Energy & Environmental Research Center (EERC)

REGIONAL ECONOMIC IMPACT OF CARBON CAPTURE UTILIZATION AND STORAGE (CCUS)

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Critical Challenges. **Practical Solutions.**

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

- Nonprofit branch of the University of North Dakota focused on applied research and energy and environmental solutions.
- More than 254,000 square feet of state-of-the-art laboratory, demonstration, and office space.

Heart of North Dakota Energy Industry

EERC | UND UNIVERSITY OF NORTH DAKOTA

REGIONAL IMPACTS OF CCUS – OVERVIEW

- The regional economic impacts of CCUS technology deployment can have substantial positive effects on regional economies and state and local tax revenue.
- The lignite industry in North Dakota currently supports approximately 14,000 jobs in the state.
- Use of CO_2 in conventional oil fields will boost productivity of existing assets in North Dakota.
- This study evaluates a potential scenario for wide-scale CCUS implementation in North Dakota and the potential impact to the state's economy.

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY | Lignite Energy Council

EERC | UND UNIVERSITY OF NORTH DAKOTA

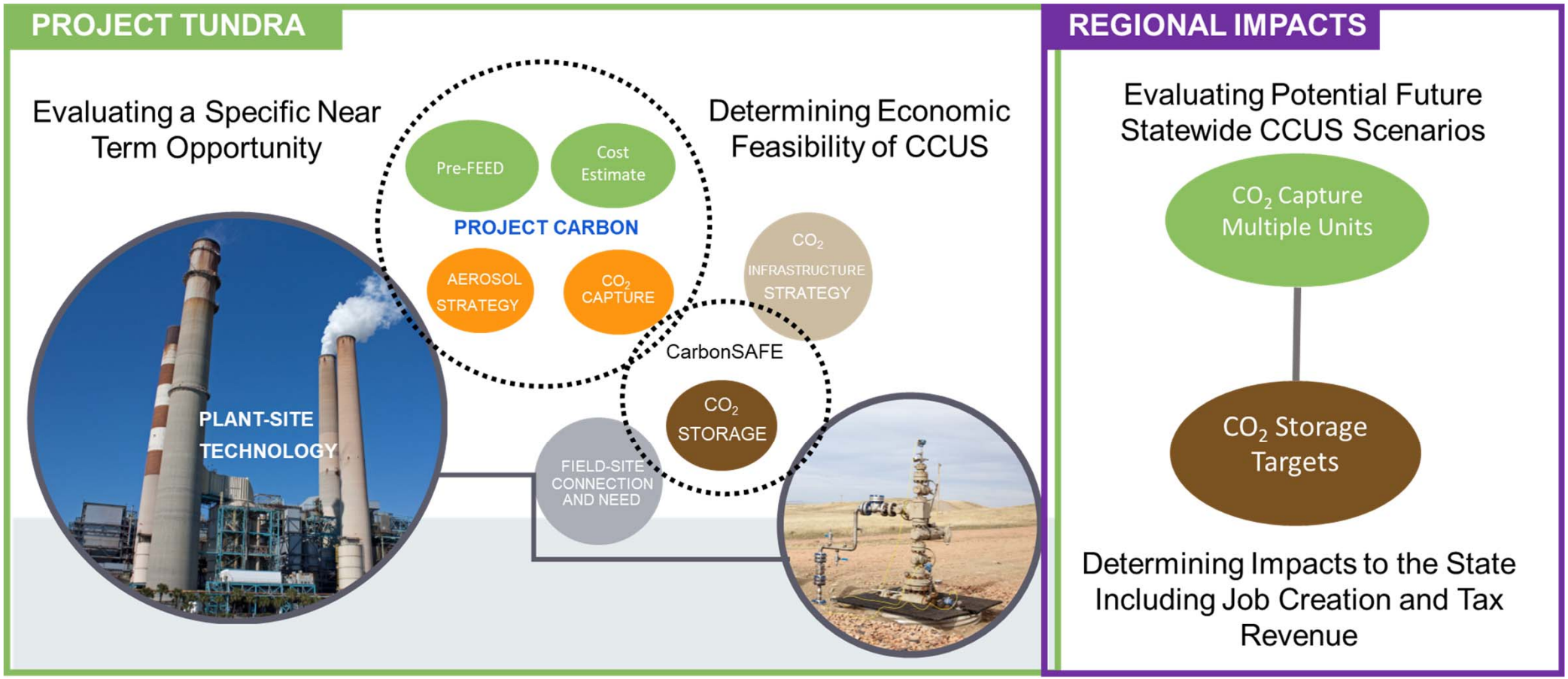
PAST CHALLENGES AND TODAY'S OPPORTUNITIES

- On August 3, 2015 the EPA and President Obama announced the Clean Power Plan Final Rule
  - Drastic changes from the proposed rule.
  - Required North Dakota to reduce carbon emissions by 45%.

    - New Source Performance Standards
      - Establishes carbon emission limits for new electricity generating units.

- Though the Clean Power Plan is in the process of being replaced by the proposed Affordable Clean Energy (ACE) Rule, North Dakota is in a unique position to utilize CO_2 for economic benefit.

OVERVIEW OF CCUS STUDIES AT THE EERC



REGIONAL IMPACTS CASE STUDY

If the largest coal-fired power plants in North Dakota captured 90% of their CO_2 and targeted near-term enhanced oil recovery (EOR) opportunities, what would be the economic impact to the state?

