



# **Lignite R&D Update**

## **Carbon Management and Emerging Markets**

LEC Annual Meeting

Bismarck, ND

April 24, 2019

# Topics of Presentation

- Background
- Carbon Management Updates
  - Regional Impact Study
  - Carbon Safe
  - Allam Cycle
  - Project Tundra
- Emerging Markets
  - Value Added Opportunities
  - Future Opportunities





# Research & Development Priorities for the LEC

- Support continued options to enhance performance of the existing fleet
- Invest in transformational research (Next generation of Lignite conversion systems that integrate CO<sub>2</sub> capture)
- Focus on Carbon Capture Utilization & Storage (CCUS)
- Leverage international R&D breakthroughs
- Renewed Focus
  - Additional value propositions for lignite
  - Polygeneration opportunities

**PRIORITY**

# REGIONAL IMPACTS CASE STUDY

If the largest coal-fired power plants in North Dakota captured 90% of the CO<sub>2</sub> and targeted near-term enhanced oil recovery (EOR) opportunities, what would be the economic impact to the state?

# STUDY INPUTS

Linking the Industries

Existing Infrastructure

Existing Infrastructure

New Construction

CO<sub>2</sub> Capture and  
Compression Facilities

CO<sub>2</sub>  
Compression  
and Recycle  
Facilities

Conventional Oil  
Fields

Coal Mines

Coal Power  
Plants

CO<sub>2</sub> Pipelines

CO<sub>2</sub> Injection  
Wells



LIGNITE  
MINING

ELECTRICAL  
GENERATION

CO<sub>2</sub> CAPTURE &  
COMPRESSION

TRANSPORTATION

COMPRESSION/  
RECYCLING

ENHANCED OIL RECOVERY &  
ASSOCIATED CO<sub>2</sub> STORAGE

# LIGNITE INDUSTRY IMPACTS TODAY

- Studies released every 2 years by NDSU<sup>1</sup> highlight the economic impact the lignite industry has on the state.
- Approximately \$5.7 billion in business activity and ~14,000 total jobs.

Total Business Activity  
\$5,734,000,000

Direct Jobs  
3820

Secondary Jobs  
10,200  
(Indirect + Induced)

<sup>1</sup>Bangsund, D.A and N.M. Hodur. 2018. *North Dakota Lignite Energy Industry's Contribution to the State Economy in 2017*; Agribusiness and Applied Economics, NDSU (report forthcoming).



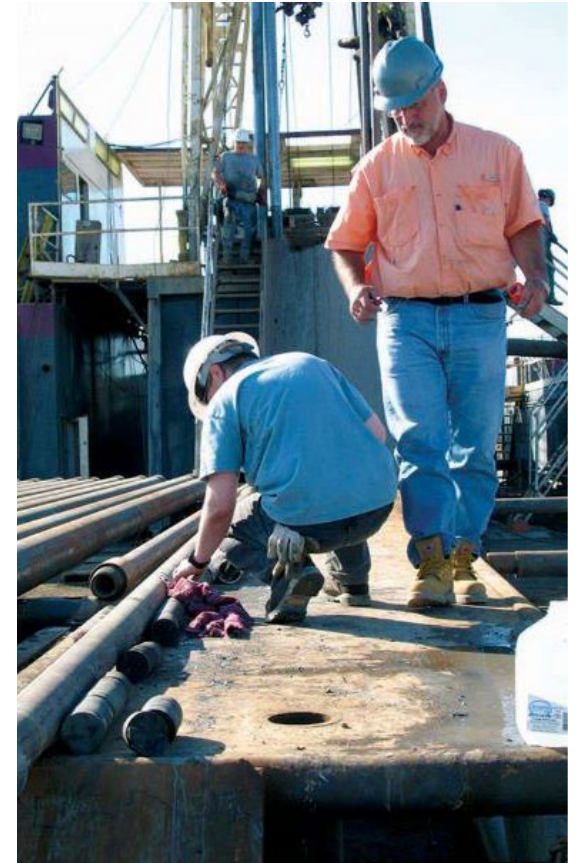
# SCENARIO SUMMARY

- Carbon capture and EOR operations have the potential to significantly boost the economy in North Dakota. Assuming one plant for EOR and balance in saline formations.

