Energy Polygeneration Industrial Complex (EPIC)

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Putting Research into Practice

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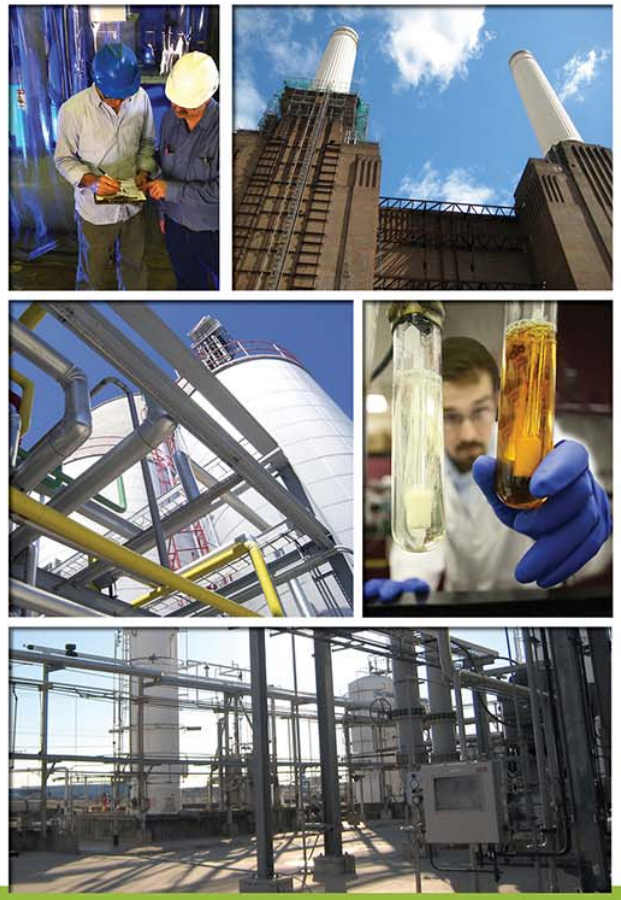
A Polygeneration Complex

- A facility or plant that produces multiple energy forms and products—as opposed to just electricity.
- Managing North Dakota resources for their highest-value future.
- Sustainably meeting growing energy demand.



New Geography of Power

Joel Kotkin (geographer) writes:

"The U.S. is developing a new geography of power, and its focus is the vast energy and commodities corridor extending from the western Gulf to the northern tip of the continent . . . ."

EPIC
Key to Sustaining North Dakota's Natural Resources

OBJECTIVES

- Demonstrate a dedicated coal–biomass–gas conversion complex in North Dakota.
- Produce clean power, liquid fuels, and chemical products.
- Turn CO_2 from an "Achilles' heel" into an economic building block through economical capture/use/storage.
- New innovations in energy that sustain North Dakota's economic vitality.

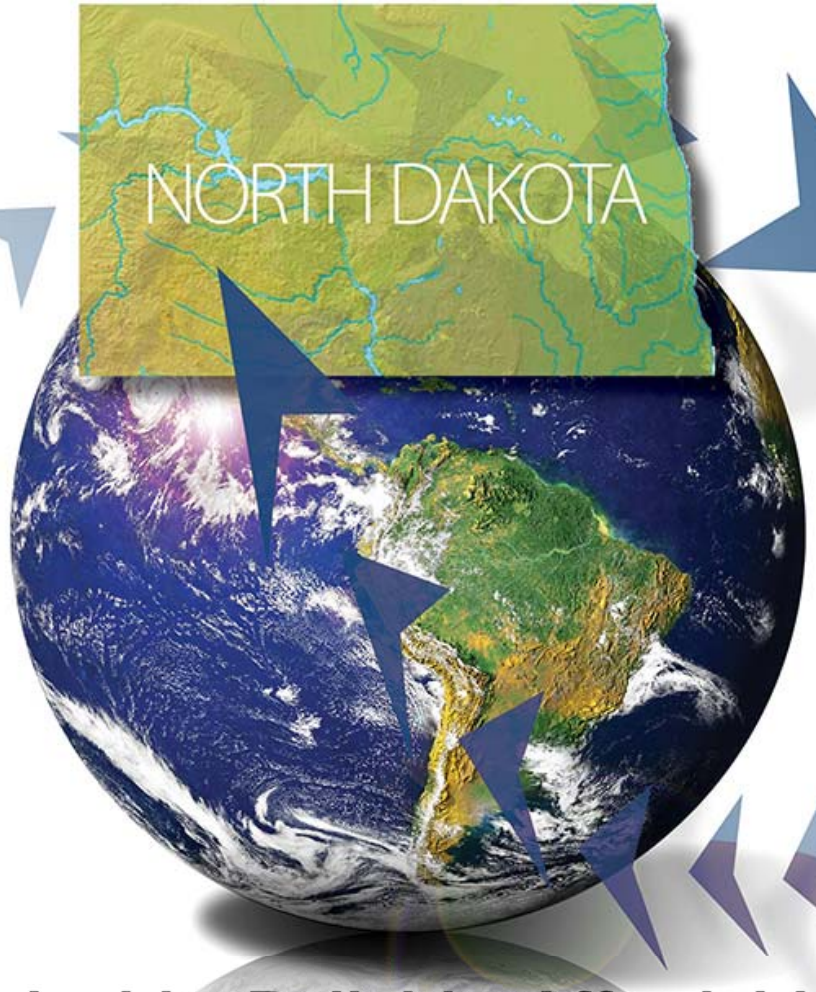
What Will EPIC Generate?

- A next-generation energy complex.
- Sustained low-carbon electricity, fuels, and chemicals from low-cost coal.
- Electricity for a 2500-MW load growth in North Dakota.
- CO_2 for enhanced oil recovery (EOR).
- 2–3.2 Bt of CO_2 which yields 4–7 Bbbl of Bakken EOR.
- Energy crops for North Dakota's ag industry.
- A new technology and industry corridor.
- North Dakota as an international leader in sustainable energy development.

North Dakota Nexus – A Link

EmPOWER North Dakota

EPIC



An EmPOWERed North Dakota Will Yield EPIC Results

Transforming Resources from the Prairie to Clean Power and Products for the World

