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

24 PU-14-736 Filed 01/23/2014 Pages: 11
Clean Coal Presentation
Rice University Energy & Environment Initiative
Charles McConnell

RICE

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

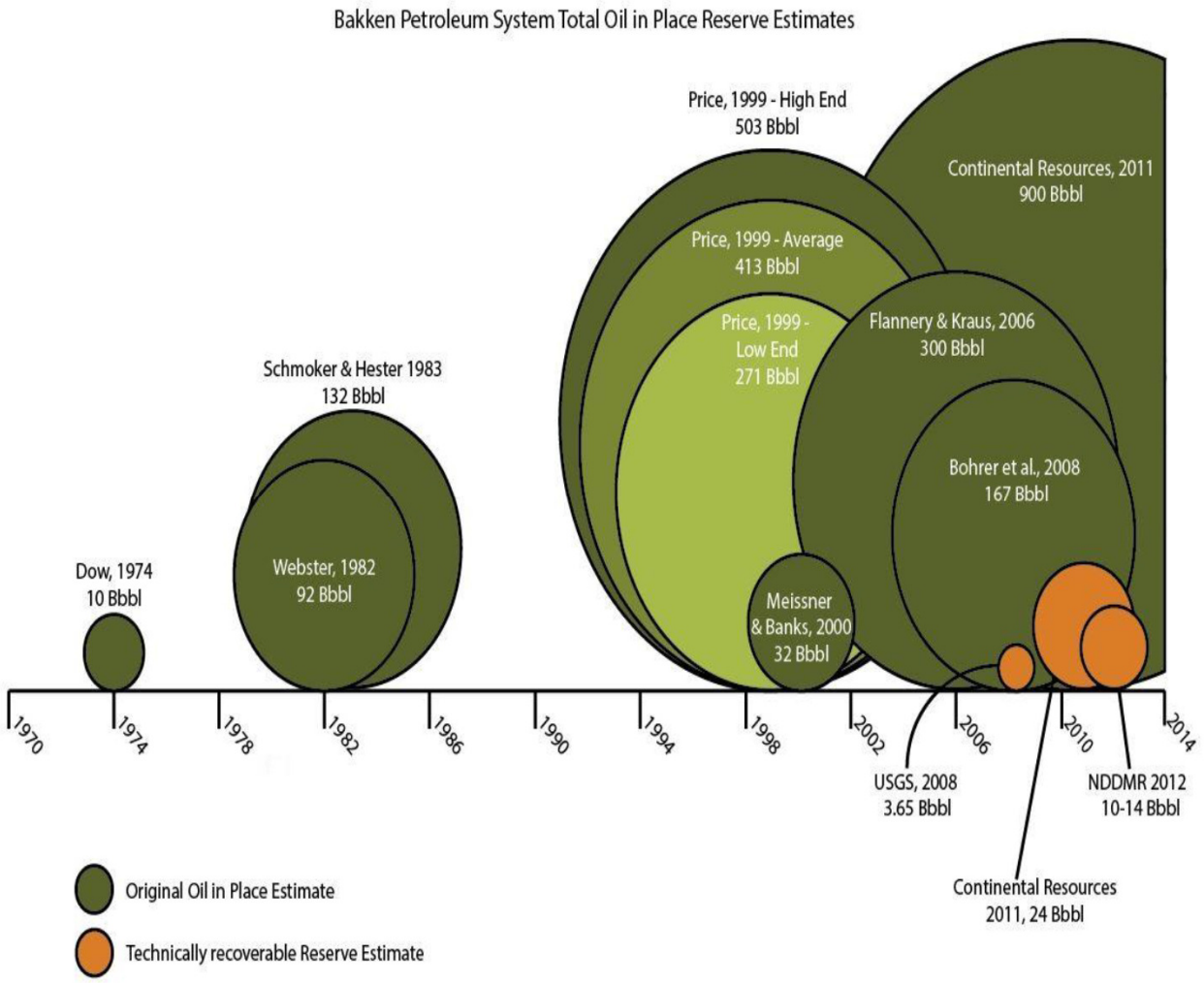
Regulatory Landscape

- 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

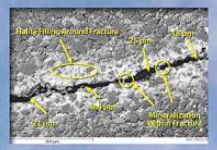
- The more we understand, the more oil and potential we see
- Currently, only a 3 – 10% recovery factor
- Small improvements in recovery could yield over a billion barrels of oil
- **Will CO_2 be a game changer in the Bakken?**
  - For business
  - For the environment



