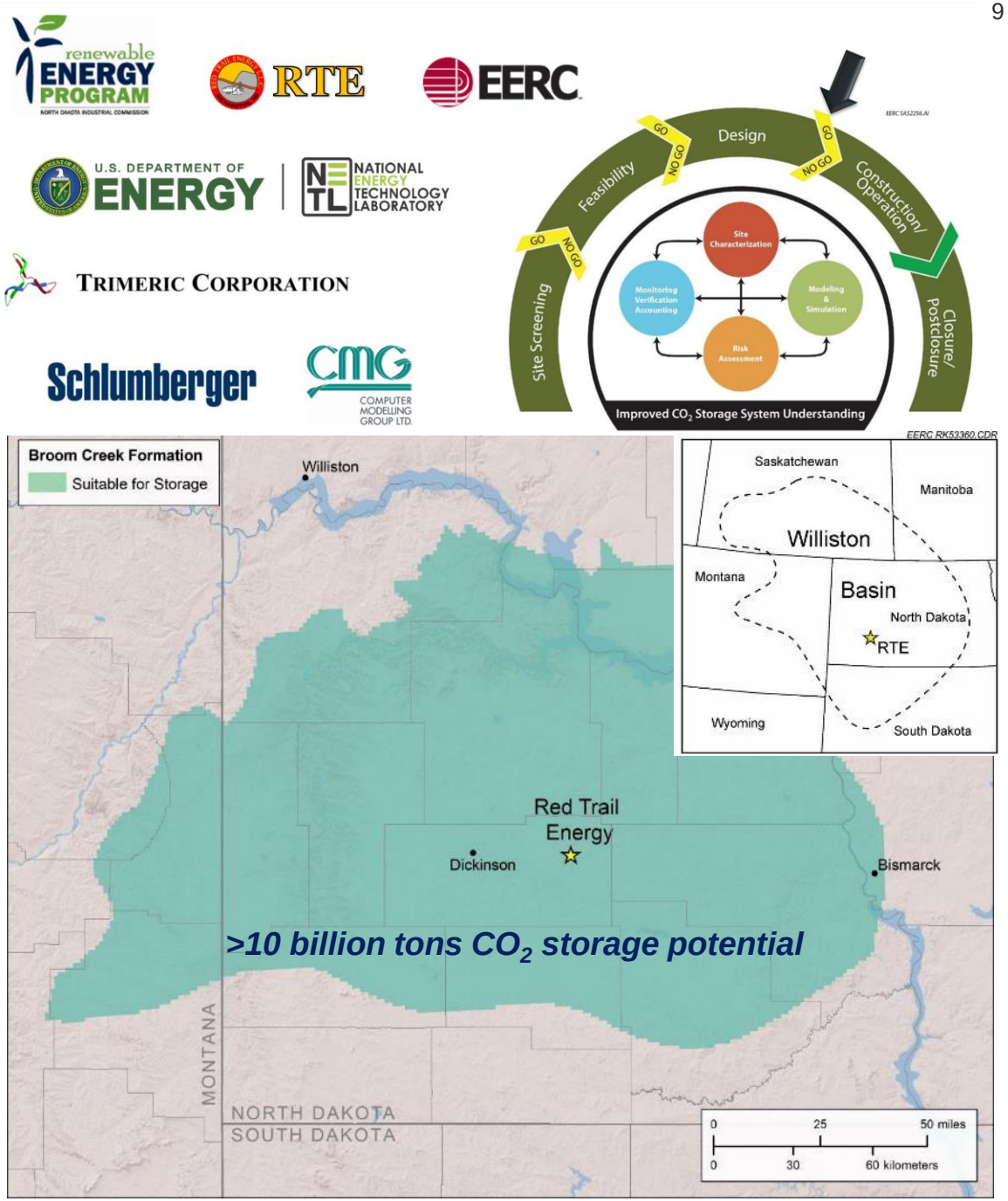


Image Credit: Energy & Environmental Research Center (modified from Peck and others, 2014)

Accomplishments

- ✓ Established technical feasibility
  - Approx. 40% net CO_2 emissions reduction
- ✓ Established economic viability
  - Via LCFS programs, federal incentives, etc.
- ✓ CO_2 capture design package
- ✓ Near-surface baseline sampling
- ✓ 3-D seismic survey and interpretation
- ✓ Characterization and test design
- ✓ Permit to drill stratigraphic test well
- ✓ Stakeholder and community outreach

Next Steps

Stratigraphic test well

- Drill, core, log, test, and install downhole monitoring
- Update modeling and implementation plans

Class VI storage facility permit and LCFS pathway

Construct and operate CCUS site

Operated by Minnkota Power Cooperative, the Young Station is a mine-mouth generating station that uses lignite coal supplied from the adjacent BNI Coal mine. Unit 2, a 455-megawatt unit that began commercial operation in 1977, is the target for Project Tundra.