Sustainable, Reliable, Affordable

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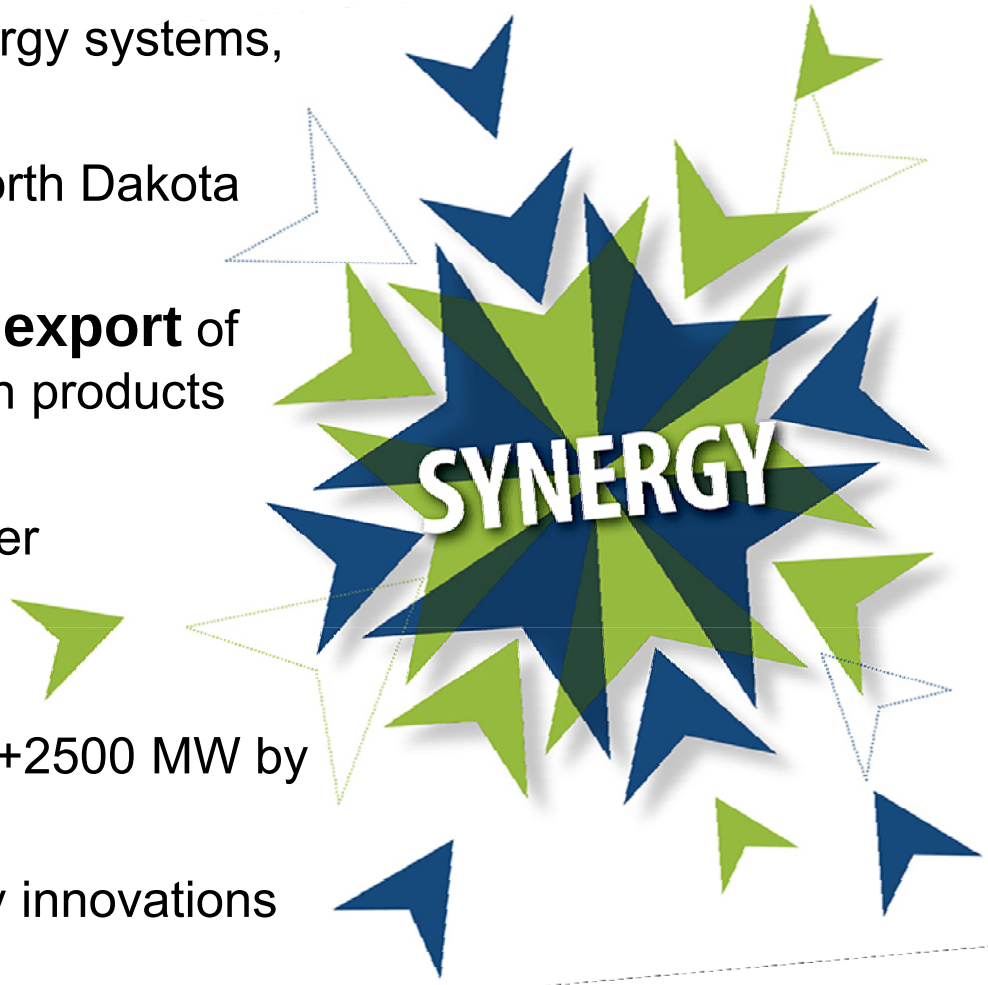
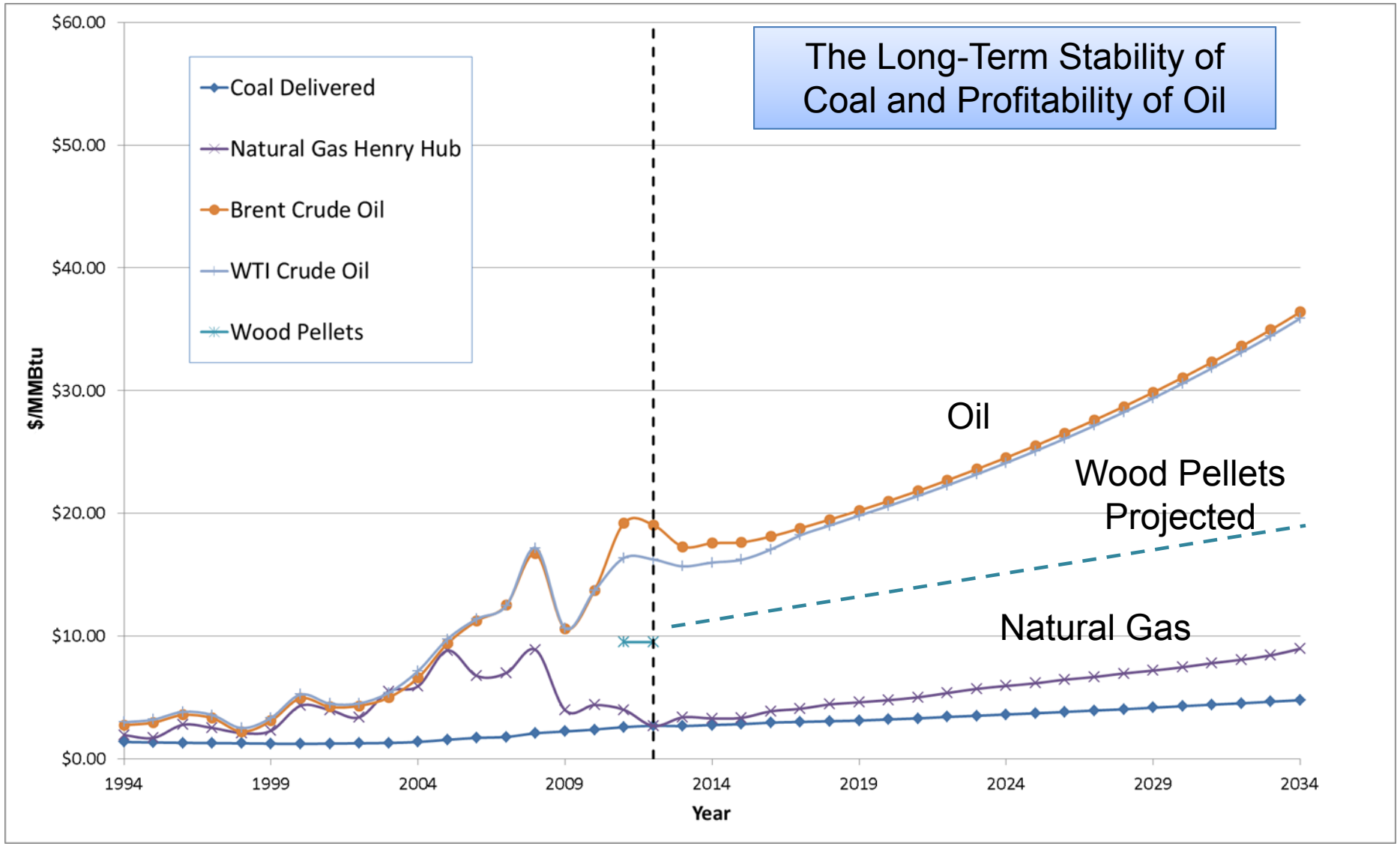
EPIC's Synergies

- **Synergy**: natural resources, energy systems, and innovative technologies
- **Sustainable expansion** of North Dakota lignite and agricultural resources
- **Production, utilization, and export** of environmentally sound, low-carbon products
  - Liquid fuels
  - Chemical feedstocks and fertilizer
  - Oil
  - CO_2 for EOR
  - Electricity (North Dakota needs +2500 MW by 2032)
- **Manufacture** of new technology innovations



Historical/Projected Costs of Coal, Crude, Natural Gas, and Biomass



Maximized Revenue per Ton of Feedstock

Coal, Biomass, Gas, Petroleum Residuals

Syngas
CO_2
Heat

Direct or Indirect Liquefaction

Liquid Fuels and Additives
Gasoline
Jet Fuel
Diesel

EOR

Nitrogen Fertilizer

Chemicals

Electricity

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EPIC Key Components

- Resources
- Polygeneration core complex
- Carbon capture and EOR
- Strategic site location
- Stakeholders