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

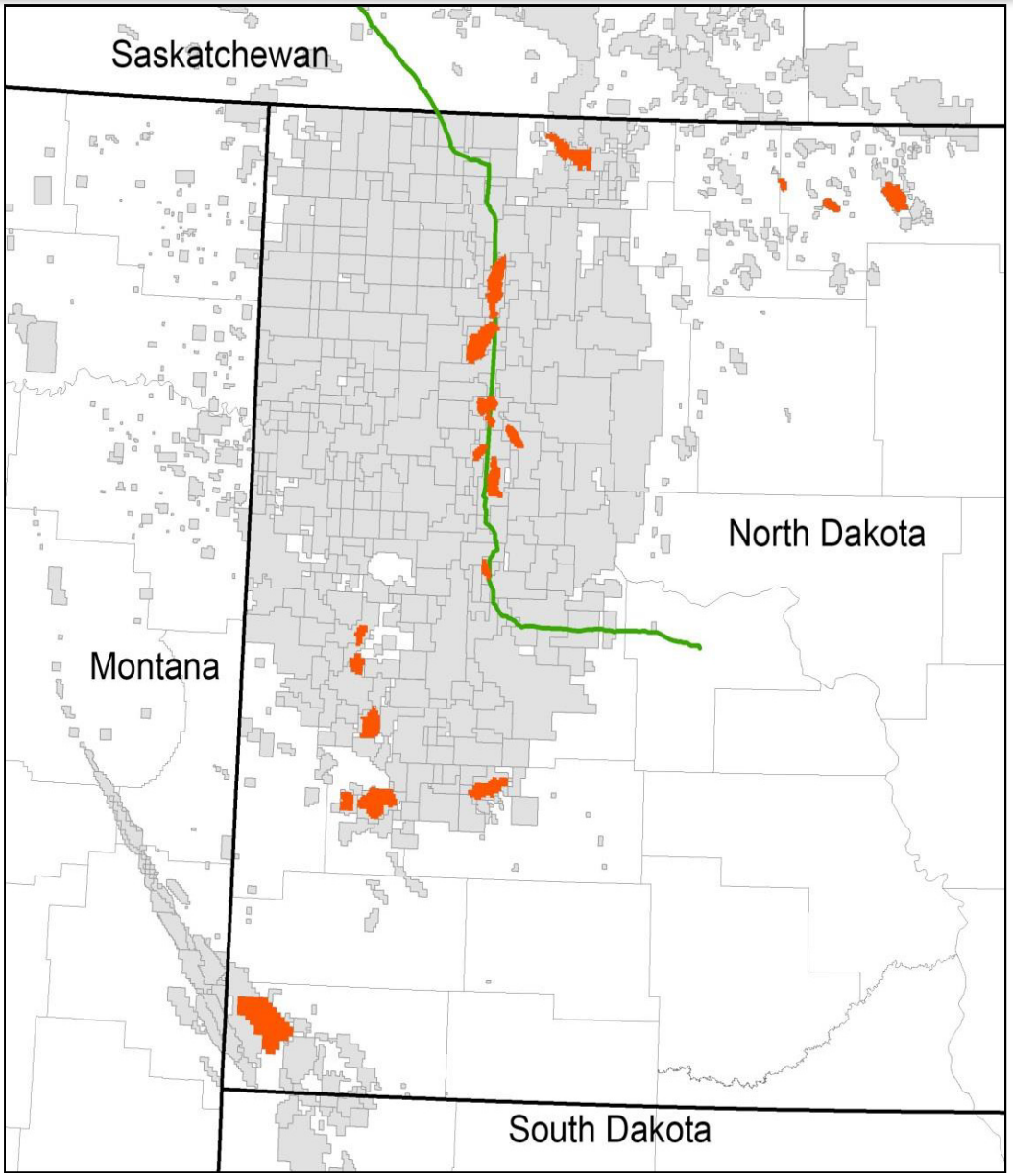
Bakken CO_2 Enhanced Oil Recovery and Storage Project

