RICE

Clean Coal Technology
&
Carbon Regulation Impacts to Coal and Fossil Fuel Industry

Charles McConnell, Executive Director,
Rice University Energy and Environment Initiative

Jan 22, 2014

North Dakota Public Service Commission
Bismarck, ND

Overview

- Global Perspective – Energy and Environment ⟶ Sustainability
- Clean Coal Technology – "CCUS"
  - CO_2 capture
  - Geologic research
  - EOR and transformative potential

- Regulatory Landscape for Power Industry
  - New coal-fired plants - NSPS
  - Existing coal-fired plants
  - Fossil fuel CO_2 future and EOR

- North Dakota and Critical Leadership for Transformation

RICE

Global Perspective

- World's Energy Demand Will Increase 100% by 2050 per the International Energy Agency (IEA)

- Growth Will be Driven By
  - Aspiration to eliminate energy poverty – 1.4B people
  - Unconventional industrial and consumer demand

- Energy Security is the Driving Force

- All of the Above must be the Energy Strategy

- By 2050, 85% of World's Energy will be Fossil Fuel

RICE

Carbon Capture Utilization & Storage

- What is CCUS? and Why is the "U" So Critical for Fossil Fuels Global Adoption and Sustainability?

- CO_2 Capture Technologies
  - Demonstration plants and current projects
  - 2nd generation technology by 2020 > \$40-60/ton CO_2*
  - Transformative technology by 2030 > \$10-20/ton CO_2*

- Geologic Research
  - Regional carbon sequestration partnerships in US
  - Global interest
  - CCUS is the answer – 100+ years of potential

*DOE targets per CCUS R&D Roadmap

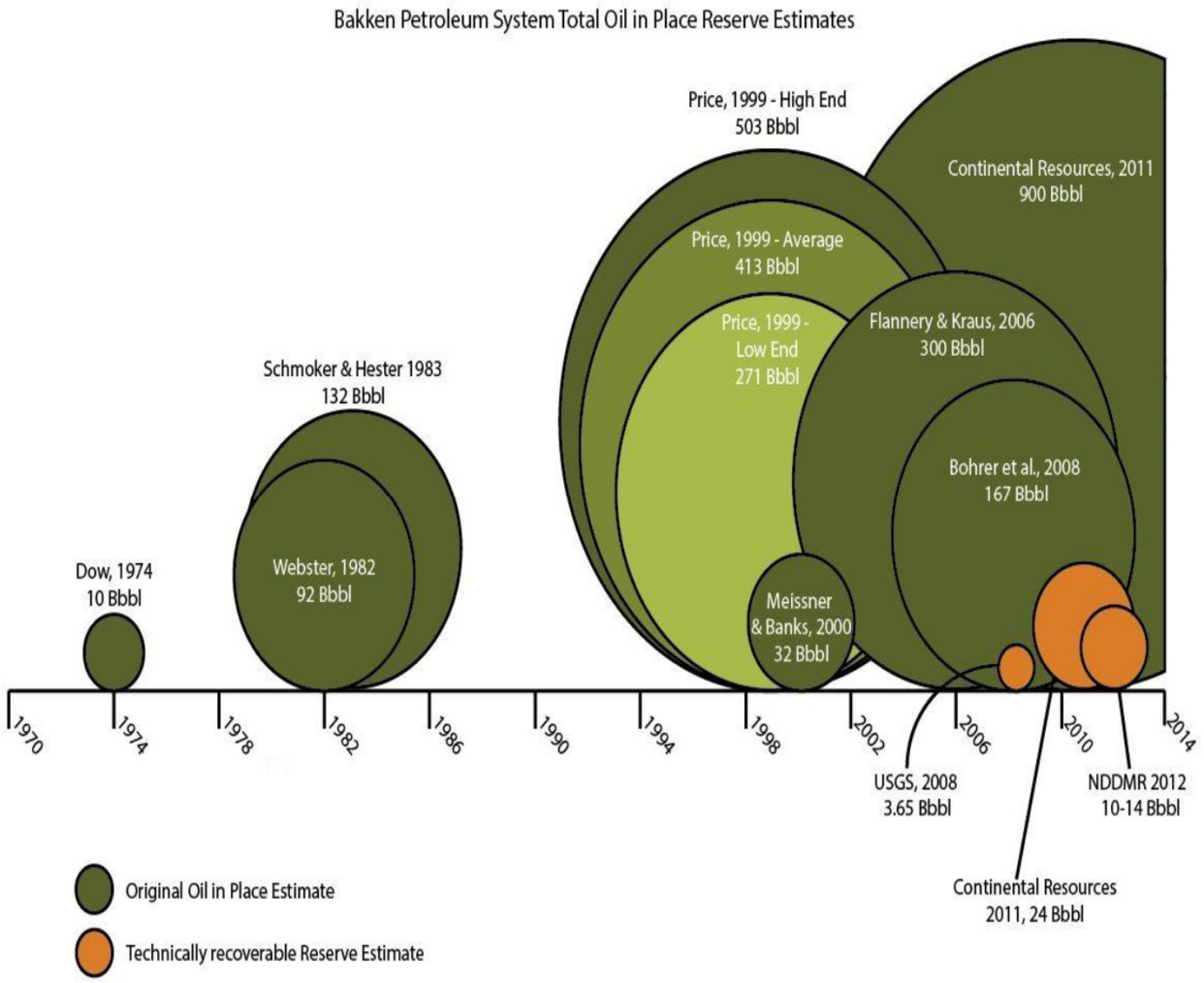
Regulatory Landscape

- New Source Performance Standards – NSPS
- Existing Coal and Fossil Plants on Horizon
- CO_2 Research and EPA Regulations – Class VI
- CO_2 EOR and Class II