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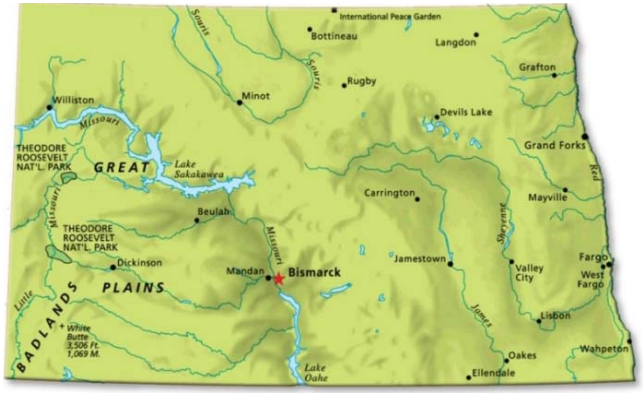
Resources

Polygeneration – Feedstocks (North Dakota)

- **Coal**
  - Currently use 29 Mtpy in North Dakota.
  - >800-year supply, 25 Bt (North Dakota Geological Survey).
- **Natural gas**
  - Currently producing nearly 500 Bcfpy.
  - Exceeds annual coal use on an energy basis.
- **Biomass/agricultural residue**
  - Over 6 Mtpy of agricultural residues in North Dakota.
  - Corncobs/stover, grasses, wheat straw, and wood have heating values similar to lignite.
- **Petroleum residuals (Bakken)**
  - About 375,000 tpy of petroleum residuals produced.

North Dakota Resources
(currently being consumed/exported)



- **Coal:** 350 T Btu/year
- **Electricity:** 120 TBtu/year
  - Seven plants (including imported coal)
- **Natural gas:** 700 TBtu/year

  (200 TBtu/year currently flared)
- **Oil:** 2300 TBtu/year, second in United States
- **Wind**: sixth in potential and eleventh in production
- **Agricultural:** first in 13 commodity crops, first in energy crop potential, four ethanol plants, and one biodiesel plant
  - 80 TBtu/yr agricultural residue
- **CO_2:** 2 Mtpy captured and marketed now

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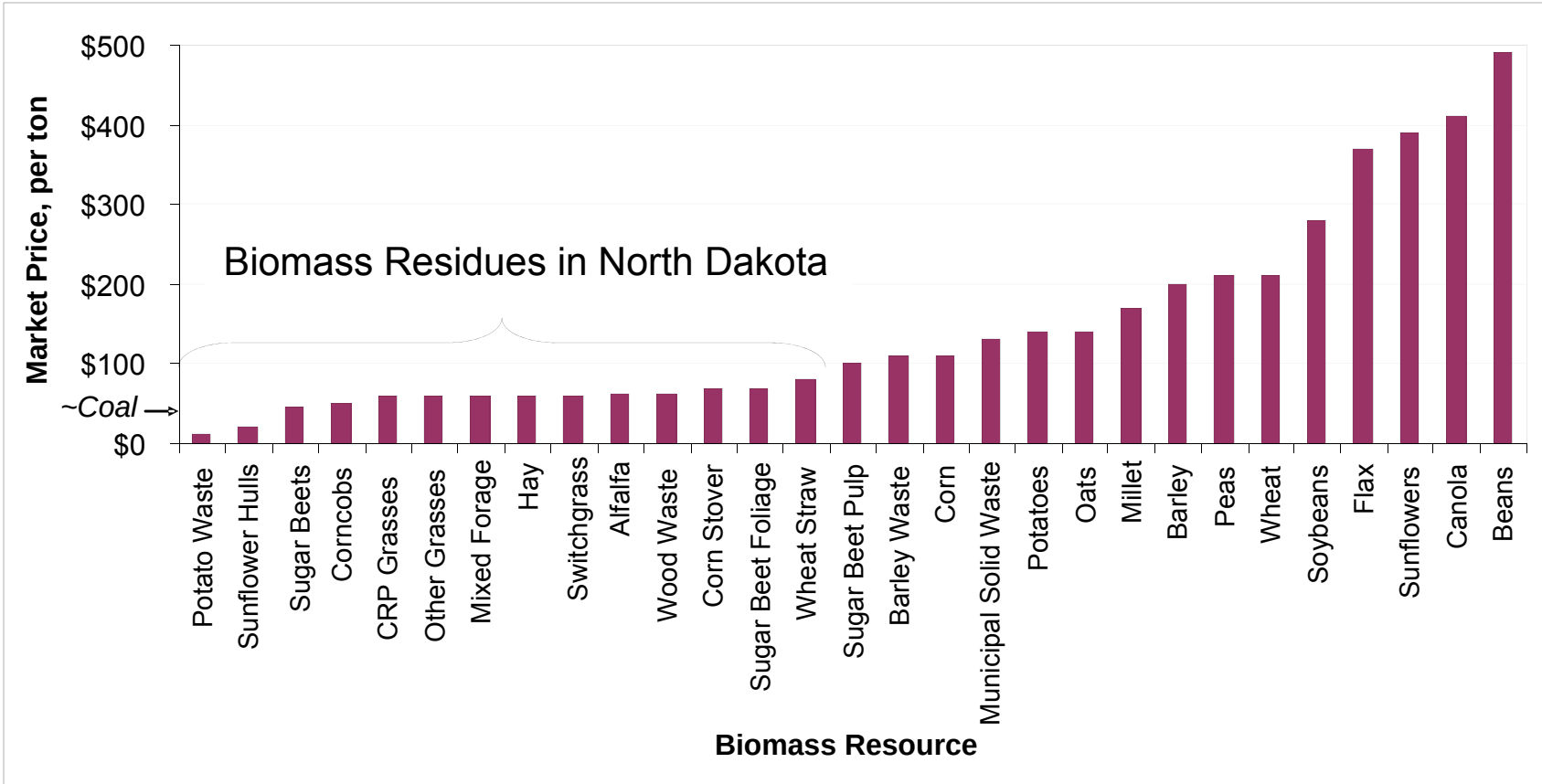
Biomass Impact on Greenhouse Gases

- Coconversion of coal, biomass, gas, and petroleum residuals can substantially reduce the overall carbon (greenhouse gas) footprint:
  - CO_2 evolved from biomass is considered terrestrial carbon.
  - Coal is plentiful; biomass residues or energy crops could supply 5%−10% of fuel input.
- Section 526 of the Energy Independence and Security Act of 2007 mandates that the *carbon footprint of alternative military fuels must be less than that of petroleum-based fuels.*
- Combined with carbon capture and storage, net-zero emissions could be achieved.

Source: Leroux, K.M.B., Hanson, S.K., Martin, K.E., Strege, J.R., and Peck, W.D., Great River Energy Biomass Cofiring Feasibility Assessment; Final Report; Energy & Environmental Research Center: Grand Forks, ND; 2009-EERC-06-10; June 2009, 13 p.