STUDY FOCUS

This study intends to:

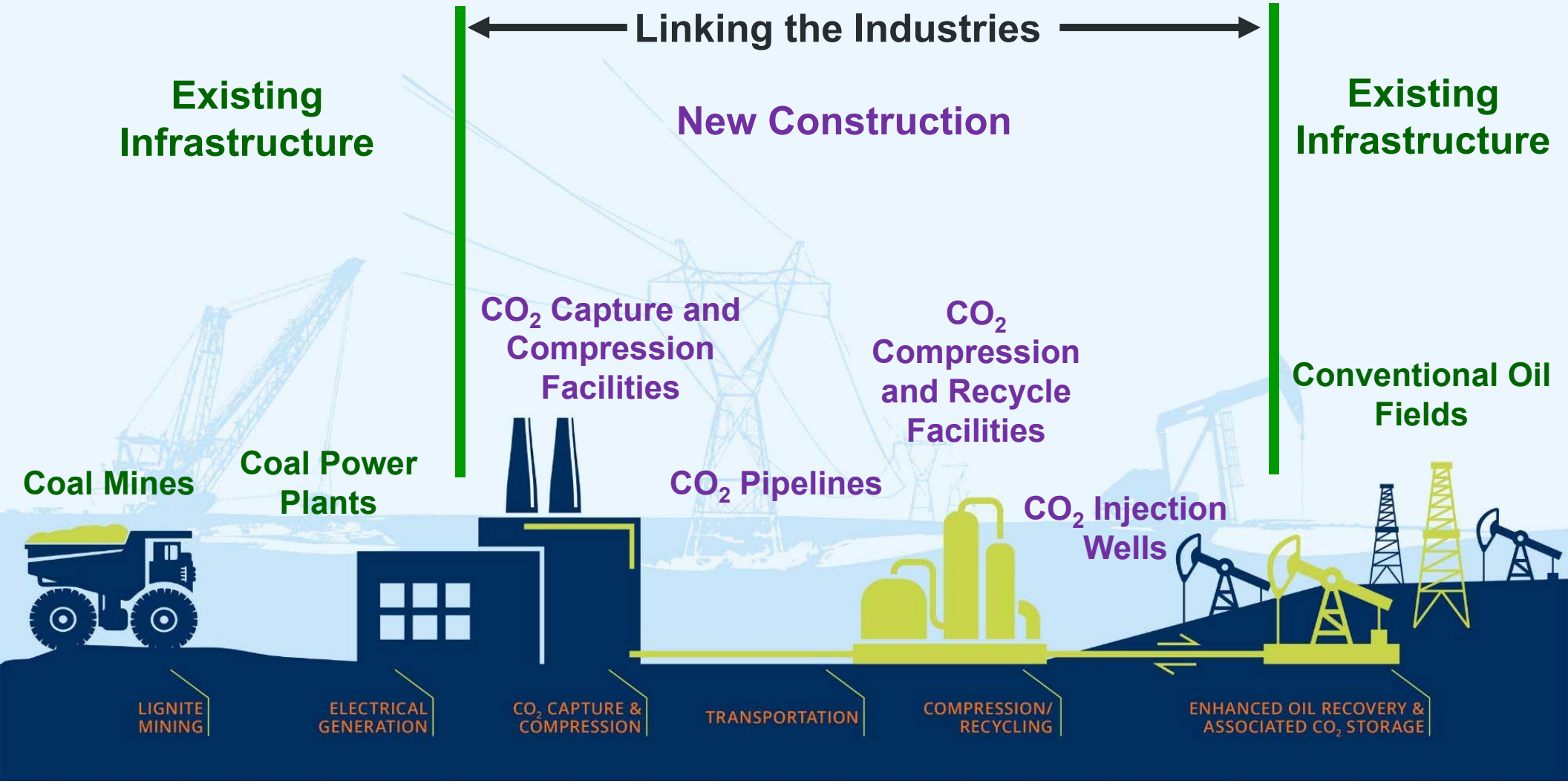
- Provide a picture of the economic impact of carbon capture and EOR in North Dakota.
- Develop high-level cost estimates for construction and operation.
- Use economic impact models to estimate *job creation and revenue to the state.*

Outside the scope of the study:

- Economic decisions for carbon capture implementation at each plant
- Economic decisions for pipelines and oil fields
- Specific technology evaluations

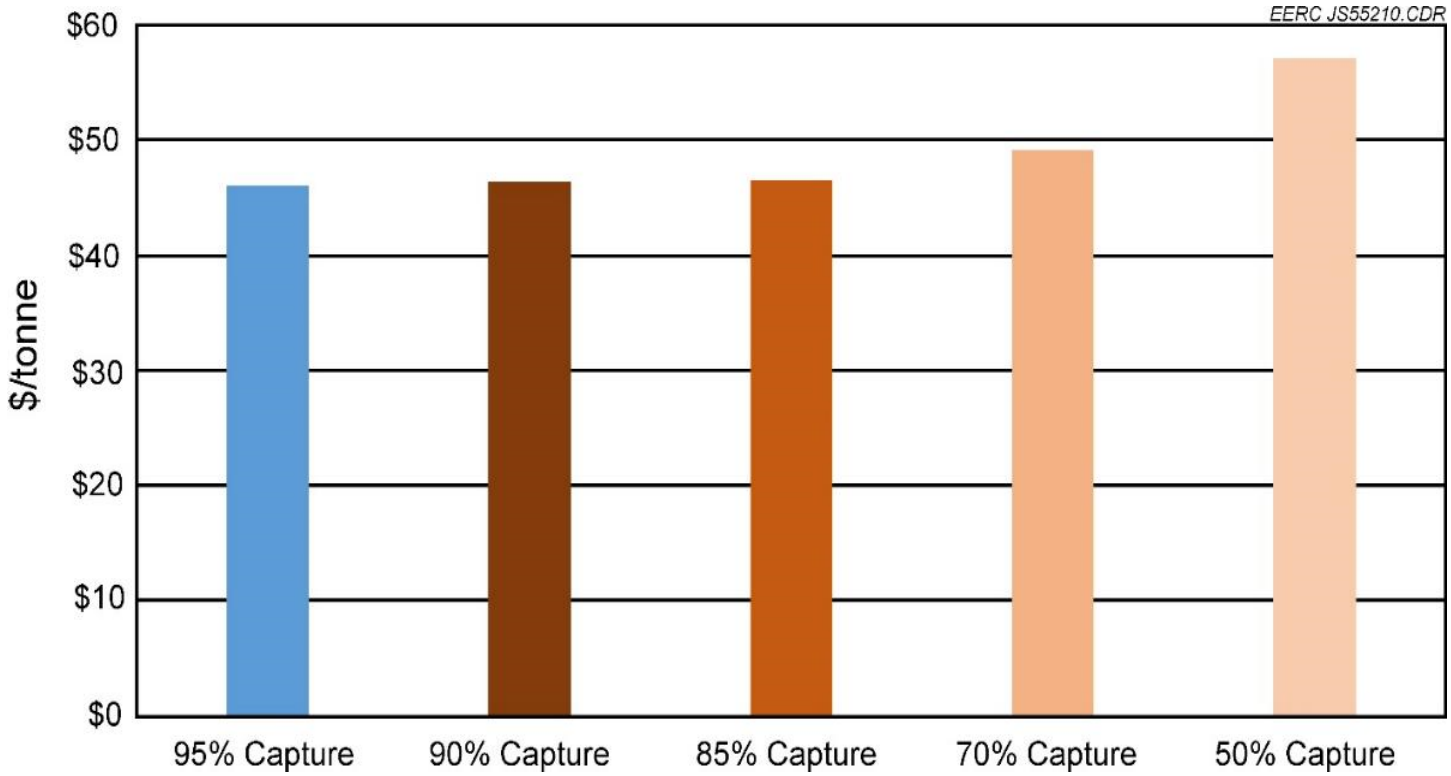
Note: Project Tundra seeks to answer these questions.

