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

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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.
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.
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 CO₂ for economic benefit.
OVERVIEW OF CCUS STUDIES AT THE EERC

PROJECT TUNDRA

Evaluating a Specific Near Term Opportunity

Determining Economic Feasibility of CCUS

REGIONAL IMPACTS

Evaluating Potential Future Statewide CCUS Scenarios

CO₂ Capture Multiple Units

CO₂ Storage Targets

Determining Impacts to the State Including Job Creation and Tax Revenue
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

Existing Infrastructure

New Construction

Existing Infrastructure

Conventional Oil Fields

Coal Mines
Coal Power Plants

CO₂ Capture and Compression Facilities

CO₂ Pipelines

CO₂ Compression and Recycle Facilities

CO₂ Injection Wells

Linking the Industries
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.

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

Five Largest Coal-Fired Power Plants in North Dakota

STUDY SCOPE
CONVENTIONAL VS. BAKKEN

Conventional – This Study
• Total CO₂ production = 26 million tonne/year
• Oilfield CO₂ demand (circled areas) = 5 million tonne/year
• Percentage of CO₂ 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 CO₂ 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

Induced Effects
(purchased by employees)
- Food
- Shelter
- Transportation
- Medical
- Retail
- Apparel

Direct Impacts
- Construction workers
- Plant operations
- Oilfield drilling
- Oilfield operations
- Pipeline workers

Indirect Effects
(purchased by companies)
- Goods/services
- Equipment
- Utilities
- Fuel
- Insurance
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.

<table>
<thead>
<tr>
<th>Total Business Activity</th>
<th>$5,734,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Jobs</td>
<td>3,820</td>
</tr>
<tr>
<td>Secondary Jobs (Indirect + Induced)</td>
<td>10,200</td>
</tr>
</tbody>
</table>

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
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)
- CO₂ 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 CO₂ 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 CO₂-BASED EOR

- No sales tax on capture-related infrastructure
- No sales tax on CO₂ sold for EOR
- Coal conversion tax: tax reduction with CO₂ capture (up to 50%)

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 CO₂ EOR projects.
- Tax credit for CO₂ stored in a qualified EOR project is $15.29/tonne; increases annually to $35/tonne in 2026.

- No sales tax on CO₂ EOR infrastructure
- 0% extraction tax for 10 years for tertiary incremental recovery
- Production tax still applies
# EVALUATED 9 UNITS

<table>
<thead>
<tr>
<th>Plant/Unit</th>
<th>Nameplate Capacity, MW&lt;sub&gt;net&lt;/sub&gt;</th>
<th>CO&lt;sub&gt;2&lt;/sub&gt; Emissions, MMtons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>435</td>
<td>3.35</td>
</tr>
<tr>
<td>Unit 2</td>
<td>435</td>
<td>2.96</td>
</tr>
<tr>
<td>Unit 3</td>
<td>550</td>
<td>4.85</td>
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<tr>
<td>Unit 4</td>
<td>550</td>
<td>4.76</td>
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<tr>
<td>Unit 5</td>
<td>429</td>
<td>3.20</td>
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<td>Unit 6</td>
<td>222</td>
<td>1.50</td>
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<td>Unit 7</td>
<td>447</td>
<td>3.04</td>
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<td>Unit 8</td>
<td>250</td>
<td>1.97</td>
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<tr>
<td>Unit 9</td>
<td>455</td>
<td>3.30</td>
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<tr>
<td><strong>Totals</strong></td>
<td><strong>3773</strong></td>
<td><strong>28.9</strong></td>
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</table>

IECM Model Produced by Carnegie Mellon University
## IECM ESTIMATE EXAMPLE

<table>
<thead>
<tr>
<th></th>
<th>Unit X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Plant Electrical Output, MW</td>
<td>417</td>
</tr>
<tr>
<td><strong>Capture, No Auxiliary Boiler</strong></td>
<td></td>
</tr>
<tr>
<td>Plant Output, MW</td>
<td>277</td>
</tr>
<tr>
<td>CAPEX, $/kWnet</td>
<td>805</td>
</tr>
<tr>
<td><strong>Capture, Auxiliary Boiler for Steam Only</strong></td>
<td></td>
</tr>
<tr>
<td>Plant Output, MW</td>
<td>369</td>
</tr>
<tr>
<td>CAPEX, $/kWnet</td>
<td>660</td>
</tr>
<tr>
<td><strong>Capture, Auxiliary Boiler for Steam and Electricity</strong></td>
<td></td>
</tr>
<tr>
<td>Plant Output, MW</td>
<td>568</td>
</tr>
<tr>
<td>CAPEX, $/kWnet</td>
<td>743</td>
</tr>
</tbody>
</table>
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 CO₂ capture infrastructure.

• Oilfields are also reworked for CO₂ 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.
CO₂ CAPTURE AND EOR STATE TAX AND REVENUE

State Revenue and Economic Activity

Year

Total Annual Economic Activity in State

Annual Tax and Revenue to State

$0

$20,000,000

$40,000,000

$60,000,000

$80,000,000

$100,000,000

$120,000,000

$140,000,000

$160,000,000

$180,000,000

$0

$500,000,000

$1,000,000,000

$1,500,000,000

$2,000,000,000

$2,500,000,000

$3,000,000,000

$3,500,000,000
TOTAL JOB CREATION IN SCENARIO 1

Annual Jobs from CO₂ EOR

Year

Annual Number of Jobs

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Direct  Indirect and Induced
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 CO₂ To Produce Up to 1,000,000,000,000 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 CO₂ 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.
Acknowledgment

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