Existing Biomass Resources



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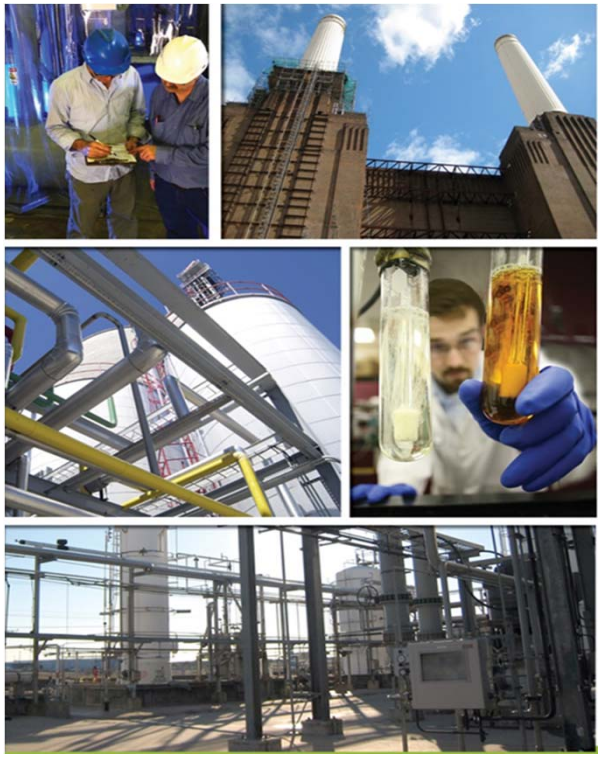
Polygeneration Core Complex

Polygeneration Development Plan

- Design of core polygeneration system
  - Flexibility: power, fuels, and products
  - Size
- Fuel selection and upgrading
- Pollution control
- Gas cleanup and CO_2 capture
- EOR and CO_2 storage
- Integration with renewables
- Process integration
- Industry integration
- Utilization of technology advancements



EPIC Core Complex

Depends on Regional, Economic, and Political Factors

- **Polygeneration considerations**
  - Direct or indirect liquefaction
  - Gas separation for CO_2 and H_2 production
  - Syngas to liquid fuels, chemicals, fertilizer, and other products
- **Electricity considerations**
  - Supercritical combustion or high-efficiency, advanced integrated gasification combined cycle (IGCC)
  - CO_2 capture for EOR

Fuel Selection and Upgrading

- Drying processes
- Mild beneficiation
- Mild pyrolysis (coal and biomass)
- Cofeeding with biomass
- Cofeeding with natural gas/shale gas
- Cofeeding other opportunity feedstocks like petroleum residuals

Wood Pellets

Torrefied Wood Pellets

Liquefaction Technologies

Coal, Biomass, Flare Gas, Petroleum Residuals, etc.

Indirect Liquefaction

Direct Liquefaction

Gasifying Feedstock to Produce CO and H_2

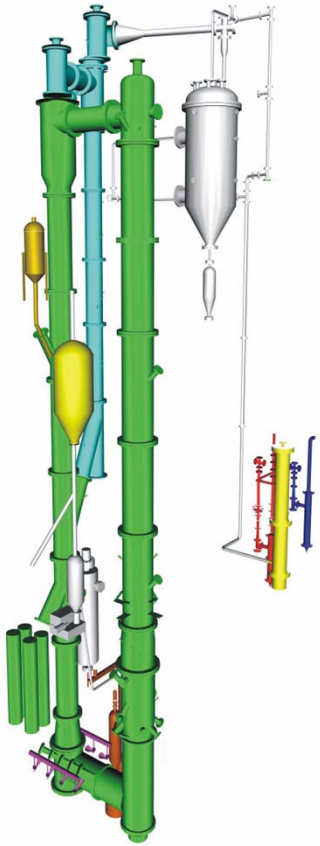
High-Pressure Conversion of Feedstock to Produce Fuel Liquids

Refining, Reforming, and Upgrading

Motor Gasoline, Jet Fuel, Diesel, Heavy Oil

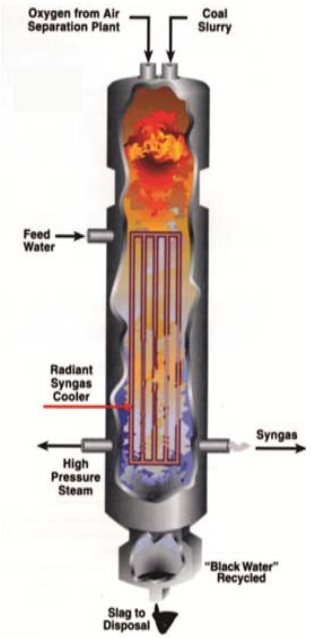
Utilization of Technology Advancements

- Gasification developments
  - Advanced gasifier designs
  - Warm-gas cleanup
  - Ion transport membrane O_2
  - Polyproduction
  - Evaluate future technologies
- Dry cooling
- By-product utilization
- Ultrasupercritical – combustion
  - Low-level pollutant measurement and control
  - Postcombustion CO_2



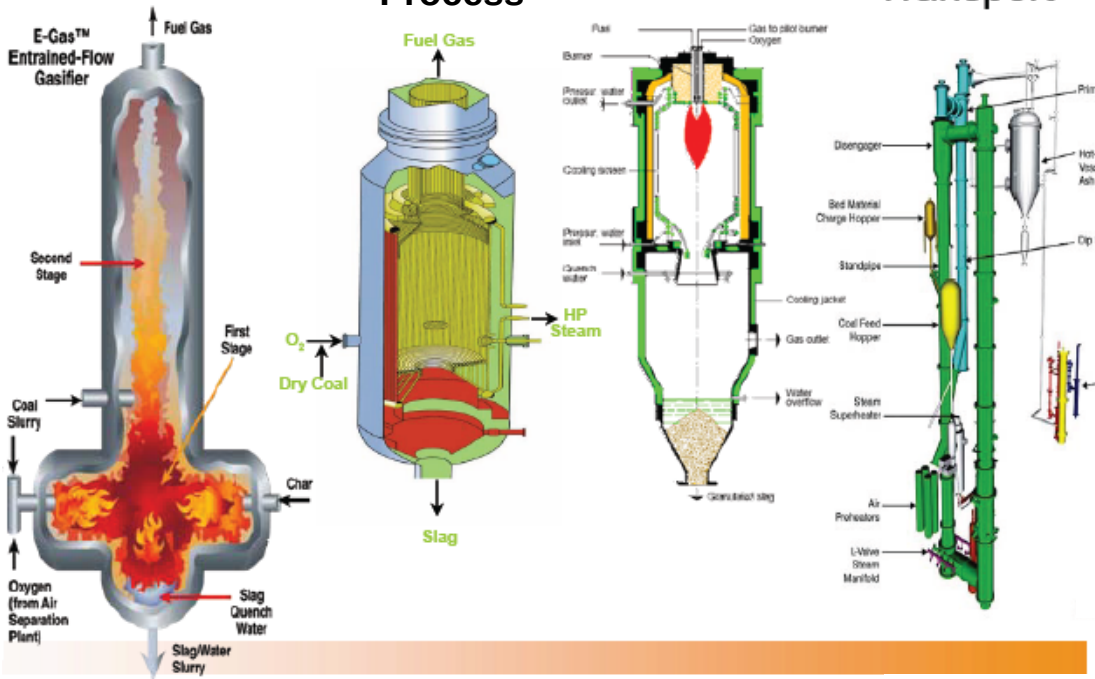
Core Gasification System

GE Energy (GEE)
(Chevron-Texaco)



