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Critical Challenges.

Practical Solutions.



Energy & Environmental Research Center (EERC)

TECHNO-ECONOMIC ASSESSMENT OF REGIONAL CARBON UTILIZATION SCENARIOS AND ATTENDANT MONITORING TECHNOLOGY

DE-FE0024233

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National Energy Technology Laboratory
Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration:
Carbon Storage and Oil and Natural Gas Technologies Review Meeting
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PRESENTATION OUTLINE

- Introduction
- Techno-economic study of the carbon value chain in North Dakota
- Collaboration with DOE on method development for CO₂ storage resource in ROZs
- Improved seismic processing workflow

TECHNO-ECONOMIC STUDY OF THE CARBON VALUE CHAIN IN NORTH DAKOTA

BACKGROUND

Address the need for a quantitative evaluation of the overall technical and economic impacts of the full carbon value chain in North Dakota.

CARBON VALUE CHAIN



PROJECT TEAM

- Energy & Environmental Research Center
- ALLETE Clean Energy
- BNI Coal
- Eagle Operating
- Minnkota Power Cooperative
- Lignite Energy Council
- North Dakota Petroleum Council
- North Dakota Department of Commerce
- U.S. Department of Energy (DOE) National Energy Technology Laboratory



U.S. DEPARTMENT OF
ENERGY



NATIONAL
ENERGY
TECHNOLOGY
LABORATORY



INDUSTRIAL COMMISSION OF NORTH DAKOTA
LIGNITE RESEARCH COUNCIL



Eagle Operating Inc.



PROJECT TIME LINE AND ACTIVITIES

- Duration: October 1, 2017 – March 31, 2019 (18 months)
- Activity 1 – CO₂ EOR Field Development
 - Select two North Dakota oil fields for CO₂ enhanced oil recovery (EOR) field development through a screening process that considers depth, API gravity, waterflood history, etc.
 - Determine the following for the two fields:
 - ◆ Costs associated with developing the necessary infrastructure for CO₂ EOR.
 - ◆ Costs associated with implementing monitoring, verification, and accounting (MVA) strategies for verification of CO₂ EOR storage.
 - ◆ The magnitude of increased energy needs necessary to deploy CO₂ EOR operations.
 - Evaluate economic impacts to North Dakota, including tax benefits and associated excise taxes.