STUDY INPUTS



WHY CAPTURE 90%?

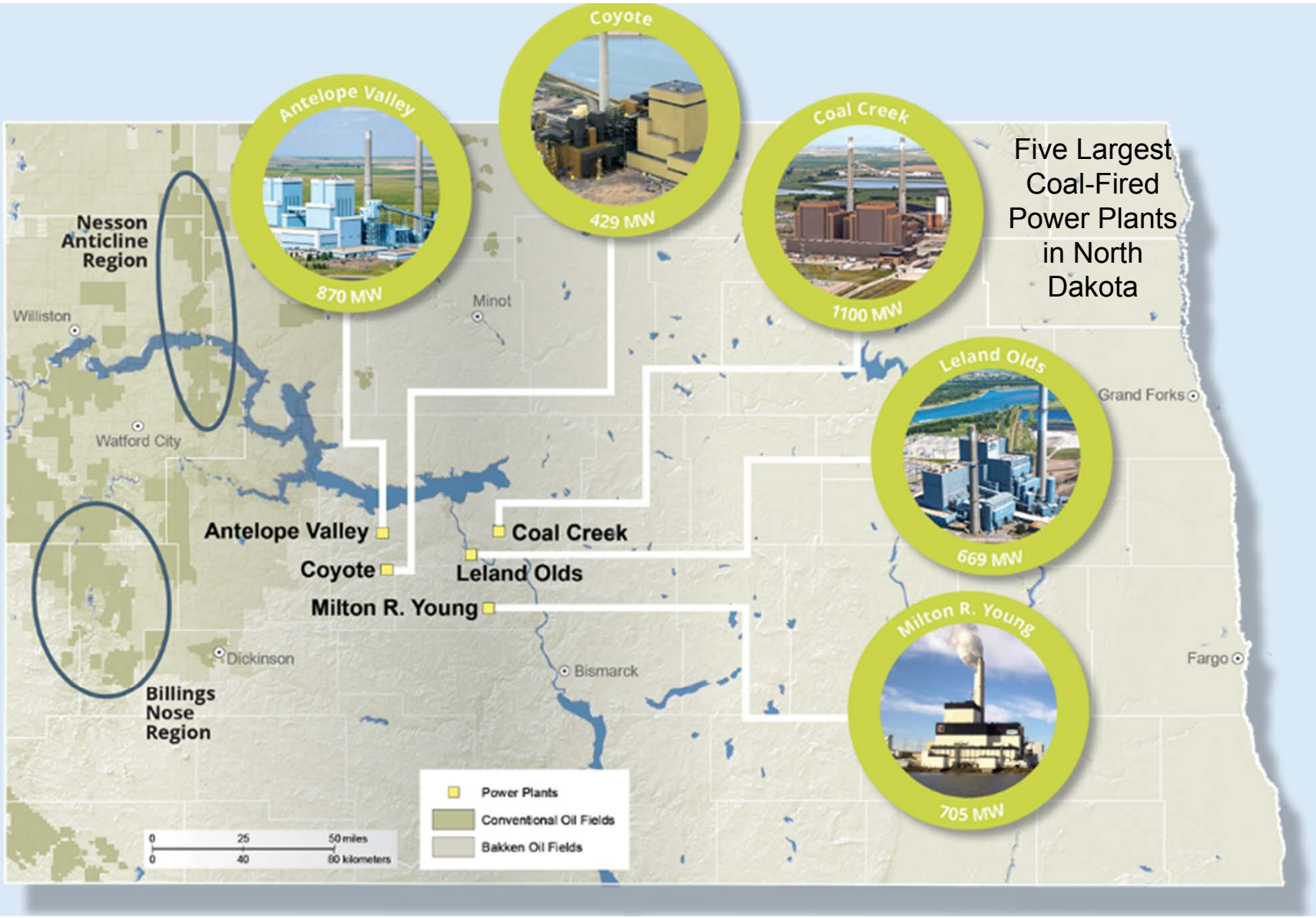
- Section 45Q incentives
- Minimized capture cost.
  - Studies show[1] the optimal capture rate is between 85% and 95% with conventional technology.
  - Project Carbon/Tundra is currently evaluating 95% capture with advanced technology.



[1]Stanislowski, J.J. et. al.; Support of DOE Carbon Capture Systems Development and Modeling; Draft Final Report; June 2018.

STUDY SCOPE

Circled areas represent 270 million barrels of potential incremental oil recovery through EOR.



Five Largest Coal-Fired Power Plants in North Dakota

CONVENTIONAL VS. BAKKEN

Conventional – This Study

- Total CO_2 production = 26 million tonne/year
- Oilfield CO_2 demand (circled areas) = 5 million tonne/year
- Percentage of CO_2 used for EOR = 19%
- Incremental oil production = 270,000,000 barrels
- Full potential for oilfield demand in North Dakota = 13 million tonne/year
- Full potential for incremental oil production = 1,000,000,000 barrels

Bakken/Three Forks – The Future!