Total Annual Economic Activity  
\$2,500,000,000

Annual Taxes and Revenue  
>\$140,000,000

Annual Jobs  
8000



# Unlocking the Full Potential of Conventional EOR in North Dakota

Identified

**201**

Conventional Oil Fields

Requiring

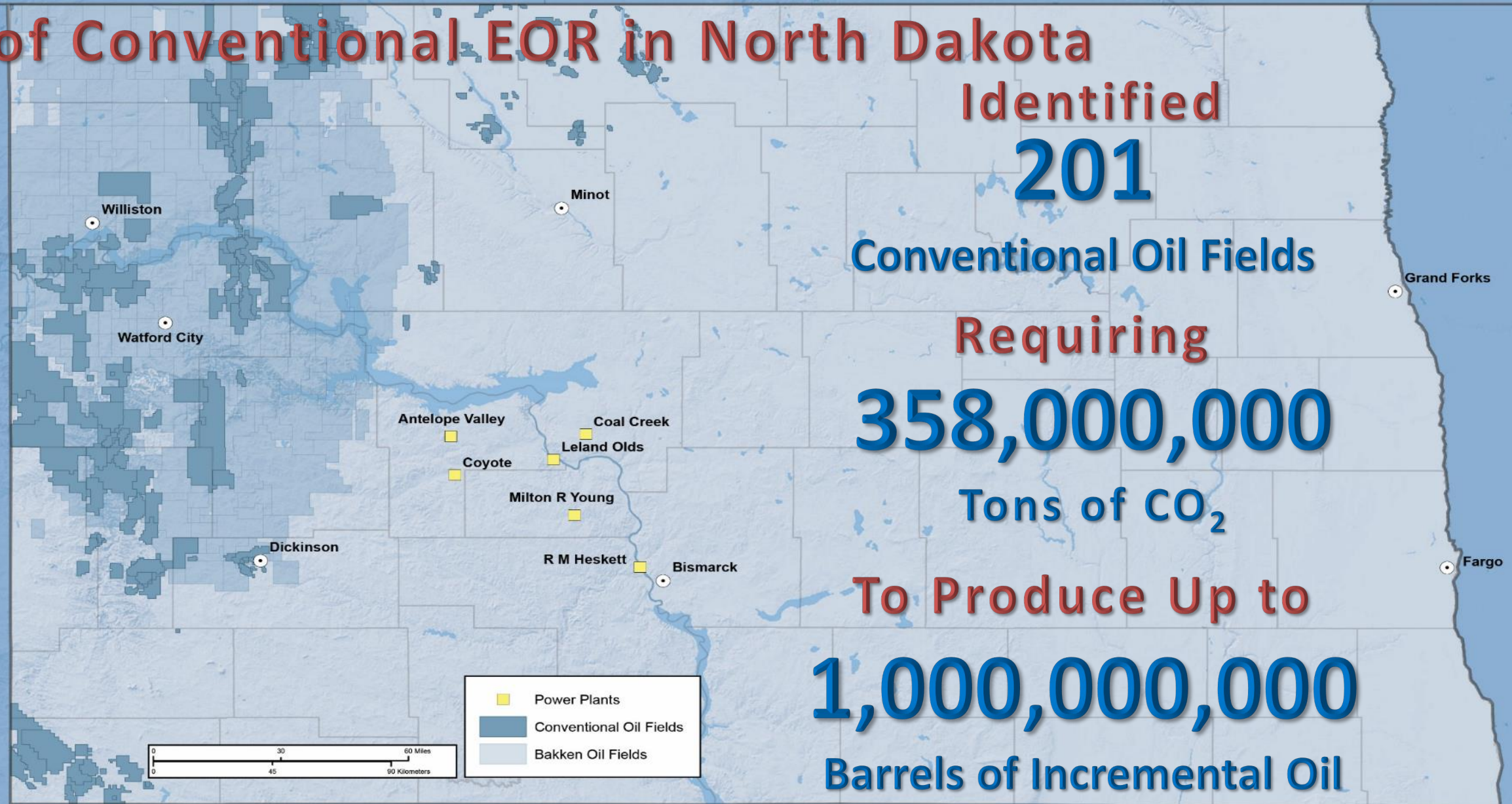
**358,000,000**

Tons of CO<sub>2</sub>

To Produce Up to

**1,000,000,000**

Barrels of Incremental Oil





# FULL POTENTIAL FOR CONVENTIONAL EOR

- If additional conventional oil fields were added to the study, up to 1 billion barrels of additional oil recovery would be possible.
- Estimating the additional severance taxes and royalties collected on EOR barrels of oil at \$65/barrel, this could add **\$300,000,000/year** to annual state revenue.
- Over 30 years, this could result in **\$45 billion** in economic impact and **15,000** long-term jobs per year.