Project Tundra is in the advanced research and design phase. If the project moves ahead, construction will commence in 2022-2023

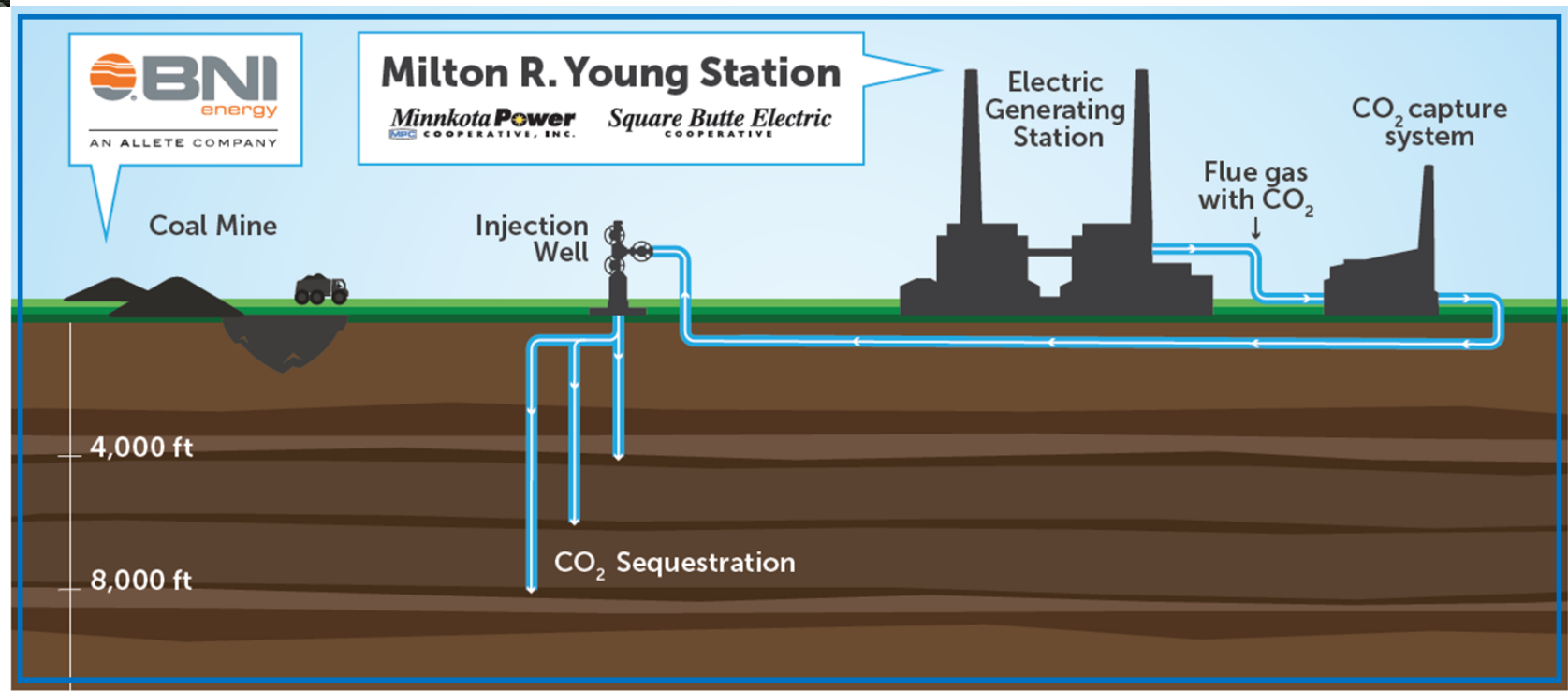
<u>Precommercial</u>:

Front-end engineering and design (FEED) study in procurement.

90% postcombustion CO_2 capture (~4 million tons per year).