- Oilfield CO_2 demand = 2–3.2 billion tons
- Potential incremental oil production = 4,000,000,000–7,000,000,000….or more!
- Based on NDIC OOIP estimates

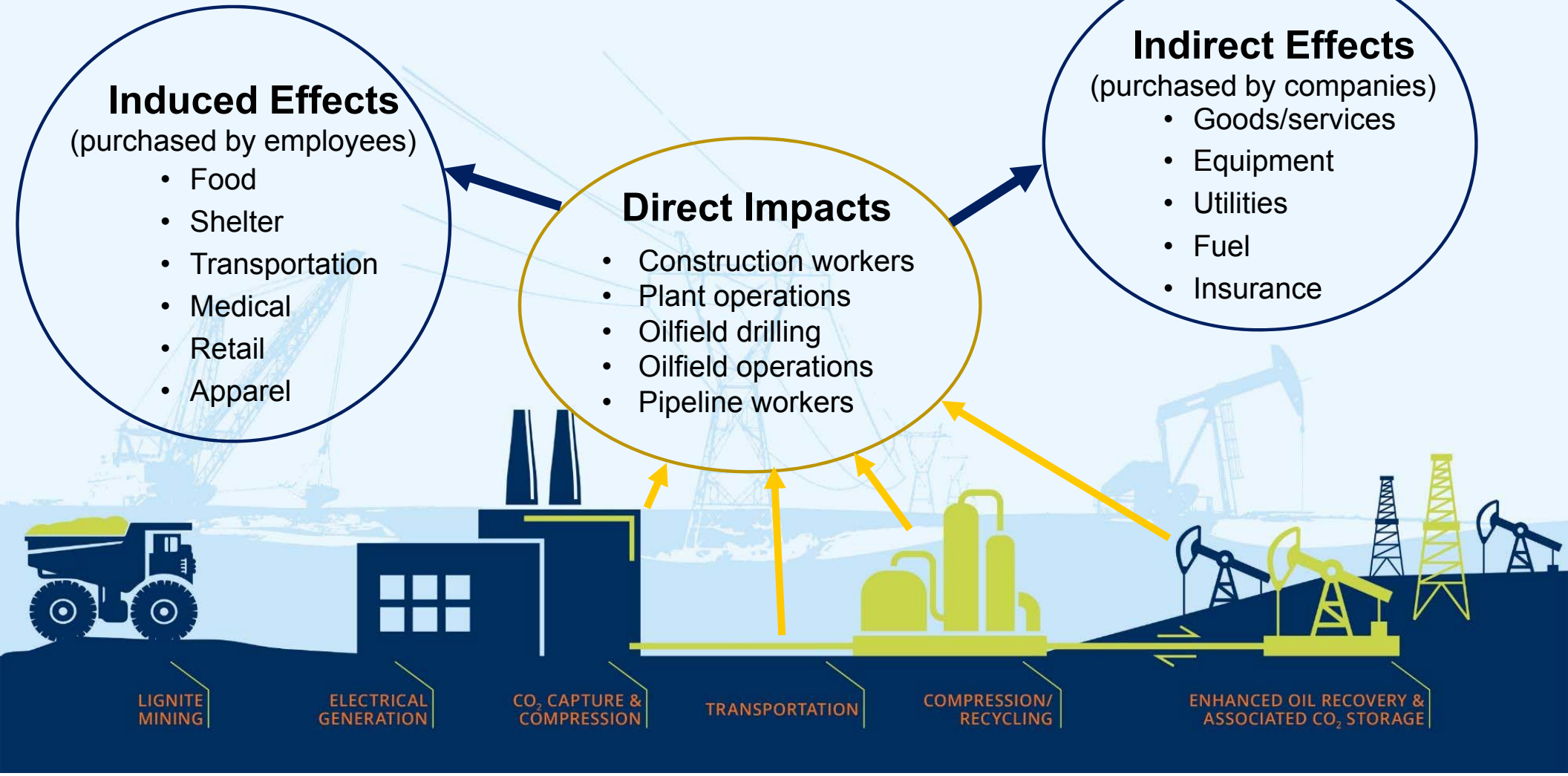
UNDERSTANDING ECONOMIC IMPACT ANALYSIS

- Direct effects—***jobs created*** by employees directly working on the new project
  - Example: construction worker pouring concrete foundations for a carbon capture facility.
- Indirect effects—***jobs created*** at companies that support the construction efforts
  - Example: a welder at a local machine shop producing components for the carbon capture facility
- Induced effects—***jobs created*** at businesses that support the local workforce

  Example: restaurant worker serving lunch to a construction crew

Direct + Indirect + Induced = Total Effect

ECONOMIC IMPACT ANALYSIS



LIGNITE INDUSTRY IMPACTS TODAY

- Studies released every two years by NDSU[1] 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
3,820

Secondary Jobs
10,200
(Indirect + Induced)

[1]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).

IMpact Analysis for PLANning (IMPLAN)

- The EERC used commercially available economic impact-modeling software to estimate overall economic impacts:
  - Based on input-output methodology
  - Includes government transfers (e.g., social security payments)
  - Allows customization
  - State model disaggregated into 536 sectors

IMPLAN
MAKE AN IMPACT.

Customized Impact Model (Bangsund, NDSU)

- Modified the default IMPLAN state-level model
  - Coal Mining and Coal-powered Electrical Generation sectors were re-built using NDSU data
  - CO_2 Capture added as a new industry sector allowing operational aspects of CO_2 capture plants to be linked to regional economy
  - CO_2 Transportation (pipelines) also added as a new industry sector
- CAPEX – modeling inputs adjusted to reflect in-state and out-of-state supply of labor and materials
- CO_2 EOR oil field development and operational expenses inconsistent with default IMPLAN data
  - Custom *industry spending patterns, labor income changes,* and *government revenue* factors linked ND CO_2 EOR oil field operations to modified impact model