# PROJECT CARBON OVERVIEW

- Project Carbon lays a solid foundation for Project Tundra.
- Testing of MHI solvent technology at MRV2.
  - Parametric
  - Long term
  - Solution for aerosol emissions
- Economics of CO<sub>2</sub> capture in North Dakota.
  - Cost of capture evaluation specific to MRV
  - Reducing parasitic load
  - Pre-FEED cost estimate for MRV2



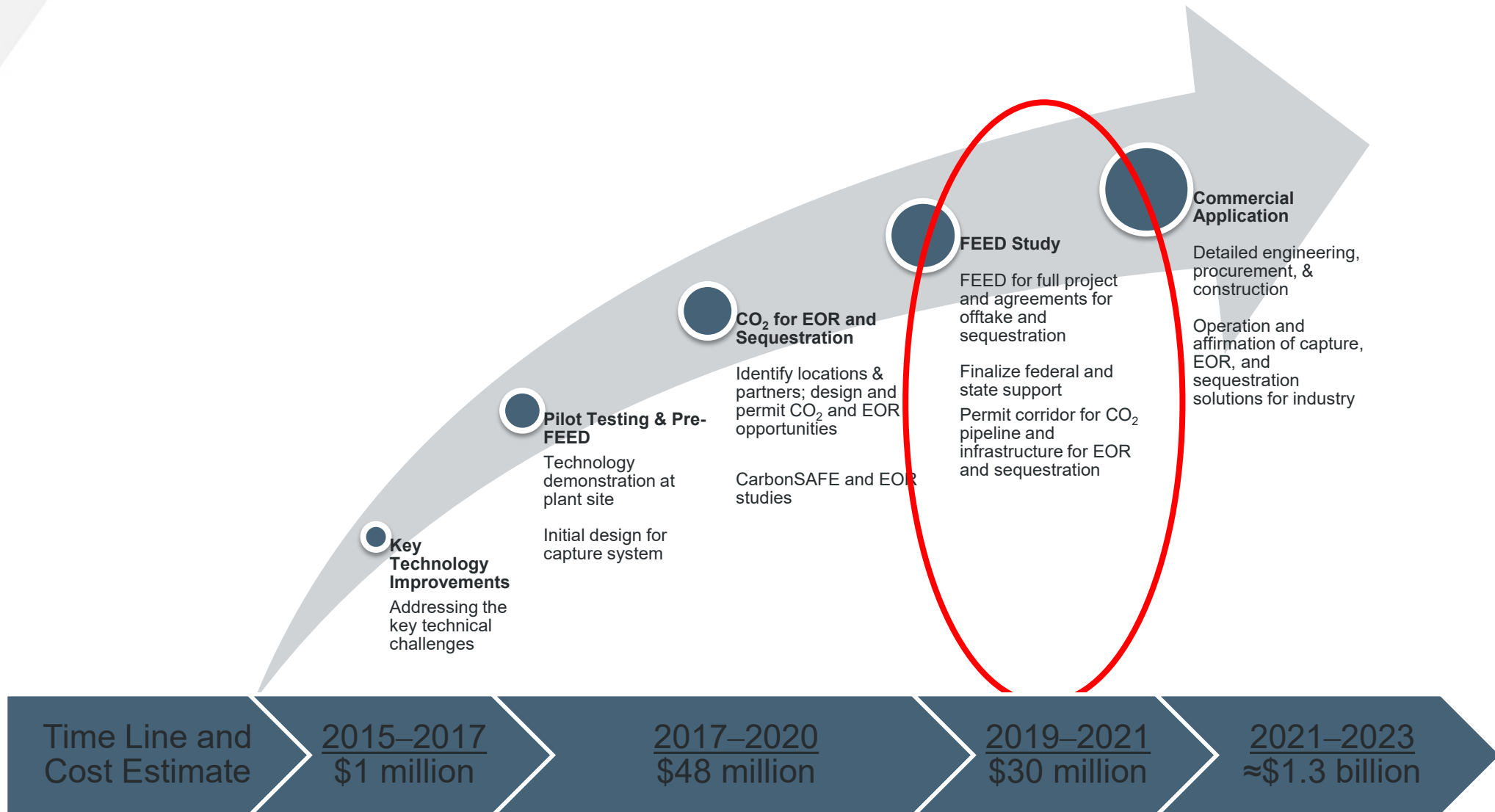
# PROJECT CARBON UPDATE

- Postcombustion capture system assembled at MRY2.
- Shakedown testing this week!
- Longer-term (3-month minimum), continuous test will be performed this summer.
- Heat integration strategies identified = improved efficiency.
- Pre-FEED completed this summer.