Slurry-Fed: Not Ideal for Lignite

ConocoPhillips
E-Gas



Slag By-Product

Slurry-Fed: with R&D on Char Recycle

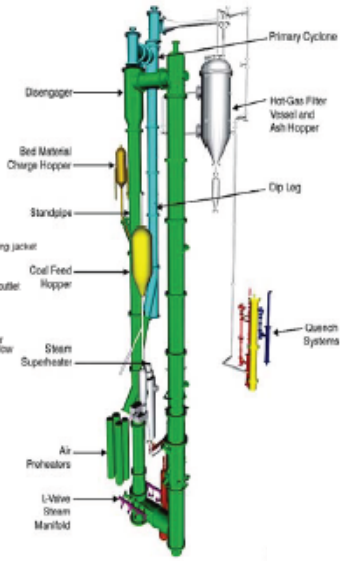
Shell Coal Gasification Process

<10% H_2O with Pulverized Coal (pc) Grind

Siemens
(GSP/Noell)

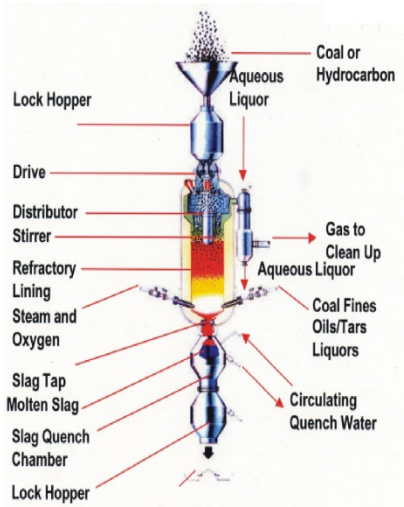
Commercial Units in China

KBR
Transport



<20% H_2O, Coarse Grind, Low Capital Expenditure (CAPX), Kemper

British Gas Lurgi (BGL)



<20% H_2O, High Tars with Recycle, Limited Commercial

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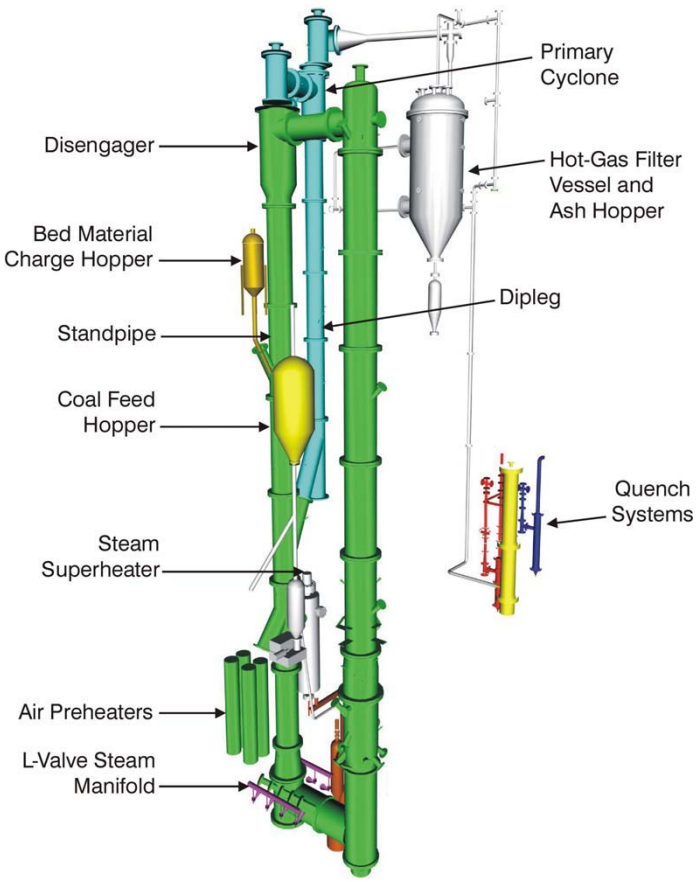
TRIG™ Attributes/Advantages

- Lower capital and operating costs due to fluid catalytic cracking design
- Lower reaction temperature (1800°F) and high heat release
- Fewer major components (reduced by one-third to one-half)
- Operated with air for syngas electricity or with oxygen for fuels and chemicals
- High-reliability design and lower operating and maintenance (O&M) costs
  - Proven non-slagging/fouling design
  - 10–20-year refractory life
- High efficiency with low-rank coal



Industry Integration

- Customize power production to fit demand from oil and gas and agriculture.
- Integrate with adjacent agricultural industry
  - Fertilizer production
  - Biofuel production
- Cogeneration steam and/or heat.
- Multiple energy systems (i.e., gasification, liquefaction, Fischer–Tropsch, catalytic biofuels).

Similar Polygeneration Projects

- **Feedstocks:** coal, petcoke, and/or natural gas
- **Products**
  - Electricity
  - CO_2 EOR
  - Syngas
  - Ammonia/urea
  - Hydrogen
  - Jet fuel/diesel
  - Gasoline
  - Methanol
  - Argon
  - Sulfuric acid

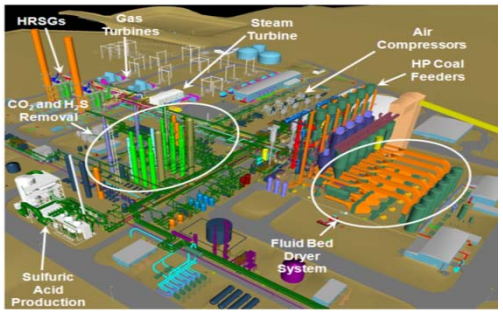
Southern Company–DOE Clean Coal Power Initiative (CCPI)
Kemper County Energy Facility IGCC Project with Carbon Capture
~$2.67B – Total, $270 M – DOE
EOR – 3 Mtpy
2014 Start

Leucadia Energy–Lake Charles Clean Energy (LCCE) Industrial Carbon Capture and DOE Sequestration (CCS) Program IGCC Project with Carbon Capture
$2.5B – Total
$261M – DOE
EOR – 4.5 Mtpy
2013 Start

Summit Power Group–DOE CCP
Texas Clean Energy Project (TCEP) IGCC with Carbon Capture
~$1.7B – Total, $450M – DOE
EOR – 3 Mtpy
2018 Start