Preparing to pursue federal and state permits required to build CO_2 capture facility and store CO_2 in deep geologic formations.

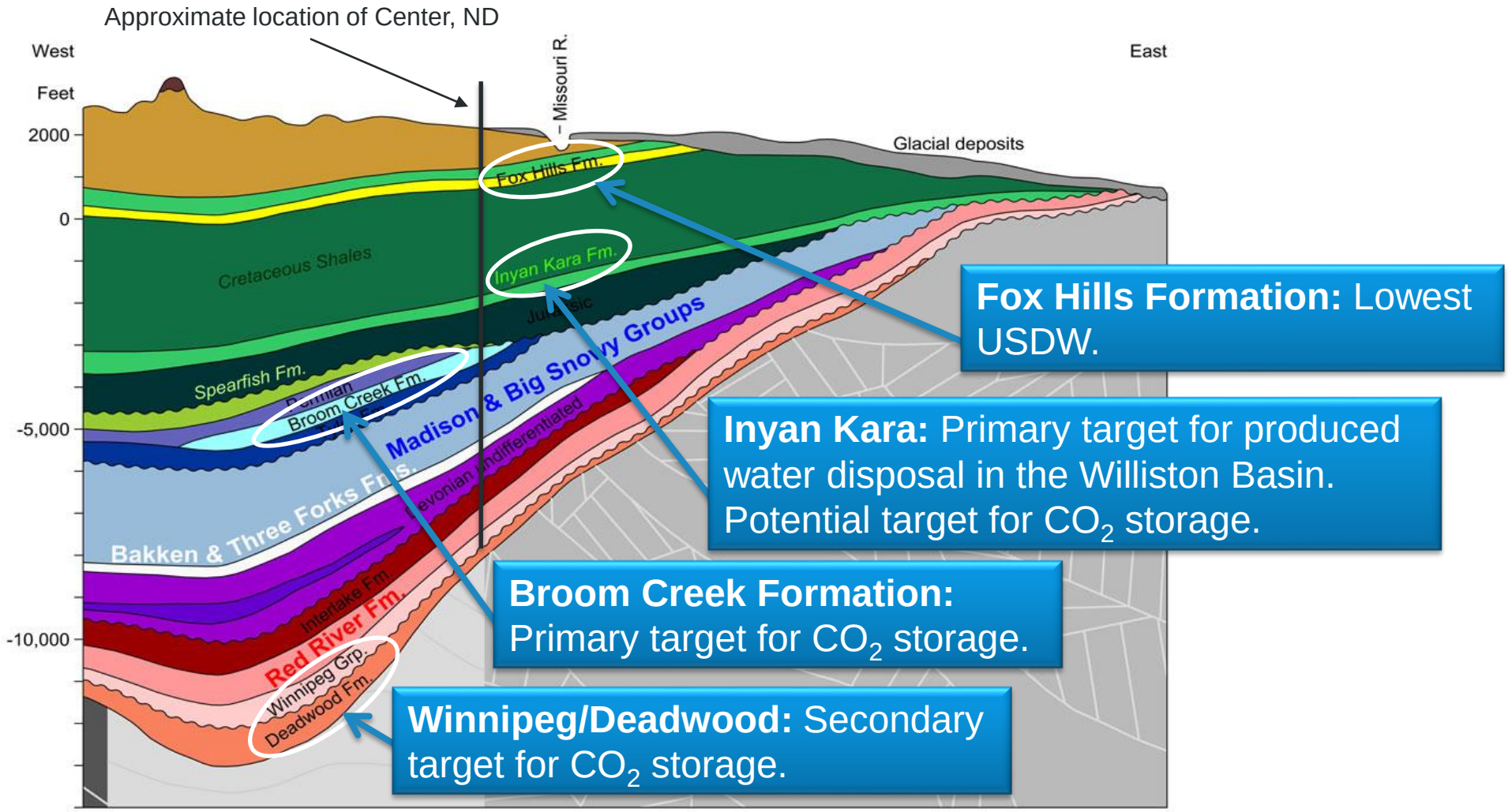
Exploring ND EOR opportunities.



NORTH DAKOTA CarbonSAFE

Critical Challenges. Practical Solutions.