# PROJECT TUNDRA ROAD MAP



# CARBONSAFE-NORTH DAKOTA INTEGRATED CARBON STORAGE COMPLEX FEASIBILITY STUDY



INDUSTRIAL COMMISSION OF NORTH DAKOTA  
LIGNITE RESEARCH COUNCIL

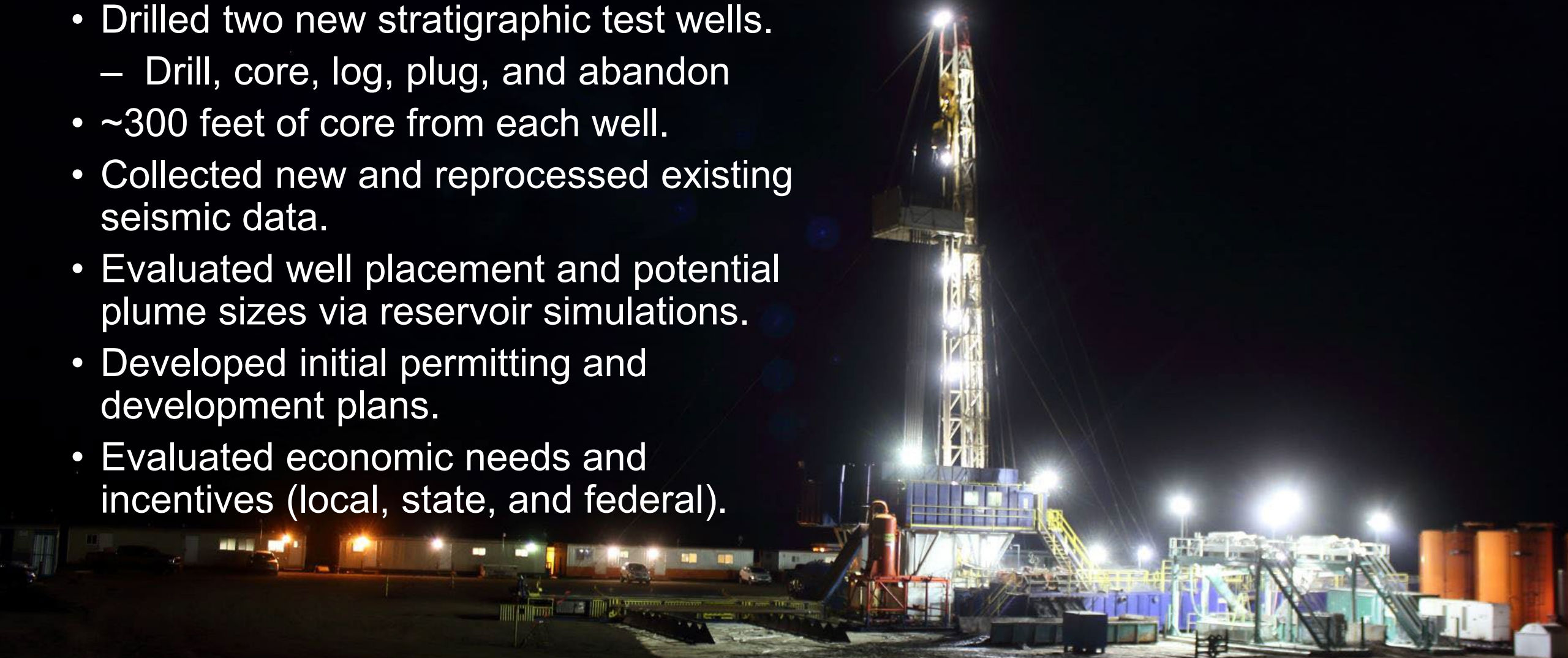
- Address technical and nontechnical challenges specific to commercial-scale deployment of a CO<sub>2</sub> storage project in central North Dakota.
- Long-term goal: develop a certified (permitted) geologic storage opportunity should a business case for CO<sub>2</sub> storage emerge.





# SOME MAJOR ACCOMPLISHMENTS

- Drilled two new stratigraphic test wells.
  - Drill, core, log, plug, and abandon
- ~300 feet of core from each well.
- Collected new and reprocessed existing seismic data.
- Evaluated well placement and potential plume sizes via reservoir simulations.
- Developed initial permitting and development plans.
- Evaluated economic needs and incentives (local, state, and federal).