Kemper County IGCC with Carbon Capture

- **Technology and Products**
  - 582-MWe IGCC
  - Two TRIG air-blown gasifiers
  - Feeding two Siemens SGT6-5000F gas turbines and one Toshiba steam turbine
  - Operated on 4 Mtpy of Mississippi lignite
  - Selexol™ for H_2S and 65% CO_2 removal
  - Coproducts:
    - 3.0 Mtpy of CO_2 for EOR
    - 135,000 tpy of sulfuric acid
    - 20,000 tpy of ammonia
- **Location:** near Meridian, Mississippi
- **Status:** start-up with natural gas – October 2013, combined cycle in commercial operation – August 2014, fully operational – 2015
- **Funding:** DOE investment – $270M



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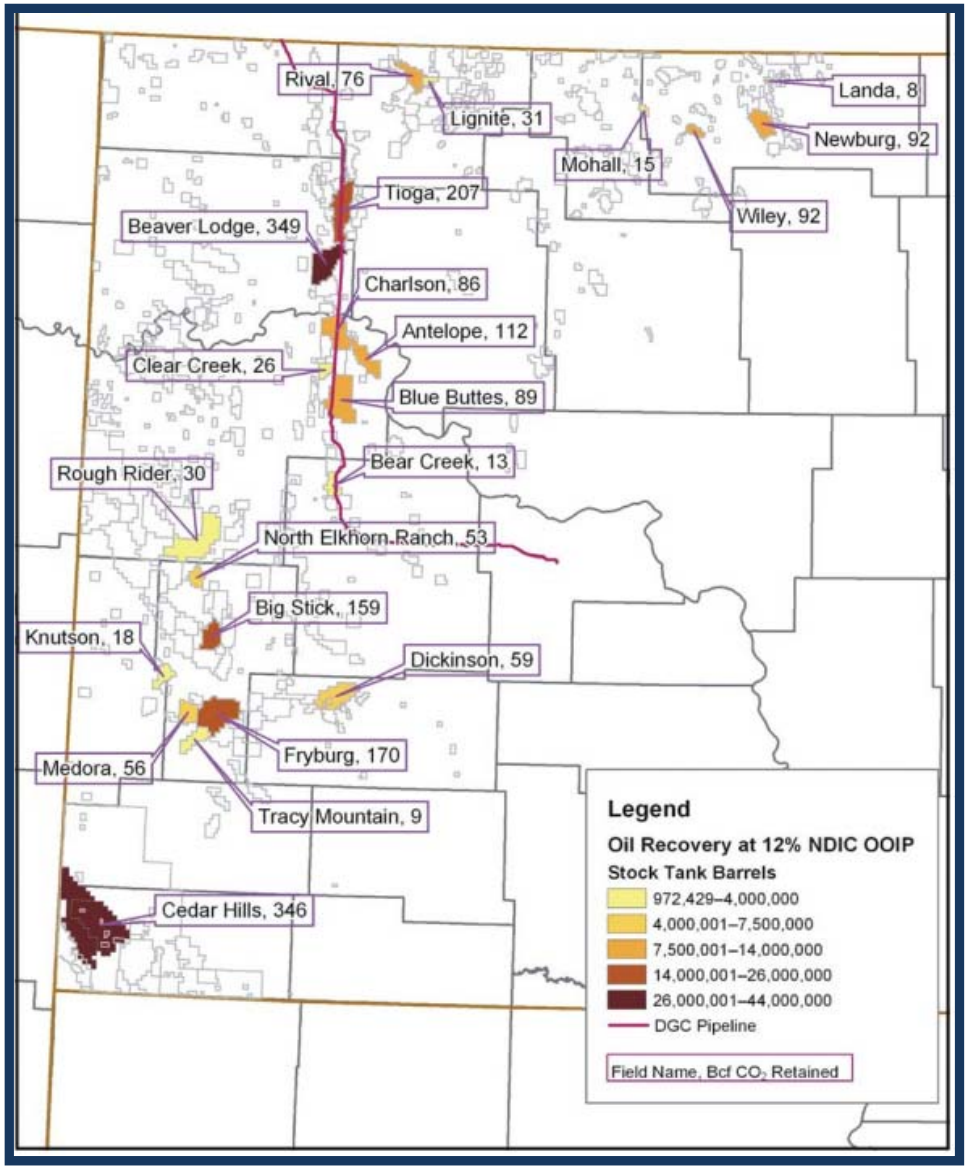
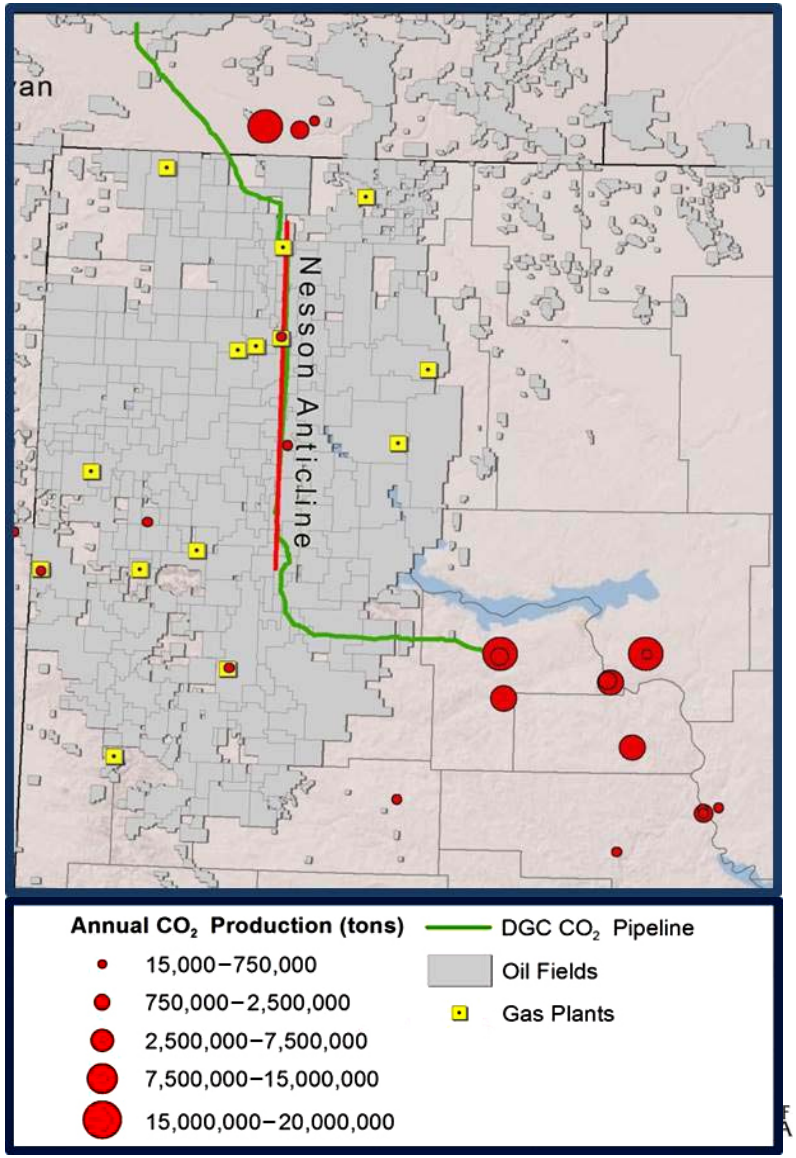
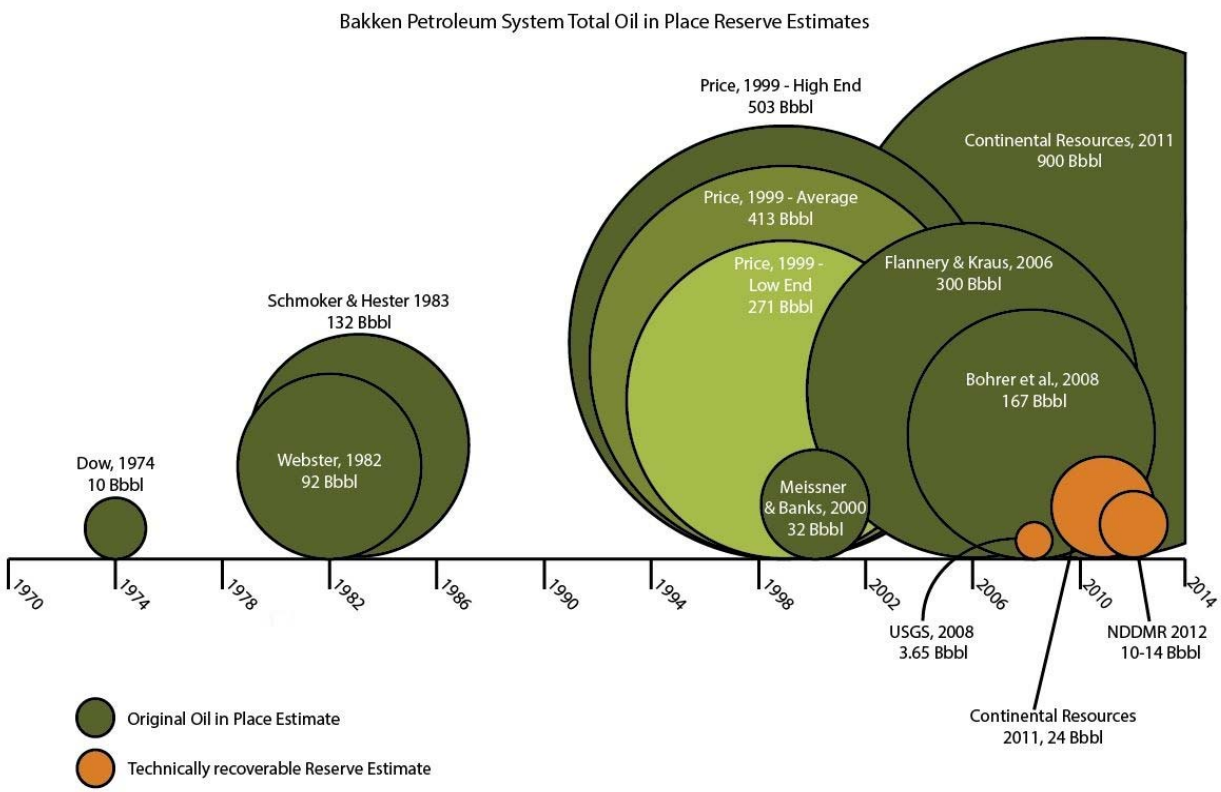
Conventional: Case Study of North Dakota Fields/Pools for CO_2 Flooding and CO_2 Sources