CARBONSAFE ZONES OF FOCUS



PCOR INITIATIVE

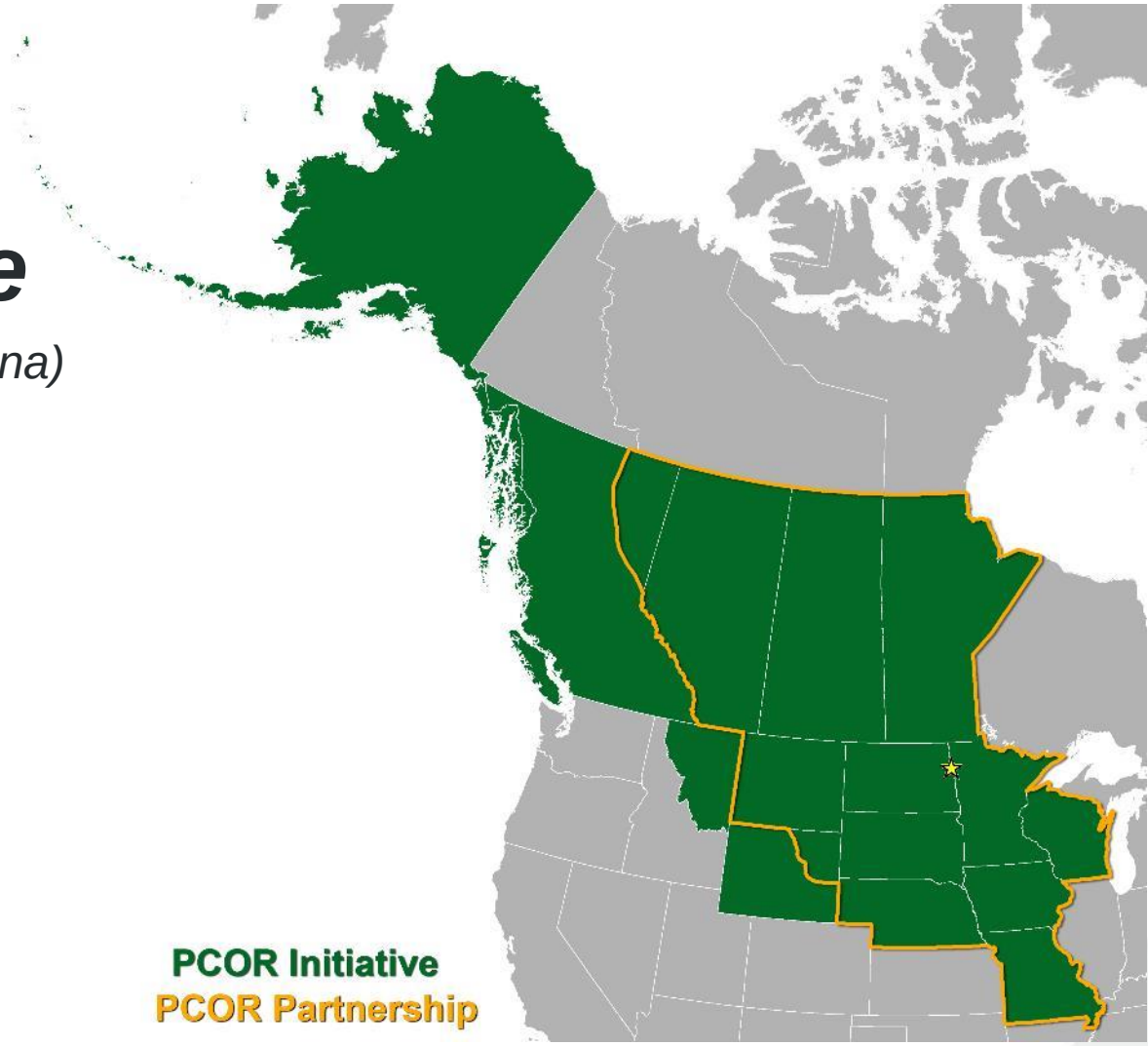
2019–2024: PCOR Initiative

(Expanded to include Alaska, Wyoming, and all of Montana)

2007–2019: PCOR Partnership Phase III

2005–2008: PCOR Partnership Phase II

2003–2005: PCOR Partnership Phase I



PCOR INITIATIVE

2019–2024

Address key technical challenges by advancing critical knowledge/capabilities; facilitate data collection, sharing, analysis, and collaboration; evaluate regional infrastructure challenges and needs; promote regional technology transfer.