# NEXT STEPS

- Evaluation of strategies to improve storage efficiency (e.g., stacked storage)
- Complete draft development plans
  - Characterization, permitting, monitoring, etc.
- Finalize draft economic investigation
- More outreach
  - Blog, newspaper, social media pieces
  - Infographics
  - Focus group – testing of products and messages
  - Hands-on materials
- Respond to potential future funding opportunities (projected release summer 2019)





# ALLAM CYCLE / PATHWAY TO LOW-CARBON LIGNITE UTILIZATION

Led by EERC – Jason Laumb with industry partners: Minnesota Power/ALLETE Clean Energy, BNI Energy, Basin Electric Power Cooperative, and Dakota Gasification Company

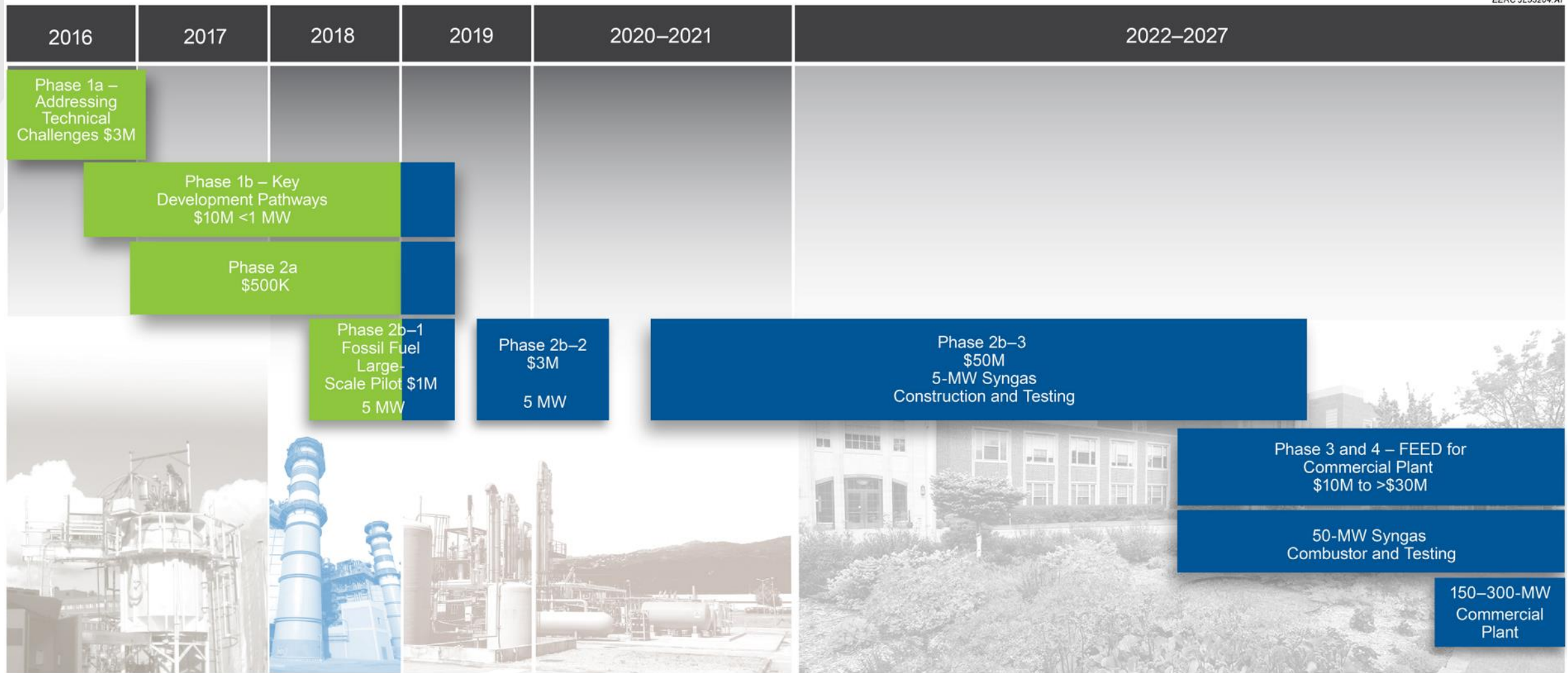
- Corrosion management
  - Commercial alloys can be used and will resist corrosion.
- Gasifier selection
  - Three gasifier platforms have been identified for use with lignite coal: SE (ECUST), BGL, SES (U-Gas)
- Impurity management
  - Precombustion technologies are applicable, which are commercially available.
- Syngas combustion
  - La Porte facility continues progressing through its test protocol and working toward full load.
- Pilot-scale planning
  - Great Plains Synfuels Plant (GPSP) selected to host 5-MW<sub>th</sub> demonstration. Proposal submitted to the U.S. Department of Energy in March 2019 for demonstration FEED.
- Management and reporting
  - Final report submitted; added scope to expand engineering for demonstration plant.