Regulations Must Support Both Energy and Environment Sustainability and Facilitate Market Realization and Deployment for Impact

Bakken

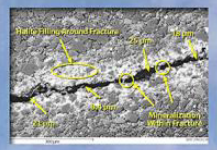
- The more we understand, the more oil and potential we see
- Currently, only a 3 – 10% recovery factor
- Small improvements in recovery could yield over a billion barrels of oil
- **Will CO_2 be a game changer in the Bakken?**
  - For business
  - For the environment



RICE

BAKKEN PETROLEUM SYSTEM

EERC
Energy & Environmental Research Center®
Putting Research into Practice


Bakken Optimization Program

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

North Dakota Oil and Gas Division
Continental Resources — America's Oil Champion
Marathon Oil
WHITING
OASIS PETROLEUM
Nuverra Environmental Solutions
Bakken Production Optimization Program

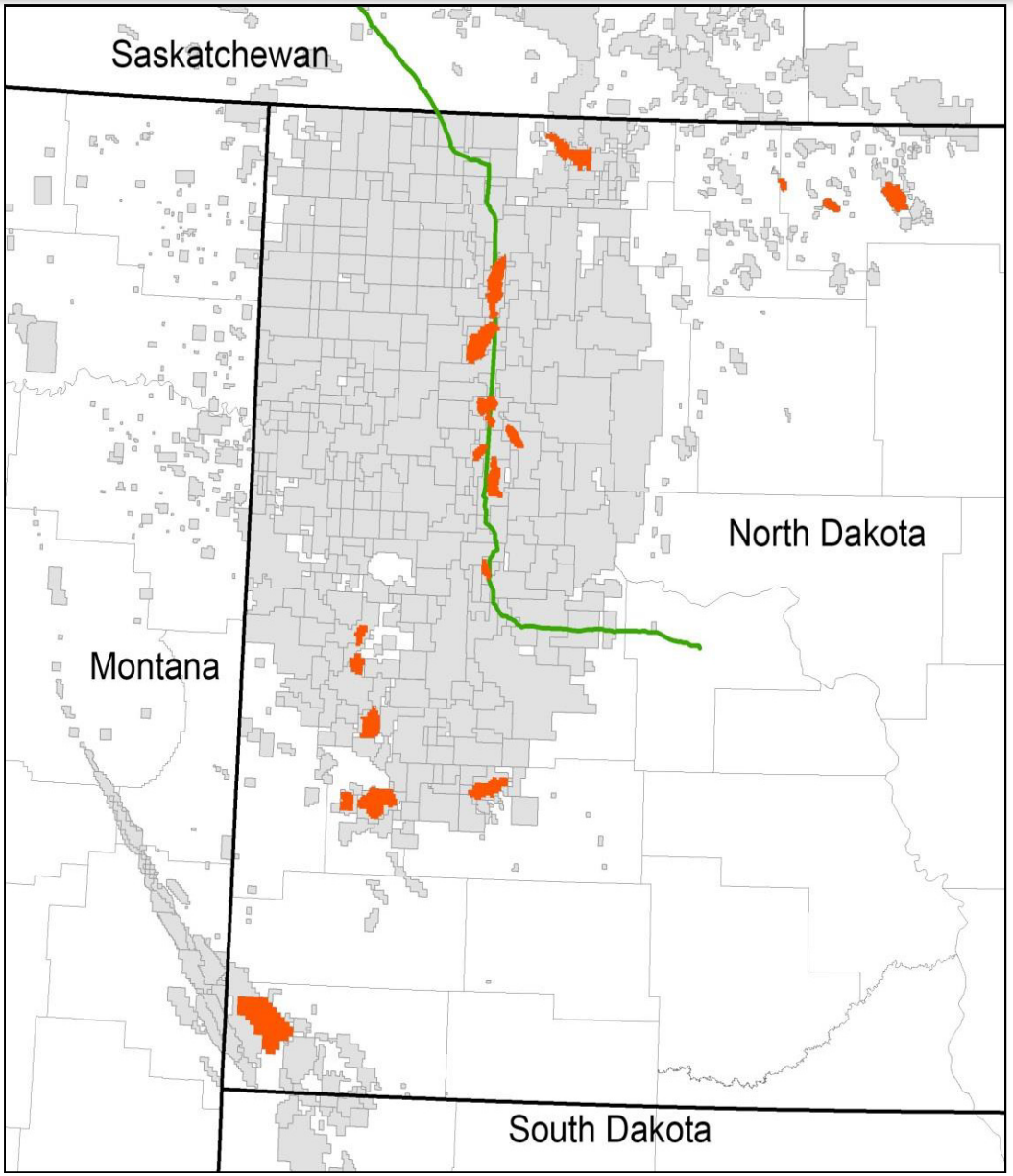
Bakken CO_2 Enhanced Oil Recovery and Storage Project