Goal:

Identify and address regional storage and transport challenges facing commercial CCUS deployment.

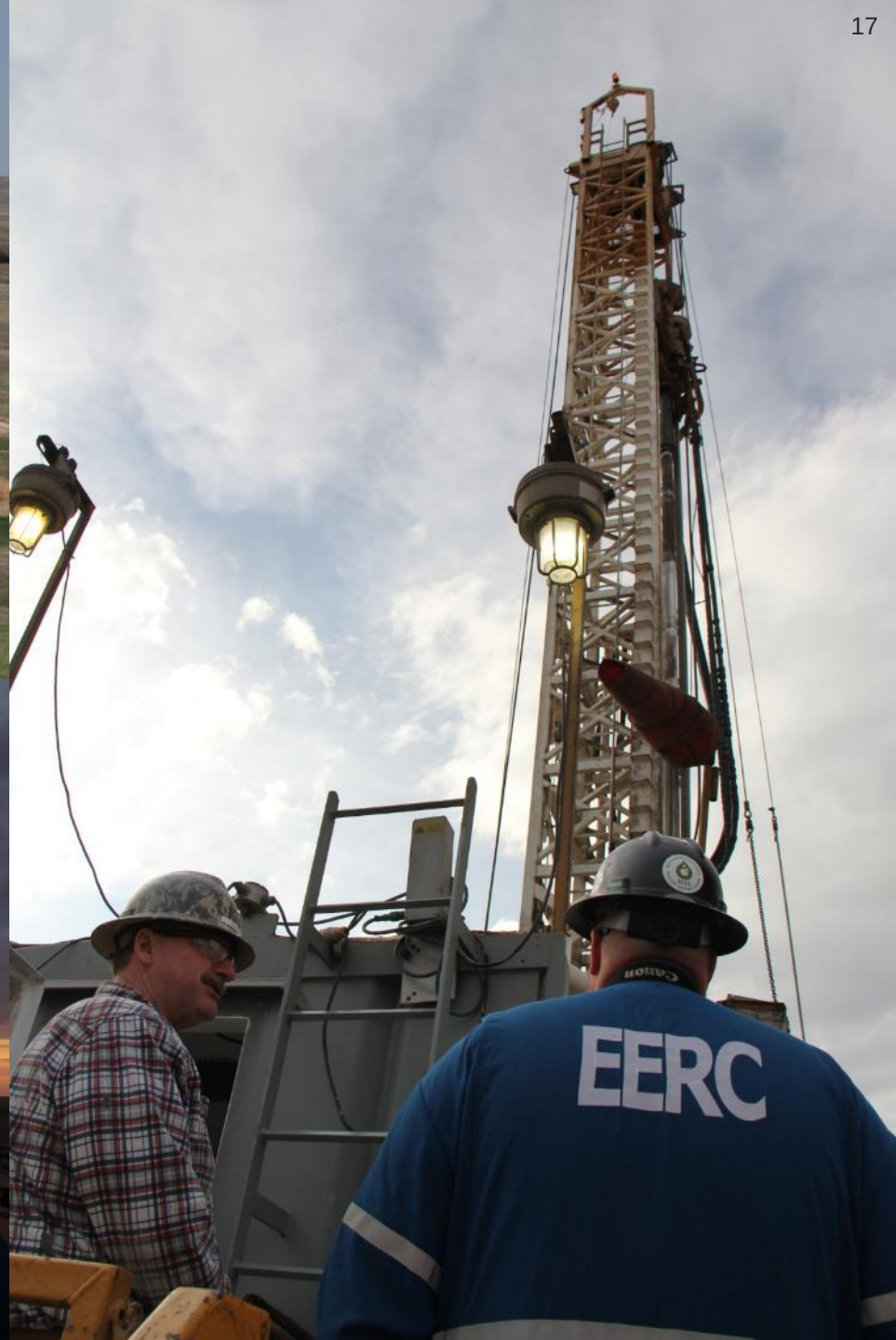
Vision:

Provide the premier regional forum to promote CCUS infrastructure and accelerate CCUS deployment.