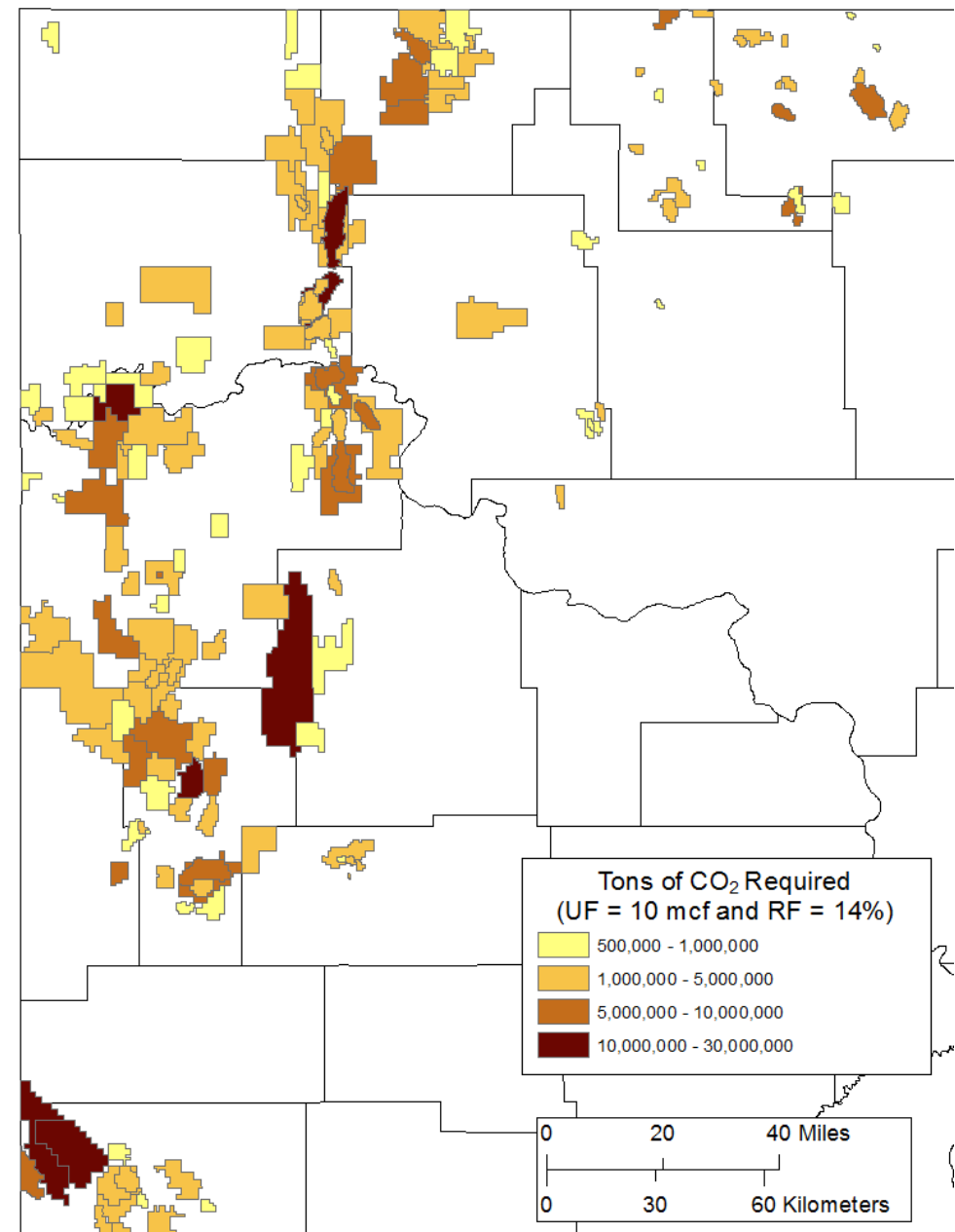
PROJECT ACTIVITIES

- Activity 2 – Data Integration
 - Integrate results from this project with those from concurrent and complementary carbon capture and storage (CCS) economic investigations at the EERC.
- Activity 3 – Life Cycle Analysis
 - Conduct a life cycle analysis to compare the carbon intensity value of oil produced through CO₂ EOR to non-EOR oil produced in North Dakota.
- Activity 4 – Business Case Scenario Analysis
 - Supported by North Dakota Department of Commerce



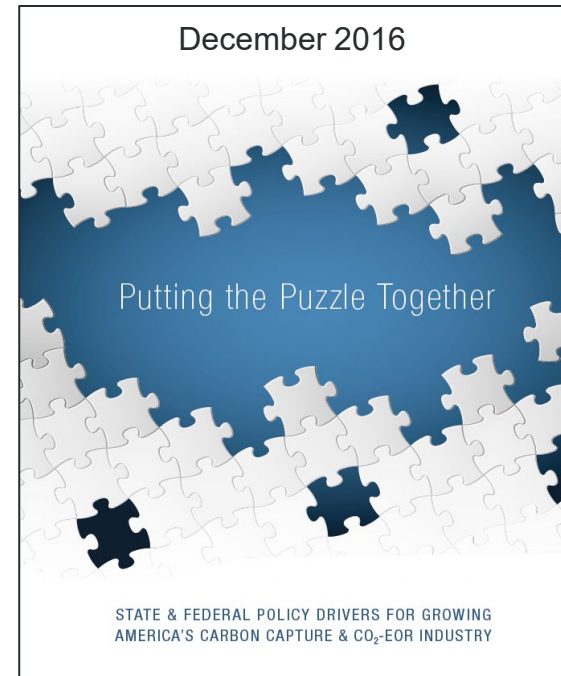
PROJECT ACTIVITIES

- Exploring two additional scenarios:
 - Select 19 fields from three production areas of North Dakota.
 - ◆ Assume a fixed annual capture amount.
 - ◆ Sequence the fields/phases to maximize tons CO₂/yr.
 - ◆ Integrate 45Q on the EOR and dedicated aspects of CO₂ storage.
 - Use all non-Bakken oil fields with minor screening criteria.
 - ◆ Assume demand = supply.
 - ◆ Represents upper limit of potential for conventional fields.