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%–5% recovery factor.
- Small improvements in recovery yield billions of barrels of oil.
- **Can CO_2 be a game changer in the Bakken?**



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

- Based on the following:
  - Traditional evaluation techniques
  - NDIC OOIP estimates
  - 4% incremental recovery
  - Net utilization of 5000 and 8000 ft^3/bbl
- 2–3.2 Bt of CO_2 needed, yielding 4–7 Bbbl of oil.
- North Dakota currently produces ~33 Mtpy of CO_2.

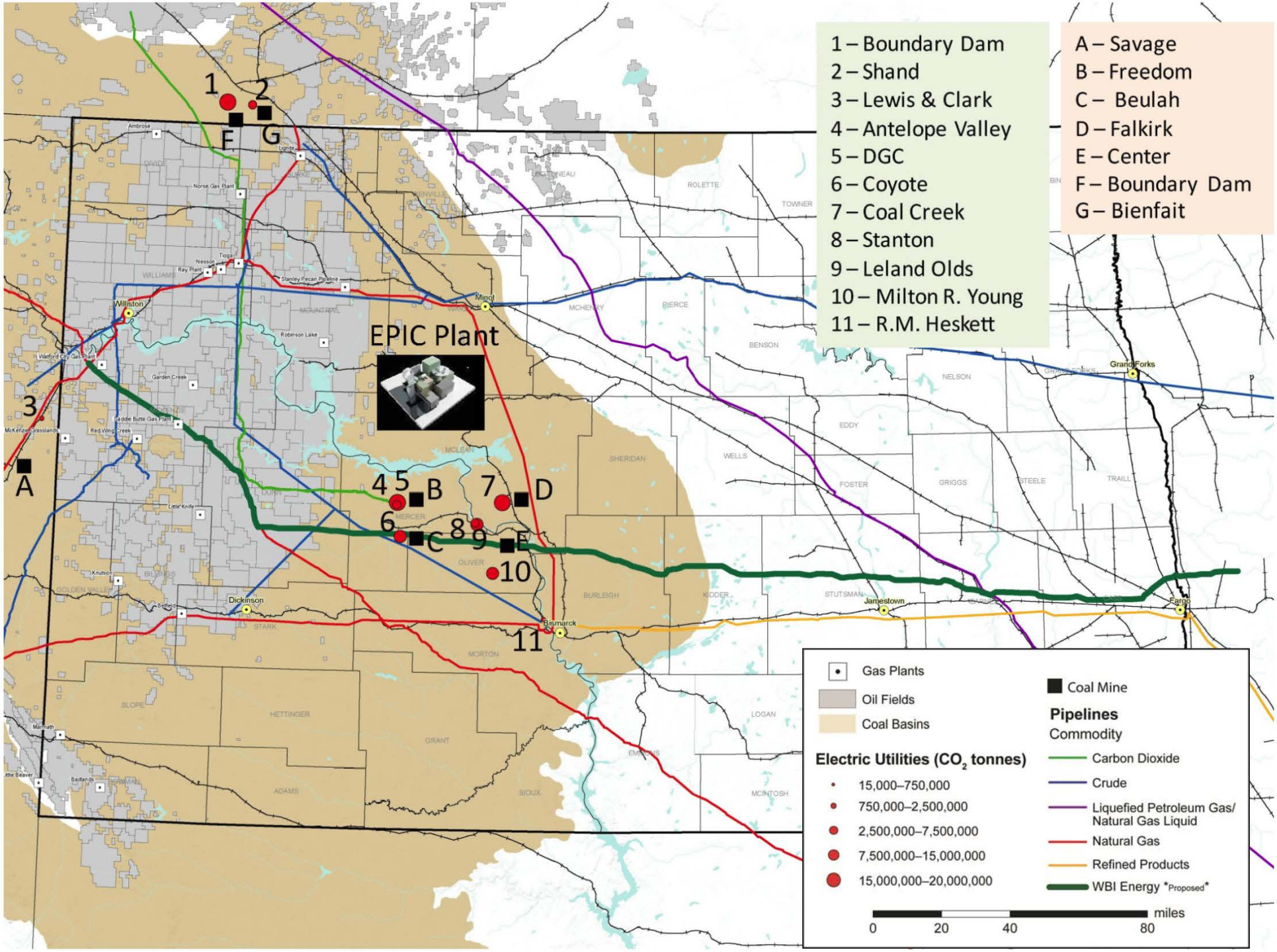
Bakken Impact to North Dakota

- 2–3.2 Bt of CO_2 yields 4–7 Bbbl of Bakken EOR.
- Assuming an average oil price of $88/bbl, this would equate to approximately $500B worth of oil.

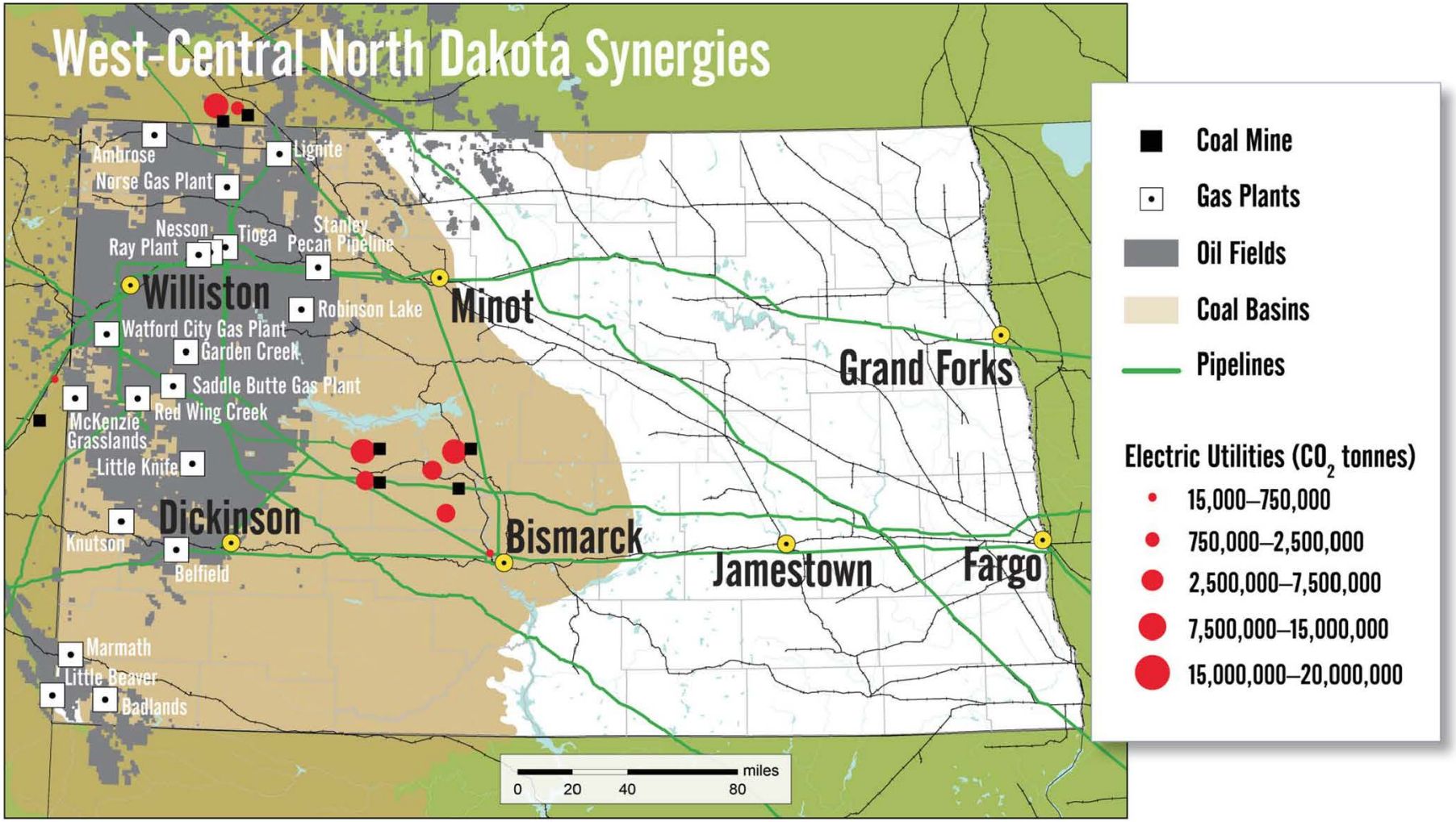
EPIC

Site Location Consideration

- Convenient for resource stakeholders and workforce
- Coal mines
- EOR pools and fields
- Gas-processing plants
- Water
- Pipelines
  - Oil and natural gas
  - CO_2
  - Refined product
- Electrical transmission
- Rail lines


1 – Boundary Dam
2 – Shand
3 – Lewis & Clark
4 – Antelope Valley
5 – DGC
6 – Coyote
7 – Coal Creek
8 – Stanton
9 – Leland Olds
10 – Milton R. Young
11 – R.M. Heskett
A – Savage
B – Freedom
C – Beulah
D – Falkirk
E – Center
F – Boundary Dam
G – Bienfait
EPIC Plant
Gas Plants
Oil Fields
Coal Basins
Coal Mine
Pipelines
Commodity
Carbon Dioxide
Crude
Liquefied Petroleum Gas/ Natural Gas Liquid
Natural Gas
Refined Products
WBI Energy *Proposed*
Electric Utilities (CO_2 tonnes)
15,000–750,000
750,000–2,500,000
2,500,000–7,500,000
7,500,000–15,000,000
15,000,000–20,000,000
miles
0
20
40
80
Williston
Minot
Dickinson
Bismarck
Jamestown
Fargo
Grand Forks

Synergies



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Next Steps

EPIC: Next Steps

- **Develop stakeholders**
  - Coal, oil, and gas producers
  - Utilities
  - Agricultural organizations
  - Local, state, and federal authorities
  - Pipeline, railroad, trucking, and transmission industries
  - Industry and engineering firms
  - Research and development community
  - Financial industry
- **Project development**

EPIC Project Activities

EERC to Promote, Manage, and Facilitate Project

- Assemble financially vested stakeholders from private and public sectors.
- Develop a refined, integrated energy and product complex concept.
- Detail the integrated complex for development and implementation.

The EERC employs over 200 entrepreneurial professionals dedicated to energy and environmental research.

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