ENGAGED PARTNERS

NORTH DAKOTA

BRINE EXTRACTION AND STORAGE TEST



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GEOLOGIC CO_2 STORAGE

CONSIDERATIONS FOR COMMERCIAL PROJECTS

- Buoyant fluid
- Large volumes = large footprint
- Transportation
- Access to pore space
  - Leasing, unitization/amalgamation, trespass
- Regulatory compliance
- Assuring permanence for incentives or credits
  - Conformance and storage efficiency

Because of a host of technical, social, regulatory, environmental, and economic factors, brine disposal tends to be more accessible and generally quicker, easier, and less costly to implement compared to dedicated CO_2 storage.

ACTIVE RESERVOIR MANAGEMENT (ARM)

TWO COMPLEMENTARY COMPONENTS

ARM Test

- Reduce stress on sealing formation
- Geosteer injected fluids
- Divert pressure from leakage pathways
- Divert pressure from CO_2 plume
- Reduce AOR and amalgamated area
- Improve injectivity, capacity, and storage efficiency
- Validate monitoring techniques, and forecast model capabilities

Brine Treatment Test Bed

- Alternate source of water
- Reduced disposal volumes
- Salable products for beneficial use

Brine extraction can enable dedicated CO_2 storage and improve the geologic CO_2 storage potential of a site.

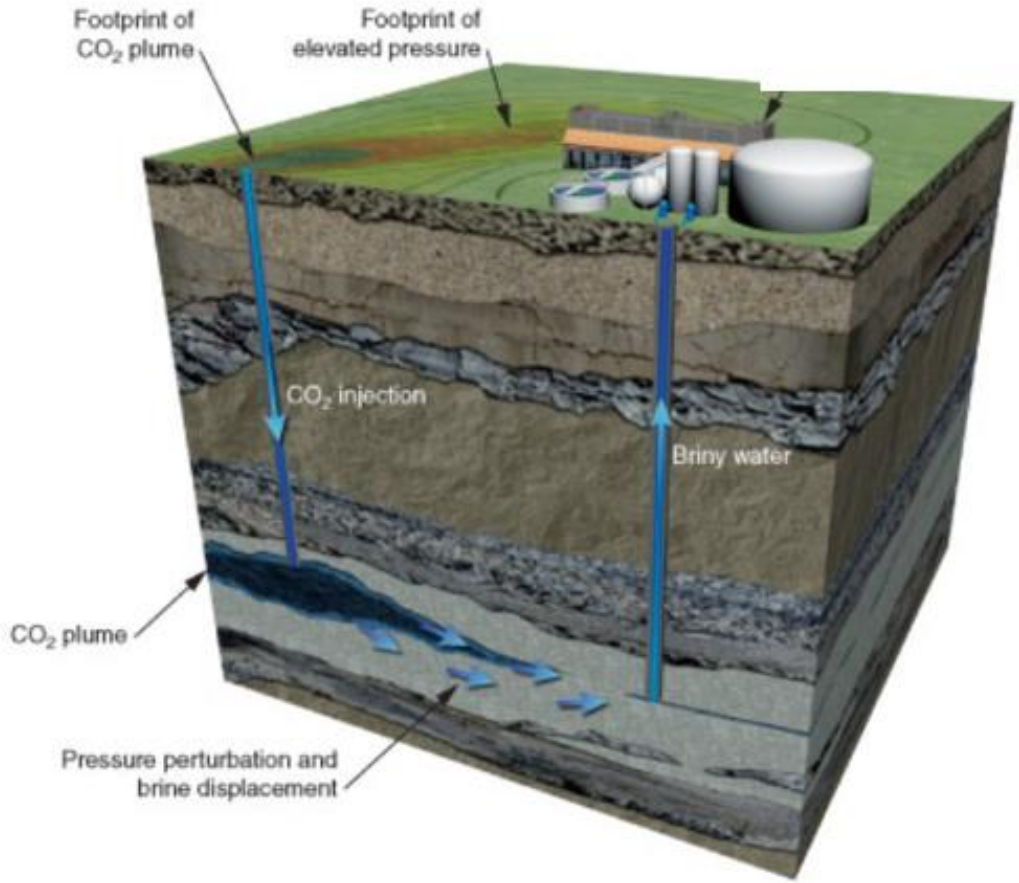

Illustration modified from Lawrence Livermore National Laboratory https://str.llnl.gov/Dec10/aines.html

ACCOMPLISHMENTS

ACTIVE RESERVOIR MANAGEMENT

ACCOMPLISHMENTS

BRINE TREATMENT DEVELOPMENT FACILITY

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