KEY SCENARIO ASSUMPTIONS

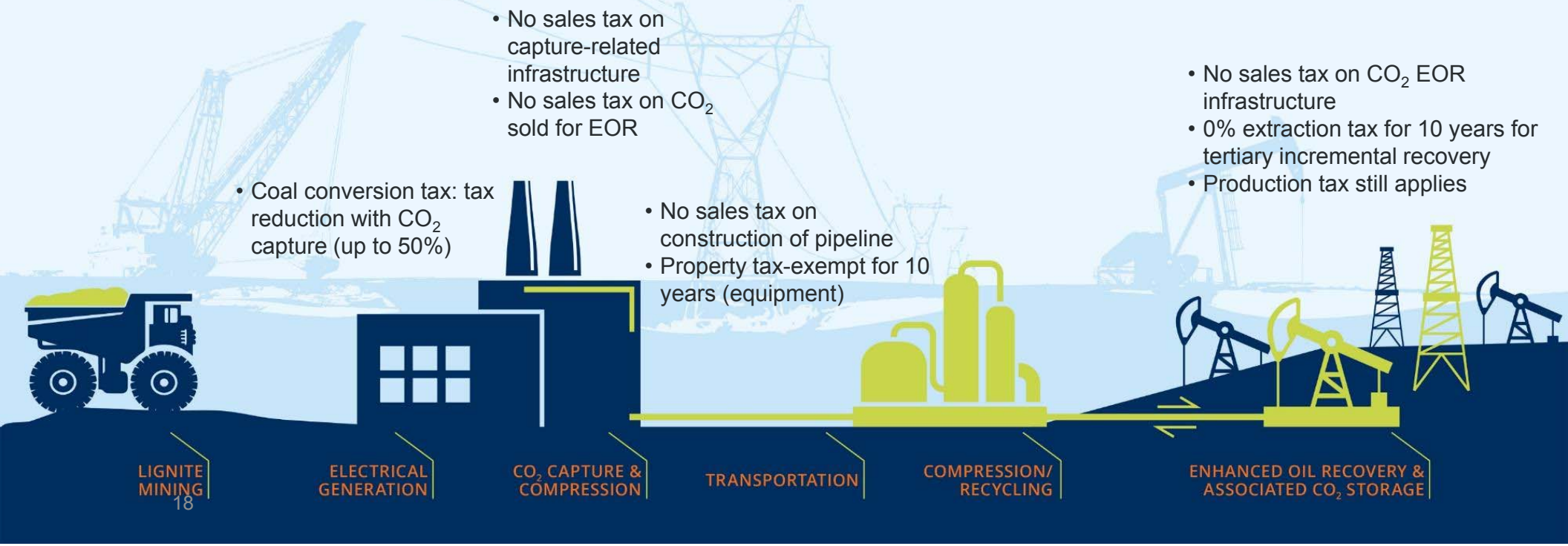
- 90% carbon capture from the five largest plants in North Dakota
- Only conventional fields (no Bakken/Three Forks…yet)
- CO_2 produced beyond oilfield demand stored geologically
- $60/barrel oil price

- Capture Plant
  - Auxiliary boiler used to produce steam for the capture unit
  - Baseline solvent (MEA)
- Pipeline
  - Trunk lines developed to transport CO_2 from the plants to the oil fields
- Oil Fields
  - Vertical wells at 80-acre spacing and a five-spot pattern
  - Recovery factor = 13.5% OOIP

EXISTING INCENTIVES FOR CO_2-BASED EOR

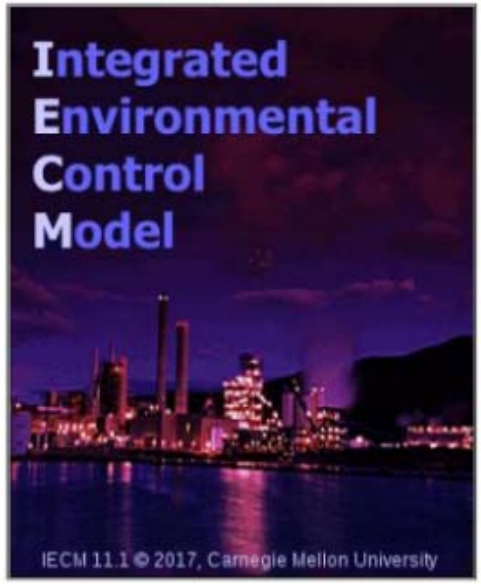
45Q

- 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.



EVALUATED 9 UNITS

Plant/Unit	Nameplate Capacity, MW_{net}	CO_2 Emissions, MMtons/yr
Unit 1	435	3.35
Unit 2	435	2.96
Unit 3	550	4.85
Unit 4	550	4.76
Unit 5	429	3.20
Unit 6	222	1.50
Unit 7	447	3.04
Unit 8	250	1.97
Unit 9	455	3.30
Totals	3773	28.9