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

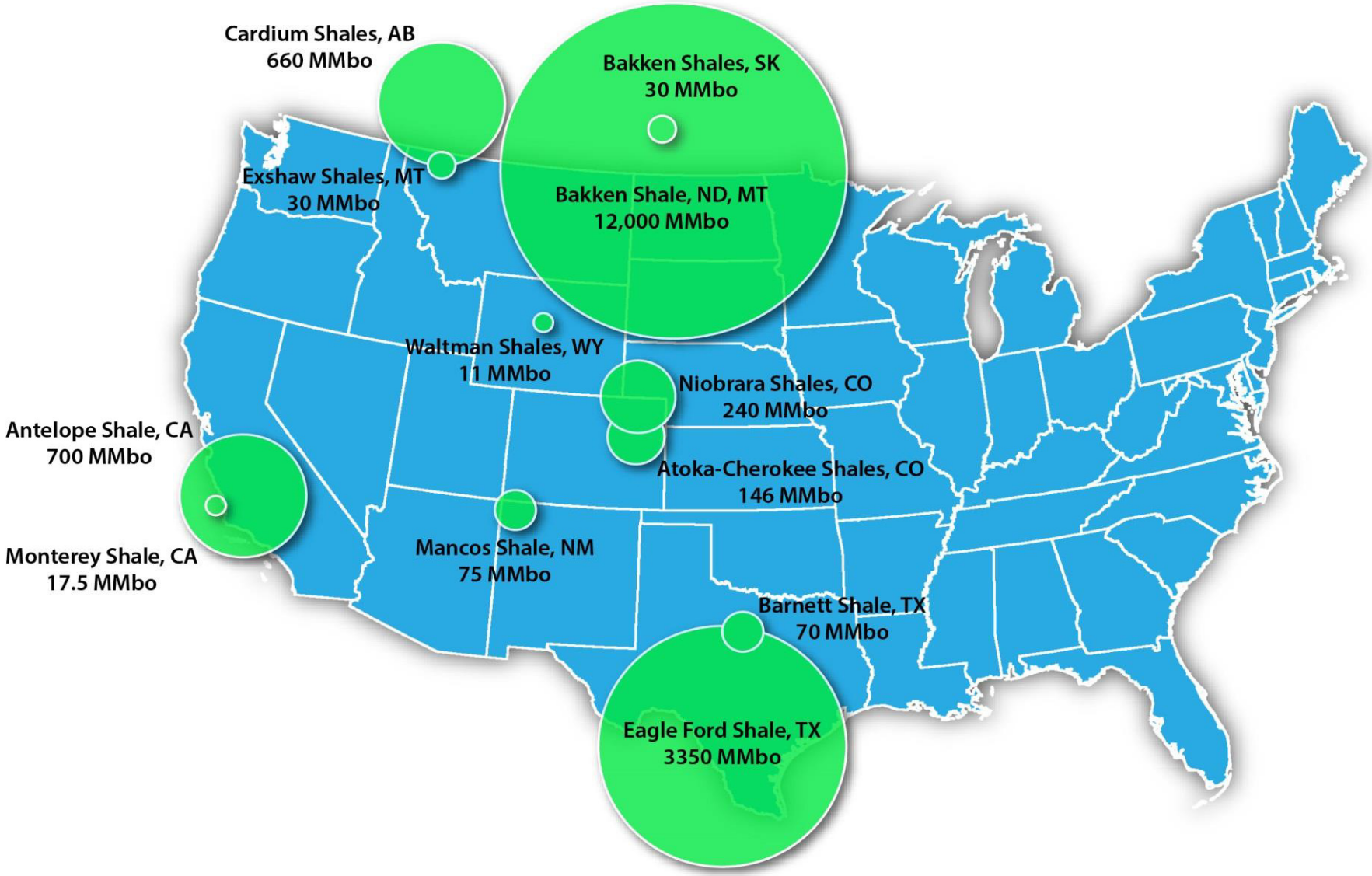
NETL
North Dakota Oil and Gas Division
North Dakota Department of Mineral Resources
Continental Resources — America's Oil Champion
Marathon Oil
TAQA

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