FEDERAL AND STATE INCENTIVES

- 45Q
- Section 43 (EOR tax credit)



Reductions in:

- Sales taxes on carbon capture or CO₂ EOR equipment.
- Property taxes associated with capture or CO₂ EOR.
- Oil taxes, such as production and/or severance taxes.

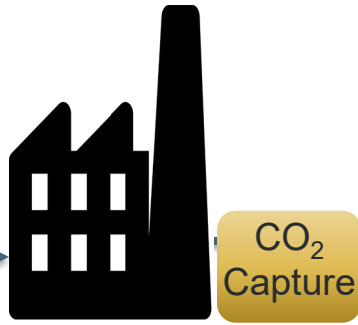
NORTH DAKOTA CO₂ VALUE CHAIN

45Q tax credit

- Who gets it?
- How does it get used?
- Who pays for MVA?

Coal Mining

- Severance tax
- Lignite research tax

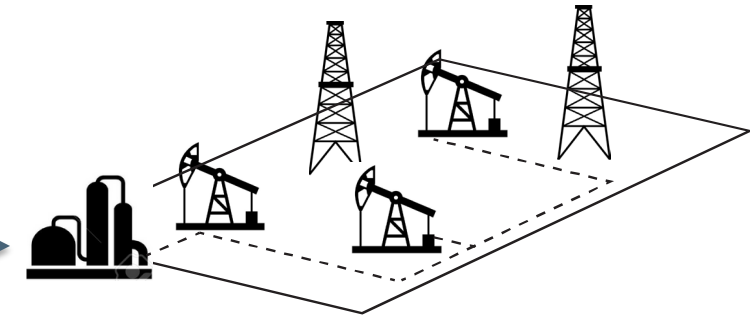


Pipeline

- No sales tax on construction of pipeline.
- Property tax-exempt for 10 years (equipment).
- Payment to counties (from ND) in lieu of taxes.

CO₂ Capture

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



Section 43 EOR tax credit

Field Development/Operation

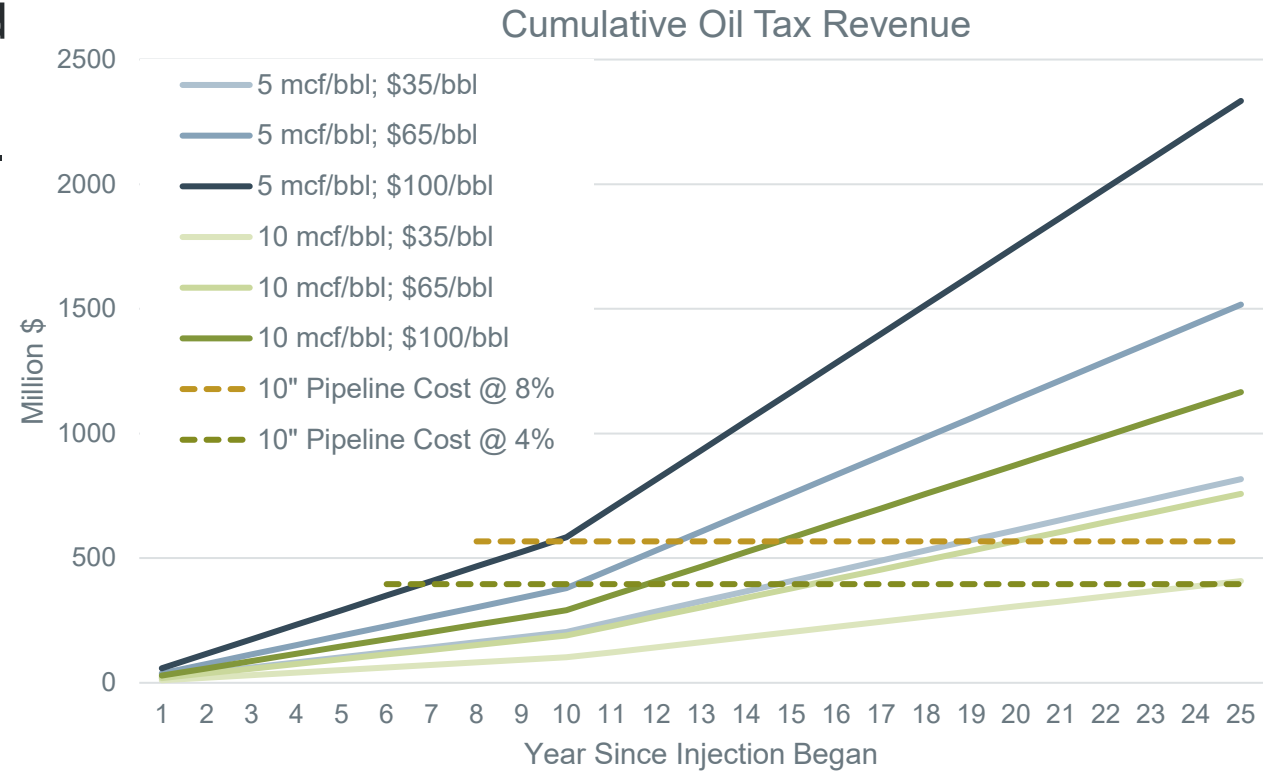
- New wells (injection and production).
- Rework existing wells.
- CO₂ separation/recycle/compression infrastructure: No sales tax on CO₂ EOR infrastructure.