IECM Model Produced by Carnegie Mellon University

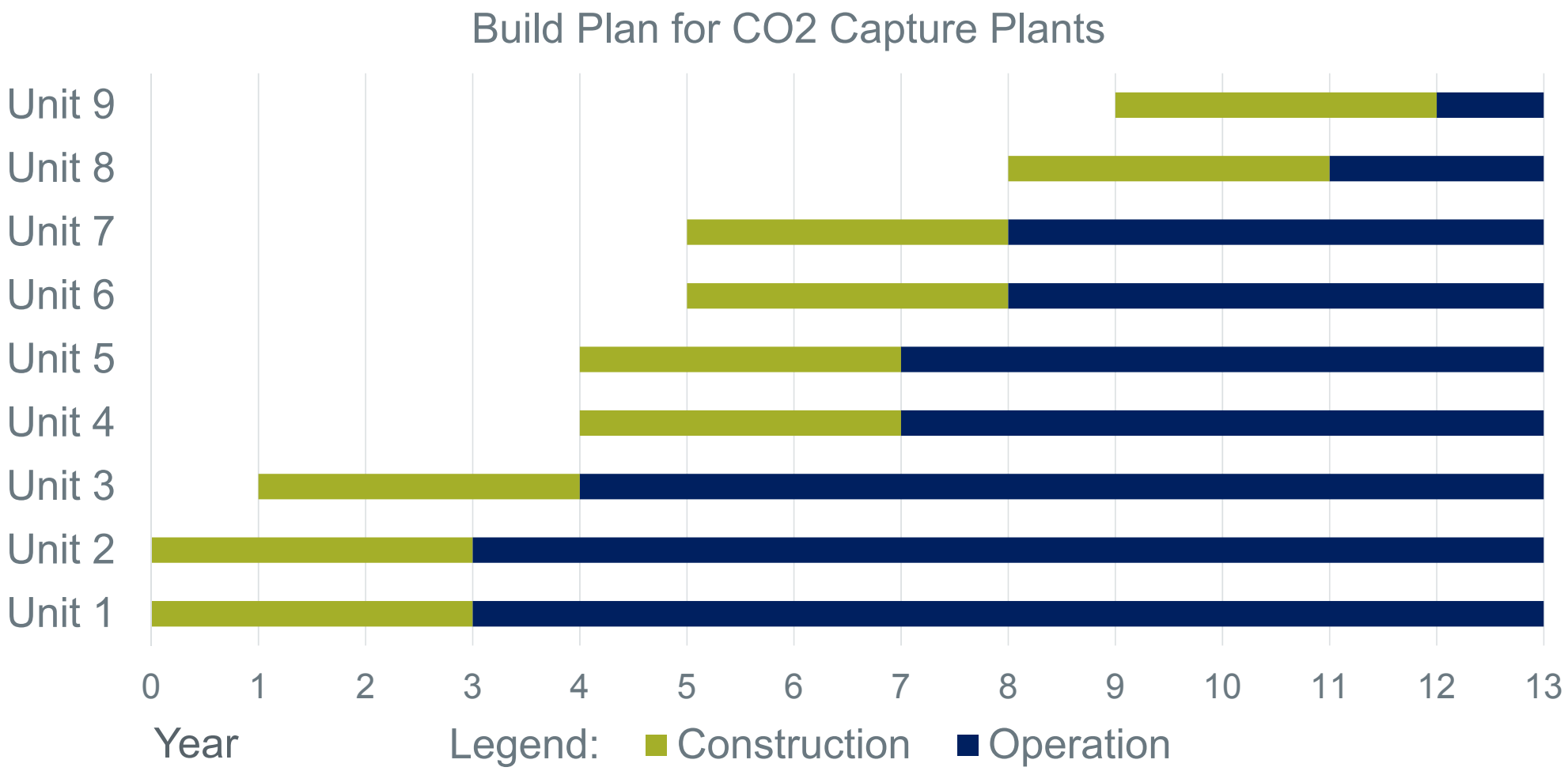
IECM ESTIMATE EXAMPLE

	Unit X
Baseline Plant Electrical Output, MW	417
Capture, No Auxiliary Boiler	
Plant Output, MW	277
CAPEX, $/kWnet	805
Capture, Auxiliary Boiler for Steam Only	
Plant Output, MW	369
CAPEX, $/kWnet	660
Capture, Auxiliary Boiler for Steam and Electricity	
Plant Output, MW	568
CAPEX, $/kWnet	743

CAPTURE PLANT CONSTRUCTION

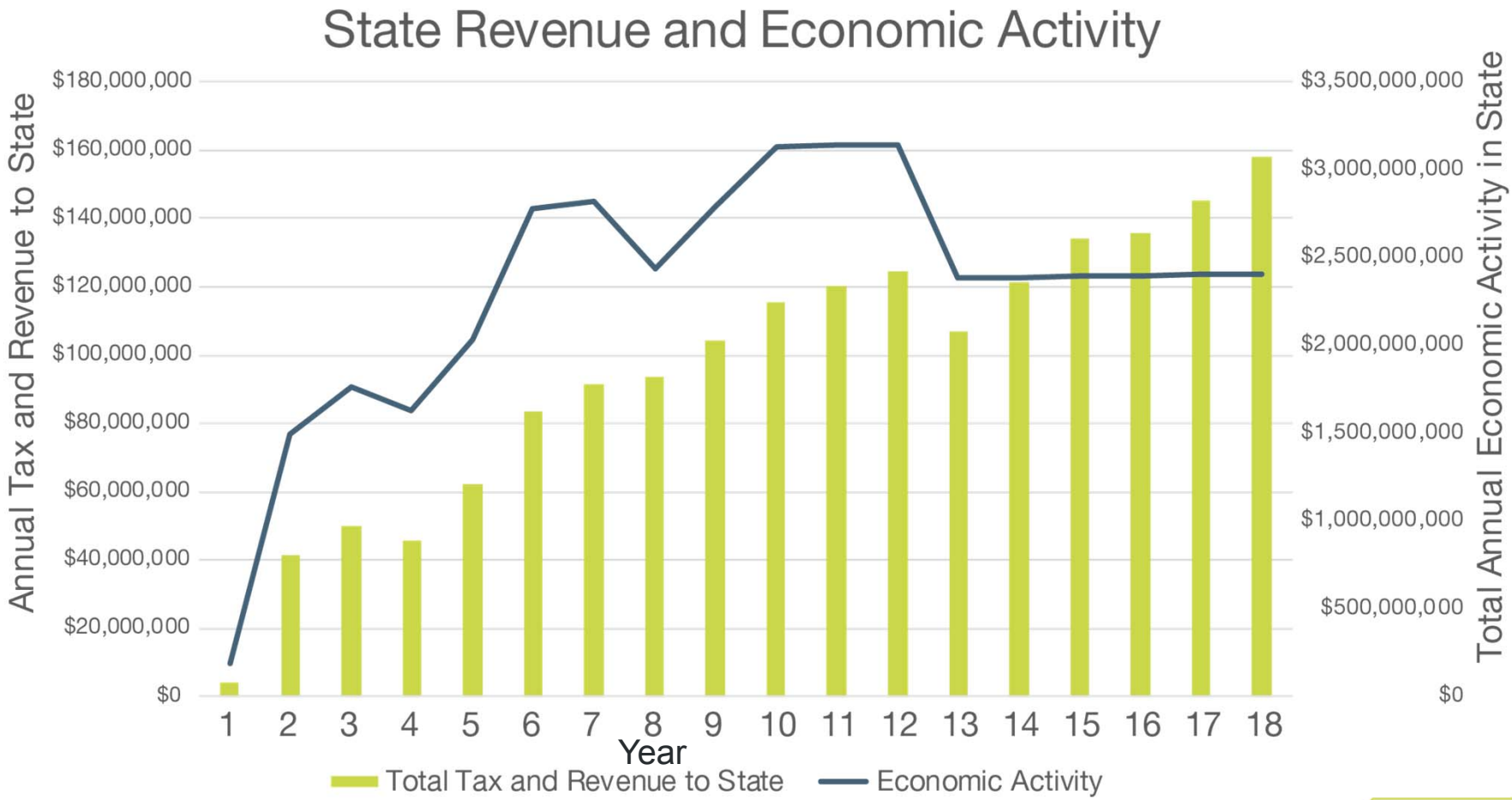
- The study assumes that a maximum of two capture plants could be built simultaneously in North Dakota.
- Additional construction activities for other plants could commence in a staged manner.
- Total of 12 years to build out the CO_2 capture infrastructure.
- Oilfields are also reworked for CO_2 EOR over a 12 year period.