# LOCATION FOR 5-MW<sub>TH</sub> DEMONSTRATION AT GPSP



# OVERALL TECHNOLOGY DEVELOPMENT ROAD MAP

EERC JL53204.AI







# **Additional Value Opportunities for Lignite**

- **Current Commercial Uses**
- **Technology Developments and Opportunities**

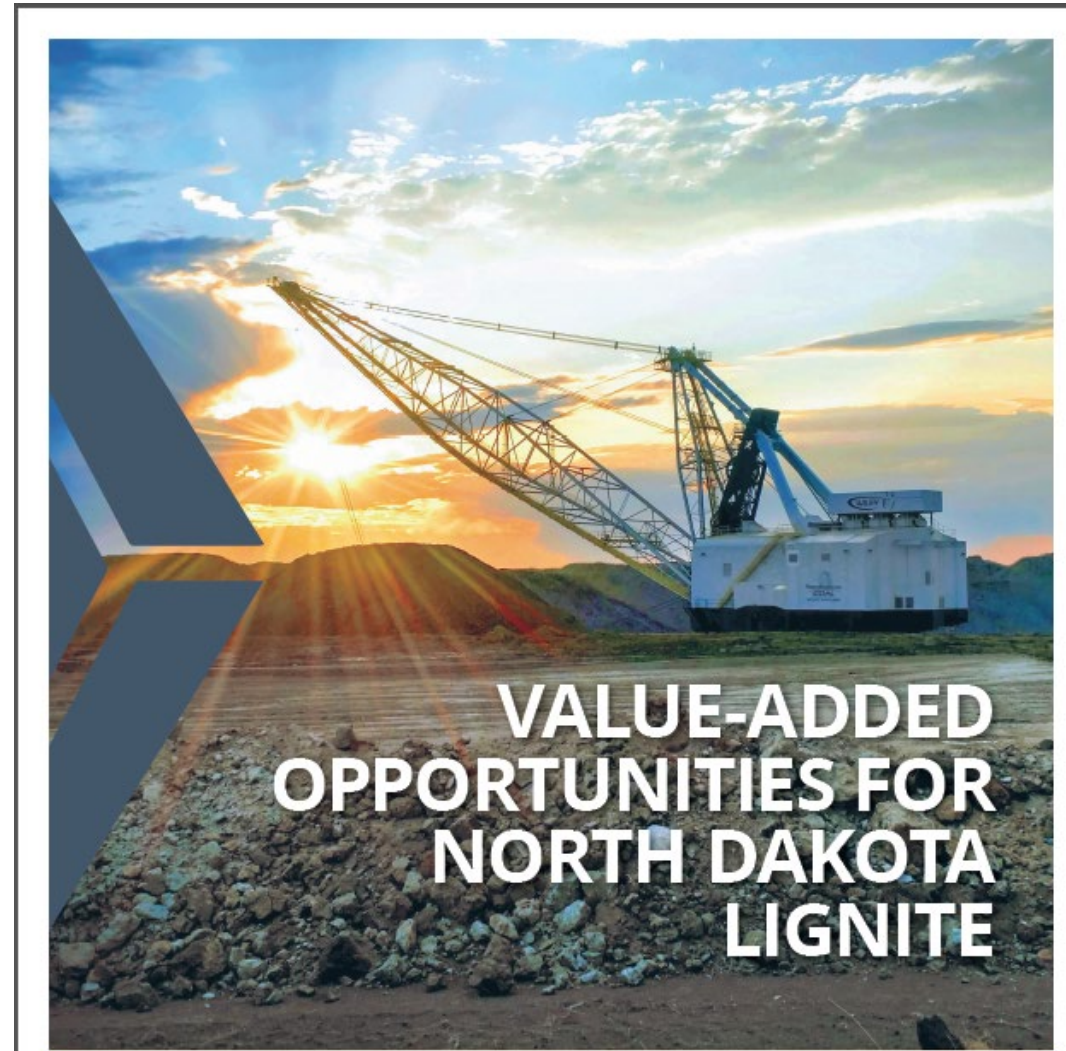
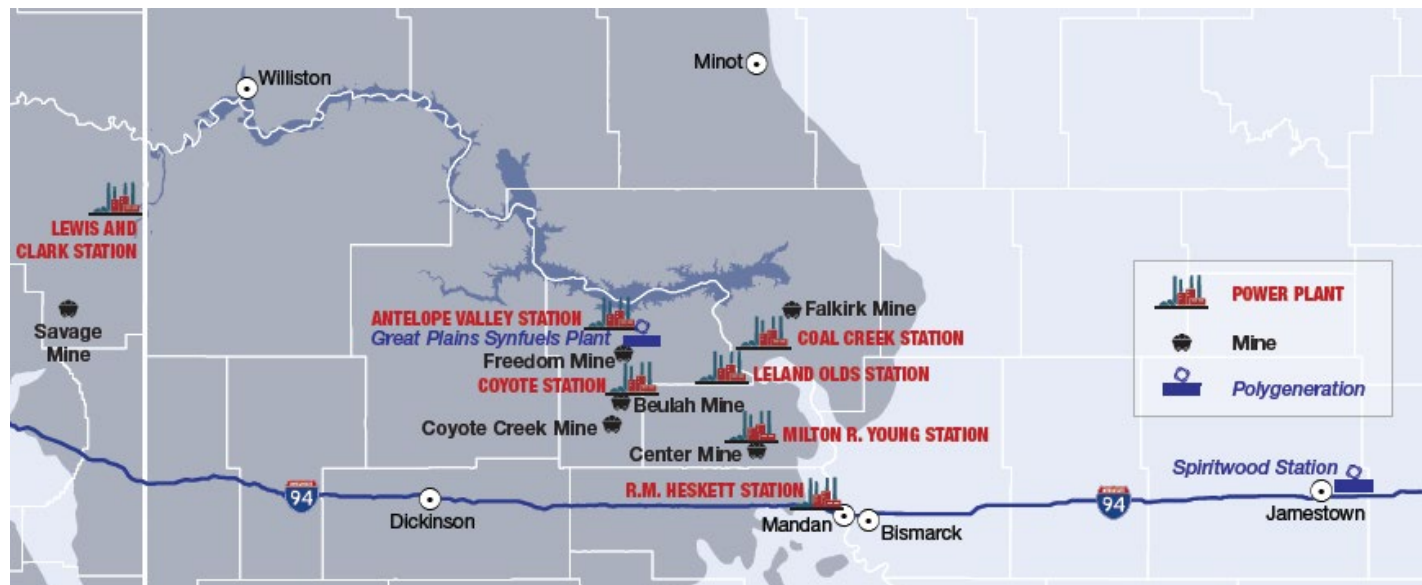