Oil Production

- Extraction tax: 0% for 10 years for tertiary incremental recovery.
- Production tax still applies.

MOTIVATION

- Maintain/grow tax revenue from coal (~\$37M/yr).
- Maintain/grow tax revenue from jobs associated with the coal industry.
- Bolster conservation of resources (coal and oil).
- Plan for future massive CO₂ demand in the Bakken (it is coming).
- Grow state population.
- Additional tax incentives may be challenging to accept.
- State investment may be more palatable.



SUMMARY

- Accomplishments to date
 - Acquired data on field production and well status.
 - Fields selected for sequencing.
 - Established procedure for estimating infill drilling.
 - Subcontracts with UW and NDSU in place.
- Lessons learned
 - ND may be more open to investment rather than tax reductions.
- Synergy opportunities
 - CO₂ from ethanol plants can capitalize on these findings and support state investment.
 - Significant potential for CO₂ EOR from unconventional reservoirs will support investment in CO₂ capture.
- Project summary
 - Next steps
 - ◆ Incorporate pipeline and compressor/recycling costs.
 - ◆ Feed field sequencing data into economic models developed by UW and NDSU.
 - ◆ Compile interim report for ND legislators.
 - ◆ Finish the project.

IMPROVED SEISMIC PROCESSING WORKFLOW

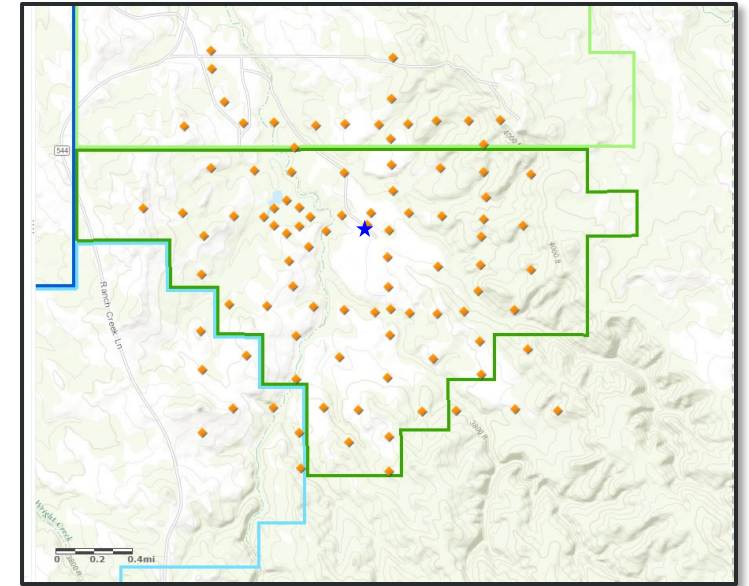
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INTRODUCTION