It should be noted that these timeline estimates are for construction only after all required engineering and permitting is complete. Engineering and permitting could take several years for each plant prior to starting construction.

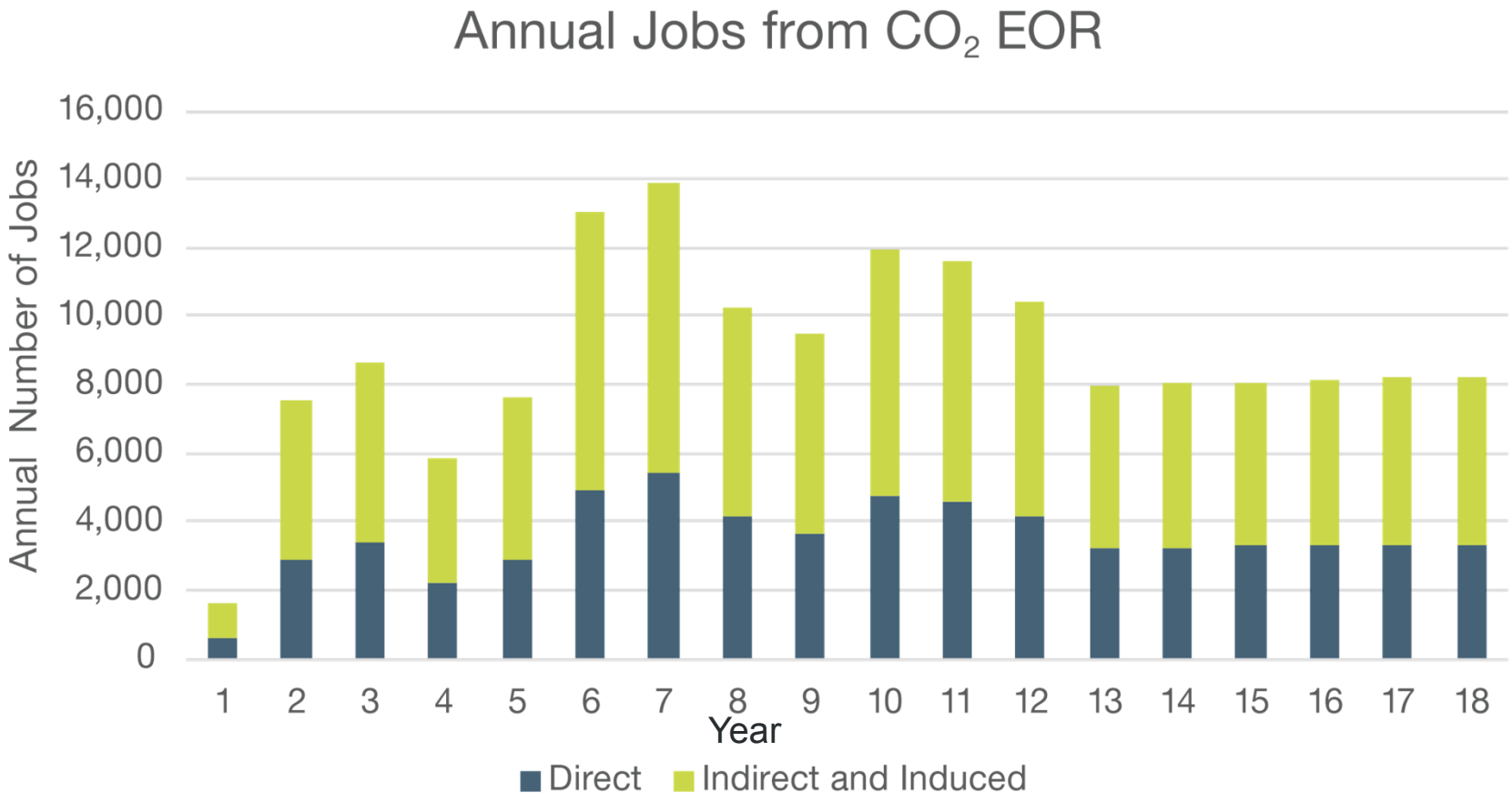


Note: 3-year estimates are for construction only after all required engineering and permitting is complete. Engineering and permitting could take several years for each plant prior to starting construction.

CO_2 CAPTURE AND EOR STATE TAX AND REVENUE



TOTAL JOB CREATION IN SCENARIO 1



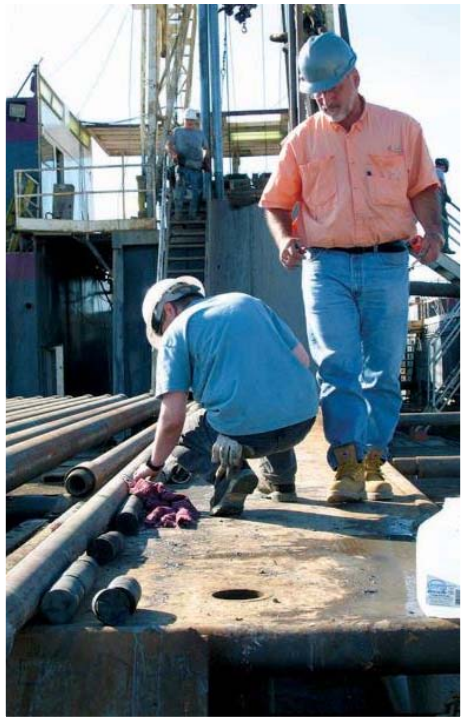
SCENARIO SUMMARY

- Carbon capture and EOR operations have the potential to significantly boost the economy in North Dakota.