# Value-Added Opportunities for North Dakota Lignite

Lignite Energy Council (LEC) commissioned a study to assess additional uses of North Dakota's immense coal resource.

The report is available at LEC's Web site:

[https://cdn.lignite.com/wp-content/uploads/2019/01/LEC-value-added-executive-summary-2018-1\\_14\\_19-small.pdf](https://cdn.lignite.com/wp-content/uploads/2019/01/LEC-value-added-executive-summary-2018-1_14_19-small.pdf)



## VALUE-ADDED OPPORTUNITIES FOR NORTH DAKOTA LIGNITE



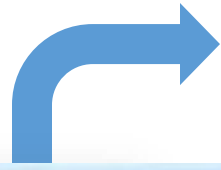
HELPING DEVELOP AFFORDABLE, RELIABLE, AND CLEAN LIGNITE-GENERATED ELECTRICITY FOR YOU

# Coal Gasification for Fuels, Chemicals and Hydrogen

Lignite



Syngas  
CO<sub>2</sub>  
Heat



Direct or Indirect  
Liquefaction



Liquid Fuels and Additives

Gasoline  
Jet Fuel  
Diesel

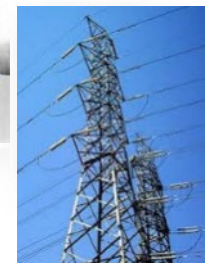


EOR

Nitrogen Fertilizers



Chemicals



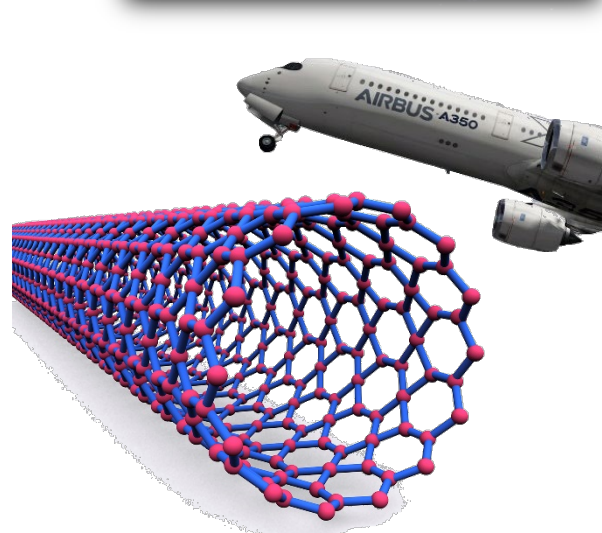
Electricity





# Carbon Based Products

- Activated Carbon
  - Facility in final design stages in Valley City, North Dakota
- Carbon Black
  - Semi-continuous pilot unit at the EERC, proof-of-concept complete
- Carbon Fiber
  - Coal-derived pitch has unique properties
  - High value product with growing market
- Carbon Nanotubes and graphite
  - High value product with growing markets



# High Value Material Extraction

- Pioneering work by the North Dakota Geologic Survey has led to a number of funded projects investigating recovery of high value materials from coal and byproducts:
  - Characterization study of coal and byproducts across North America
  - Rare earth element extraction from ND lignite
  - Rare earth element extraction from coal combustion byproducts
- Technology development is needed to optimize and improve economics of processes that extract and concentrate rare earth elements and other high value minerals.

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-71 Lanthanides	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-103 Actinides	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
		Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
		Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr



# Resource Recovery from a Coal Fired Power Plant to Enhance Agricultural Production in Open Field and Greenhouse Facilities

## Plant Integration:

- Waste heat used for greenhouse heating demands
- CO<sub>2</sub> & Flue gas used to enhance plant growth
- Plant water / condensate can supplement irrigation

## Updates:

- First planting cycle complete (data analysis ongoing)
- Low and intermediate concentrations of CO<sub>2</sub> improved plant growth and highest level was antagonistic
- Second planting cycle to include varied levels of CO<sub>2</sub>



## Grant Round 85 Awards

- **To Test, Confirm, and Initiate Commercial Design of a Post-Combustion "Bolt-On" CO2 Capture System Suitable for At-Scale, Royalty-Free Retrofit of Existing North Dakota Lignite- and Coal-Fired Power Generating Facilities (with North Dakota Manufacturing Opportunity to reach National and International Markets)** – NDIC funding of \$649,860 with total project costs of \$1,580,800. The project is led by Mattoon Power Enterprises, LLC, and is a 12 month project (currently in the contracting phase).
- **Economical Extraction and Recovery of Rare-Earth Elements and Production of Clean Value-Added Products from Low-Rank Coal Fly Ash.** Budget includes \$30,000 from NDIC with a total project budget of \$510,000. The project is led by the EERC and the project duration is 18 months. The focus is on methods of economical Rare-Earth Element extraction from coal ash.

## Grant Round 86 Awards

- **Project Tundra – FEED.** NDIC funding of \$15,000,000, with a total project budget of \$31,164,414. The project is led by Minnkota power and is scheduled to last 32 months. The focus is on the engineering and design work to help determine commercial viability of CCUS of enhanced oil recovery in North Dakota.
- **Investigating the Use of Fly Ash for Sustainable Asphalt Pavements.** Budget includes \$53,814 from the NDIC out of a total project cost of \$119,463. This is a one year project led by the UND Department of Civil Engineering, and focuses on developing the use of North Dakota lignite fly ashes in asphalt applications.

# Potential Technologies for Future Grant Rounds

**Grant Round 87 – Will Tentatively be Moved to July 1, 2019**

- **Next Phases of Carbon Management / CCUS**
- **Next Generation Power Cycles, including ALLAM**
- **DOE Emerging Markets**
  - Carbon Materials
  - Rare Earth Elements Phase III
  - Fertilizers from coal
- **DOE Coal FIRST Program**
- **NOx Technology Solutions**
- **Continued Focus on Emerging Demand Opportunities**

*Others to be identified with industry and State guidance*



Questions??