- Sparse surface array for monitoring injected carbon dioxide (CO₂): SASSA (scalable, automated, semipermanent seismic array)
- Advantages of SASSA
 - Rapid turn-around for data acquisition, processing, and interpretation
 - Low environmental impact
 - Considerably more economical than conventional arrays
- Main challenge
 - Noise attenuation
- Potential solutions
 - Seismic and ancillary data integration
 - Multidimensional noise attenuation

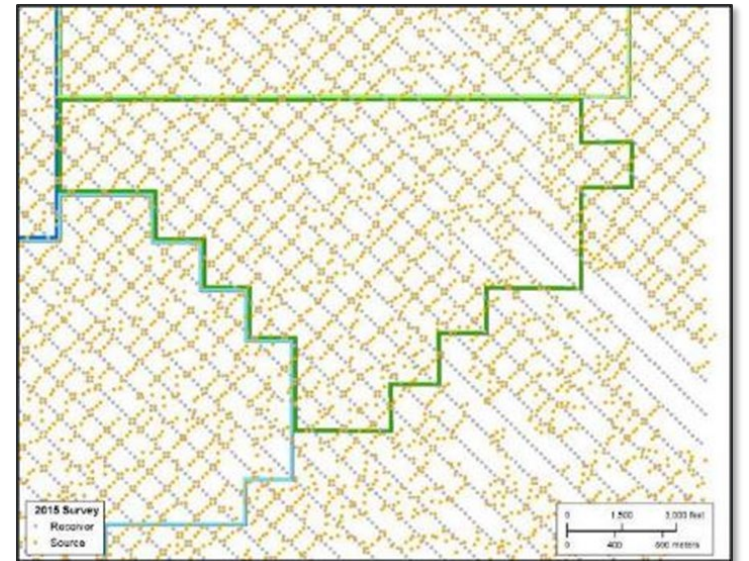
Sparse Array

- ★ Source
- ◆ Receiver



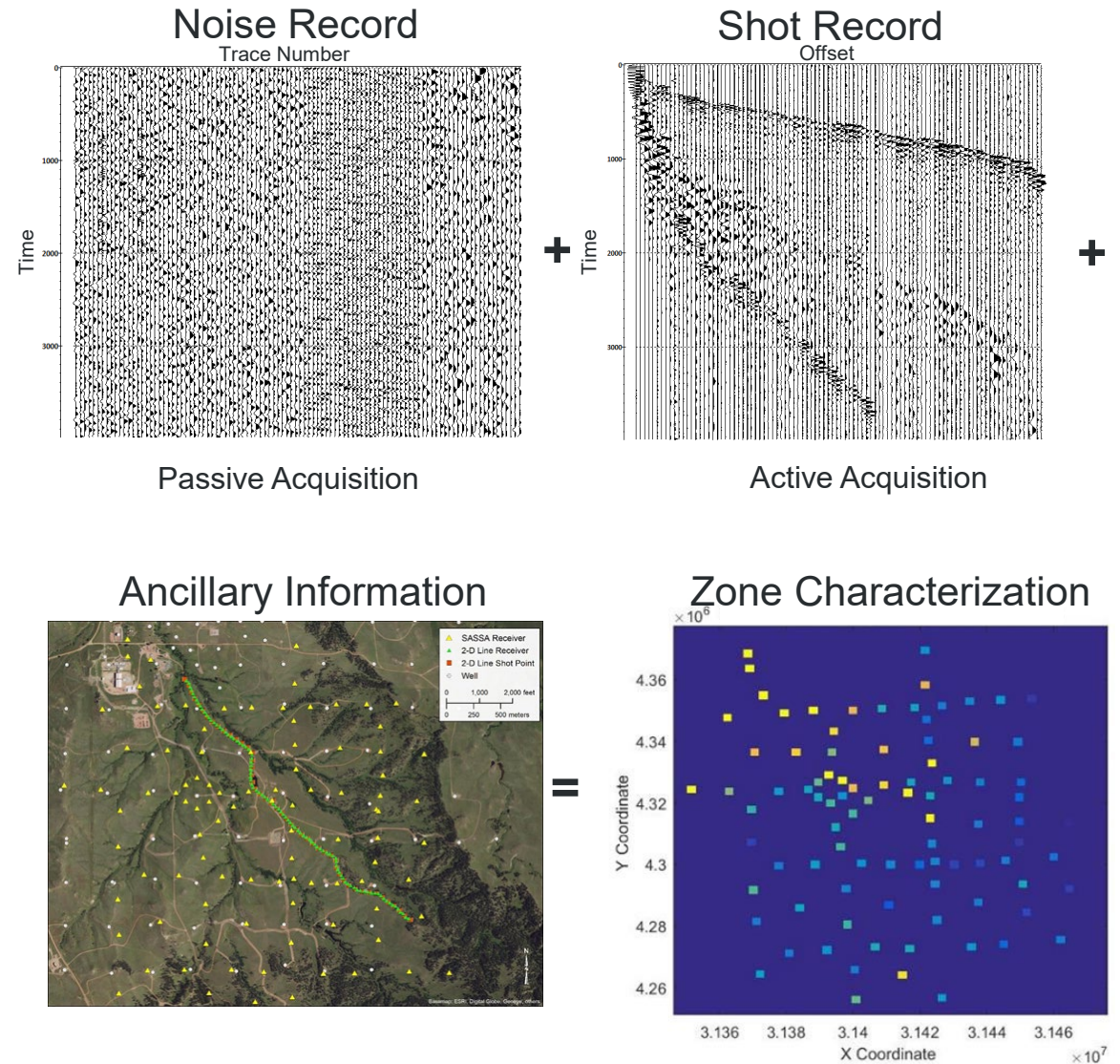
Conventional Array

- Source
- Receiver



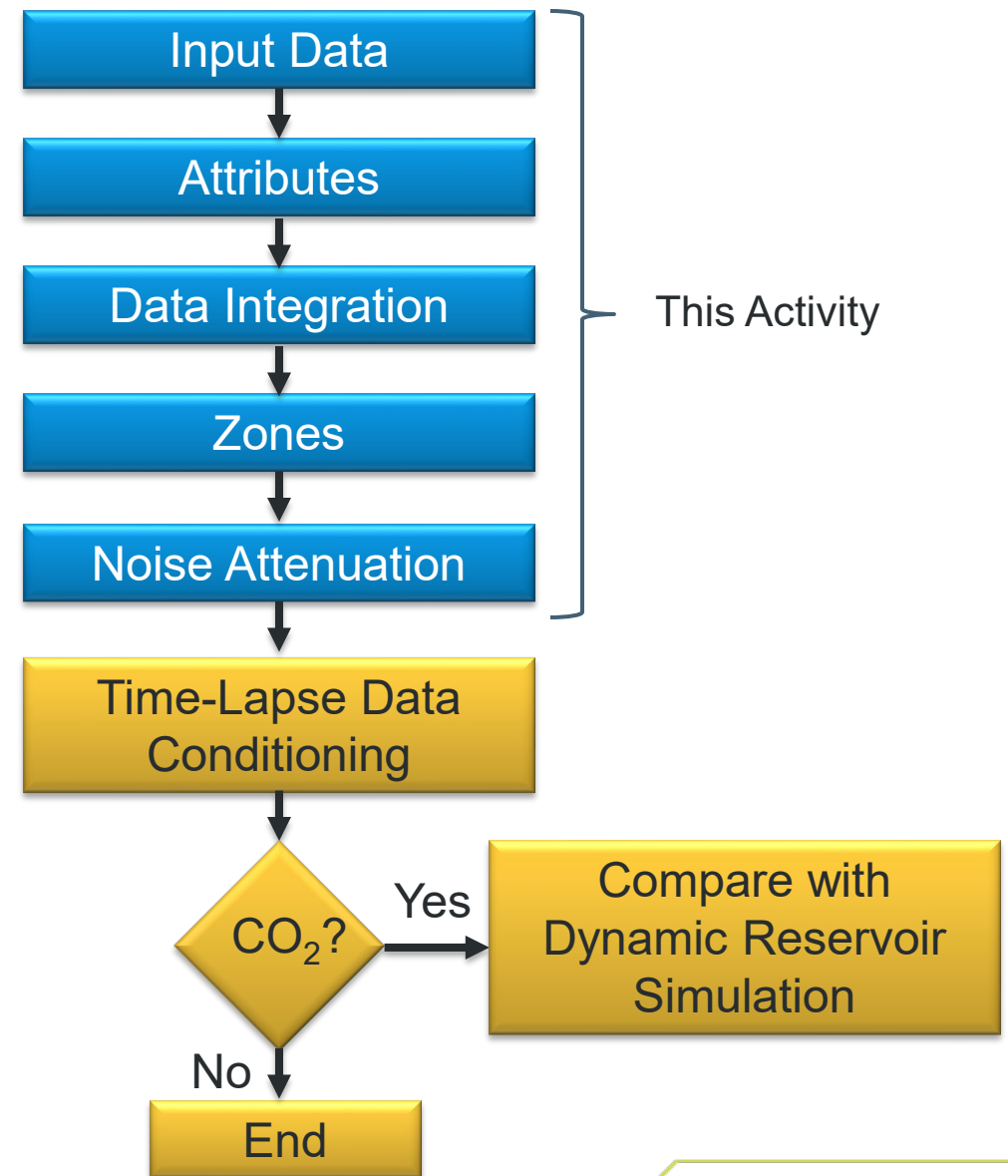
APPROACH

- Time-lapse seismic noise
 - Local anthropogenic sources
 - Near-surface conditions
 - Meteorological conditions
- Tools to assess noise conditions
 - Noise records before and after active seismic acquisition
 - Traces of active seismic survey
 - Satellite and surface geology maps
- Data-driven integration
- Time-lapse zone characterization
- Definition of noise attenuation workflow



KEY TASKS IN THIS ACTIVITY

- Attributes
 - Optimum prestack seismic attributes