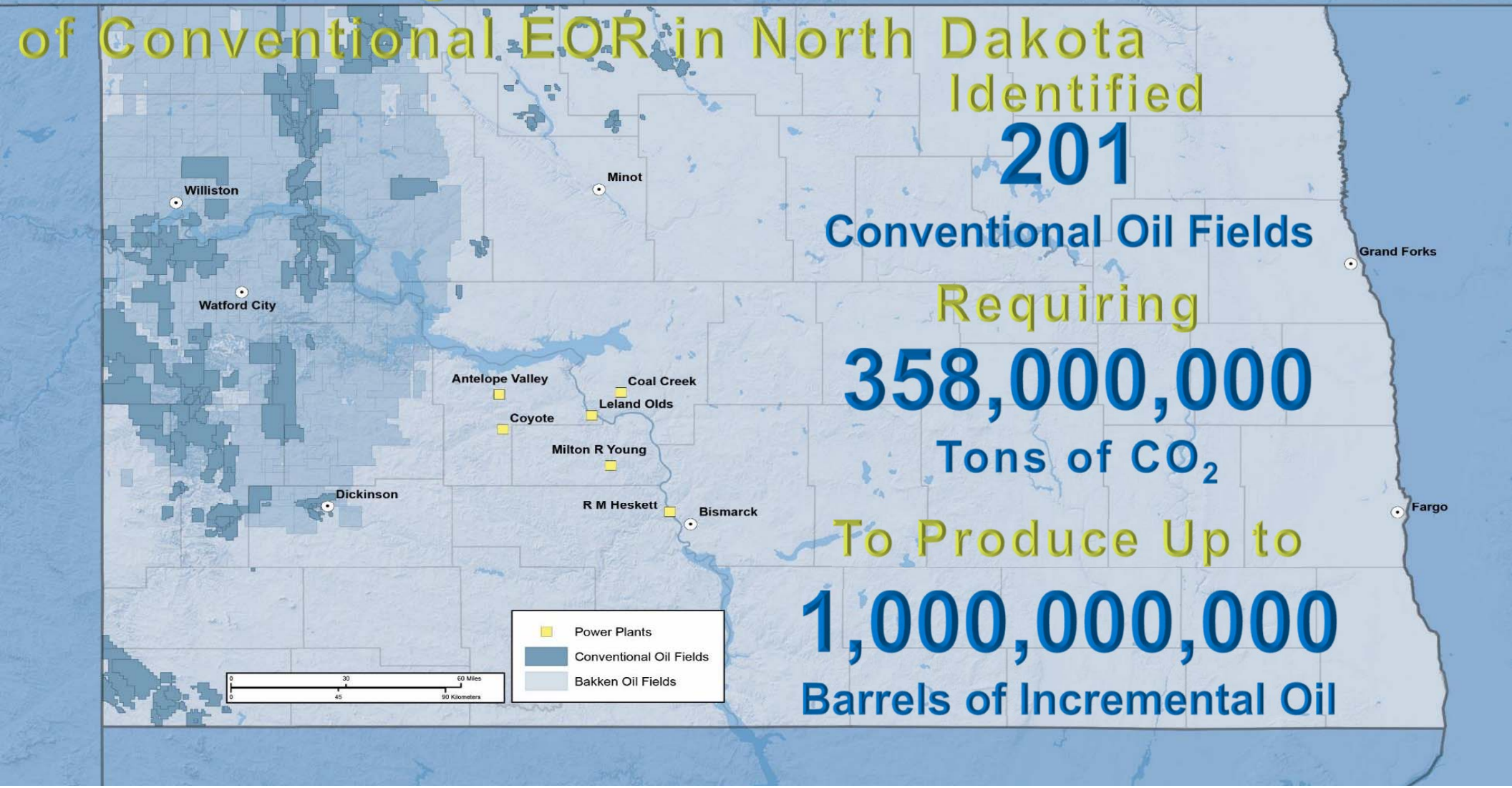
Total Annual Economic Activity
$2,500,000,000

Annual Taxes and Revenue
>$140,000,000

Annual Jobs
8,000



Unlocking the Full Potential of Conventional EOR in North Dakota



Identified

201

Conventional Oil Fields

Requiring

358,000,000

Tons of CO_2

To Produce Up to

1,000,000,000

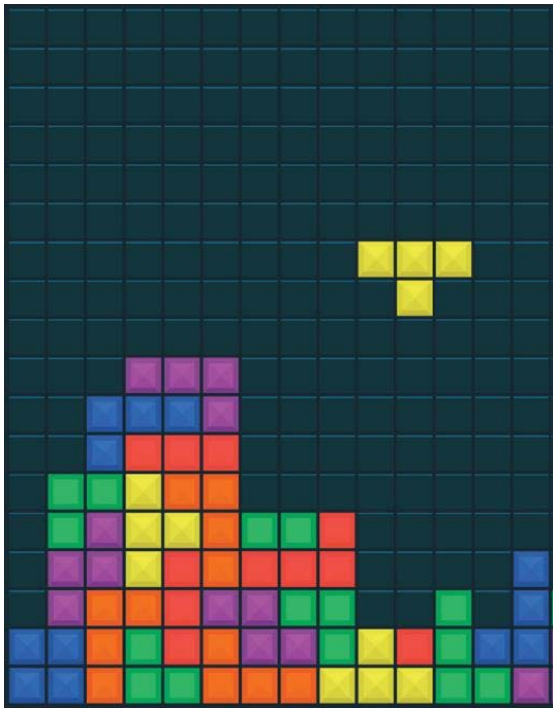
Barrels of Incremental Oil

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.

WHAT DOES IT ALL MEAN?

- From a high-level, long-term perspective, there is a positive outlook for CO_2 capture and EOR in North Dakota.
- Technology advancements (e.g., Project Tundra) can go a long way to making CCUS even more attractive.
- Resolving uncertainties in using 45Q credits will foster development.
- The benefits to the state if these technologies are deployed are very clear.



CONCLUSIONS

- The lignite industry has a significant economic impact on the state of North Dakota.
- Carbon capture will link the lignite industry to the oil industry, enhancing potential economic output for each sector.
- Implementation of CCUS technologies locally and nationally will result in substantial job creation while reducing emissions from our baseload generation units.

DOE DISCLAIMER

Acknowledgment

This material is based upon work supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory.

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