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

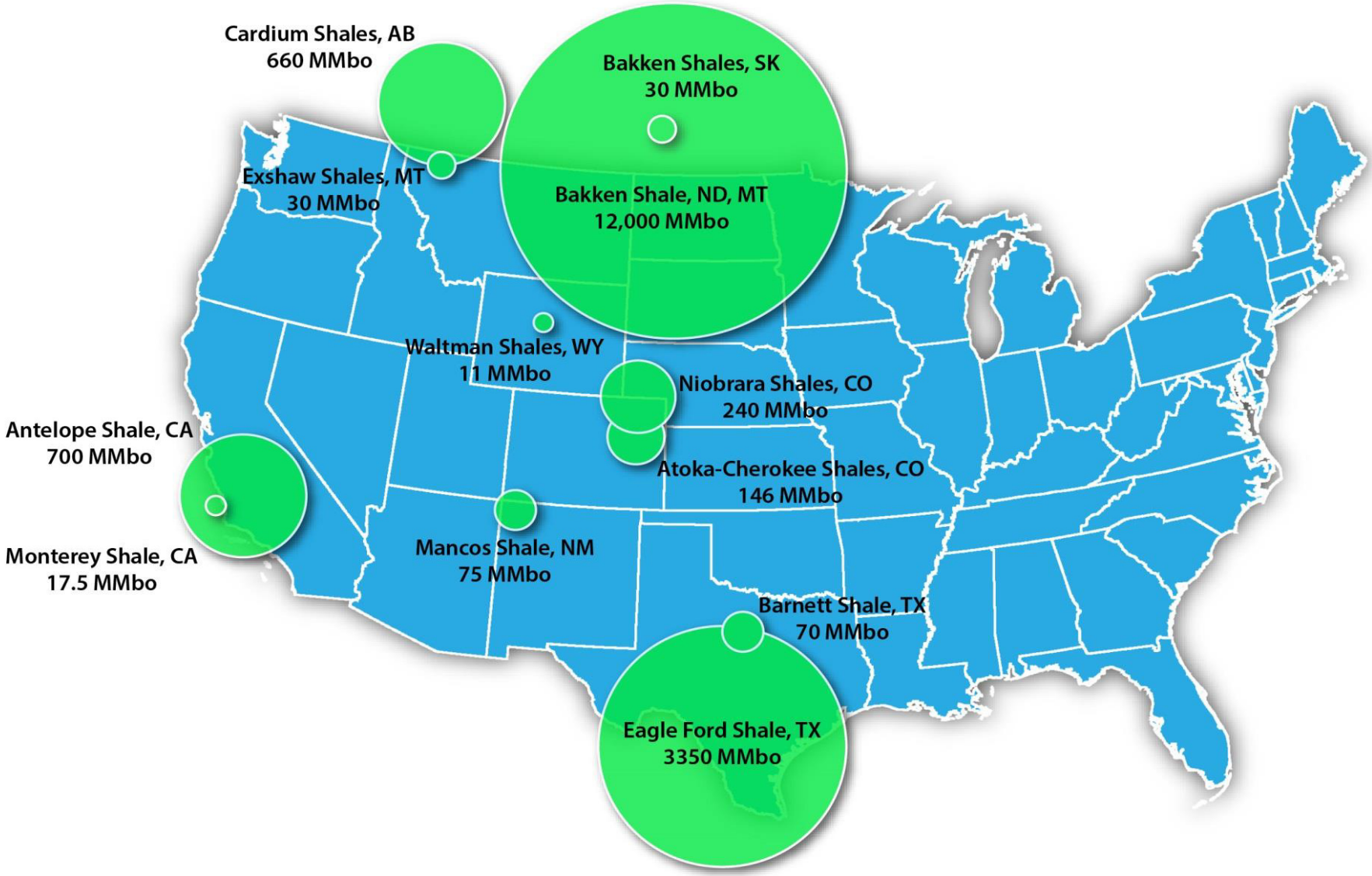
NETL
North Dakota Oil and Gas Division
North Dakota Department of Mineral Resources
Continental Resources — America's Oil Champion
Marathon Oil
TAQA

EOR Potential

- Significant Non-Bakken ND Fields/Pools Await CO_2 EOR
- Nearly 130 million tons of CO_2 needed for the top 22 candidate fields in ND



How Many More Bakkens?



CO2 & EOR in North Dakota

- Bakken CO_2 Demand for ND – A 30,000 Feet View
- Based on the following:
  - Traditional evaluation techniques
  - ND Industrial Commission original oil in place estimates
  - 4% incremental recovery
  - Net utilization of 5 and 8 mcf/bbl
- 2 to 3.2 billion tons of CO_2 needed
- ND currently produces ~33 million tons of CO_2/year

RICE

Unconventional Wisdom