 - Geological meaning of attributes from ancillary information
- Data-driven integration approach
 - Most appropriate machine learning algorithm
- Criterion for dimensionality of noise attenuation workflow
 - Most robust and simple method



SUMMARY

- Accomplishments to date
 - Software code for initial tests has been written.
- Lessons learned
 - Sparsity of data makes human interpretation of prestack seismic attributes more complicated.
- Synergy opportunities
 - CO₂ storage projects with permanent or semipermanent receiver arrays: Aquistore, Otway, Tomakomai
 - CO₂ storage projects with conventional arrays
- Project summary
 - Key findings
 - ◆ Most of the effort should be dedicated to attribute selection.
 - Next steps
 - ◆ Finalize software code for more extensive tests.
 - ◆ Define optimum attributes for seismic and ancillary data.
 - ◆ Select most appropriate machine learning algorithm.
 - ◆ Define noise attenuation workflow according to type of zones.

**COLLABORATION WITH DOE ON METHOD
DEVELOPMENT FOR CO₂ STORAGE
RESOURCE IN RESIDUAL OIL ZONES (ROZs)**

RESIDUAL OIL ZONES: CONSIDERATION OF RECOVERY AND UTILIZATION FACTORS

- Recovery factor (RF) for conventional tertiary CO₂ flood is applied to predevelopment original oil in place (OOIP).
- In ROZs, predevelopment OOIP is not the same, because ROZs have already been naturally waterflooded.
 - ROZ OOIP is analogous (?) to postwaterflood oil in place (OIP) in a conventional oil field.
- Application of a conventional OOIP-based RF has the potential to underestimate the amount of oil that can be recovered and resulting storage potential.

SUMMARY

- Accomplishments to date
 - Conference calls and a face-to-face meeting with the larger team to discuss approaches.
- Lessons learned
 - This is a challenging task with many variables to consider.
- Synergy opportunities
 - ROZs have a tremendous potential for associated CO₂ storage. An approach to define potential storage and incremental oil will provide additional leverage to develop a broader CO₂ EOR industry.
- Project summary
 - Next steps
 - ◆ Continue to work with DOE and the team to establish a method for estimating CO₂ storage and incremental oil from ROZs.

CONTACT INFORMATION

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THANK YOU!

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APPENDIX

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BENEFIT TO THE PROGRAM

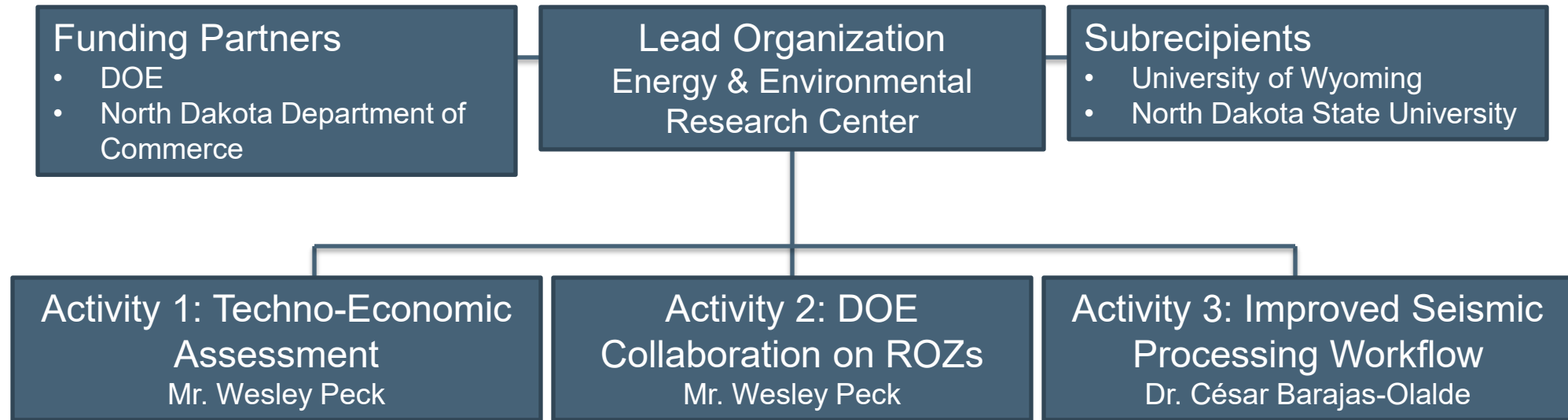
- These DOE cooperative agreement activities will support Goals 1 and 2 of the DOE Carbon Storage Program by generating new information to support 1) the development of future best practice manuals (BPMs) focused on well management activities and monitoring, verification, and accounting (MVA) and 2) industry's ability to predict CO₂ storage capacity in geologic formations to within ±30%.
- Specifically, the techno-economic assessment will yield information for possible future BPMs that enables industry and regulatory decision makers to develop cost-effective plans for broad deployment and management of commercial-scale CO₂ injection wells and MVA technologies in the context of the CO₂ life cycle associated with CO₂-based EOR.

PROJECT OVERVIEW

GOALS AND OBJECTIVES

- Assess the regional techno-economic life cycle of CO₂ EOR in North Dakota, quantify prospective CO₂ storage resource in ROZs, and develop new techniques for monitoring geologic CO₂ storage.
- The three activities proposed in this subtask specifically address two strategic goals enumerated in the DOE–EERC Cooperative Agreement, namely, 1) to advance foundational science and 2) to inform data-driven policies that enhance U.S. economic growth and job creation, energy security, and environmental quality.
- Success criteria:
 - A techno-economic assessment of implementing lignite-based CO₂ EOR in North Dakota will be developed and reported to stakeholders.
 - The steps needed to define a prospective CO₂ storage resource method applicable to ROZs will be established.
 - New seismic processing workflows capable of improving the time-lapse detection of CO₂ from sparse seismic array acquisitions will be disseminated.

ORGANIZATION CHART



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Period of Performance: October 1, 2017 – March 31, 2019

Year	2017			2018												2019		
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Activity 1 – Techno-Economic Assessment of Implementing Lignite-Based CO ₂ EOR in North Dakota			M1 ◆										M3 ◆					
Activity 2 – Collaboration with DOE on CO ₂ Storage in ROZs			M2 ◆															
Activity 3 – Improved Seismic Processing Workflow														M4 ◆				

◆ = Milestone.