EERC

UNIVERSITY OF NORTH DAKOTA

Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

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

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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

August 13–16, 2018

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PROJECT FRAMEWORK

Three pieces:

- Techno-economic study of the carbon value chain in North Dakota
- Collaboration with DOE on method development for CO_2 storage resource in ROZs
- Improved seismic processing workflows to address noise attenuation

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

Upstream

Lignite Mining
and
Power Generation

Transportation

Downstream

CO_2 EOR
and
Associated CO_2 Storage

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
- North Dakota State University
- University of Wyoming
- U.S. Department of Energy (DOE) National Energy Technology Laboratory

INDUSTRIAL COMMISSION OF NORTH DAKOTA
LIGNITE RESEARCH COUNCIL

Eagle Operating Inc.

PROJECT TIMELINE AND KEY ACTIVITIES

- Duration: October 1, 2017 – March 31, 2019 (18 months)

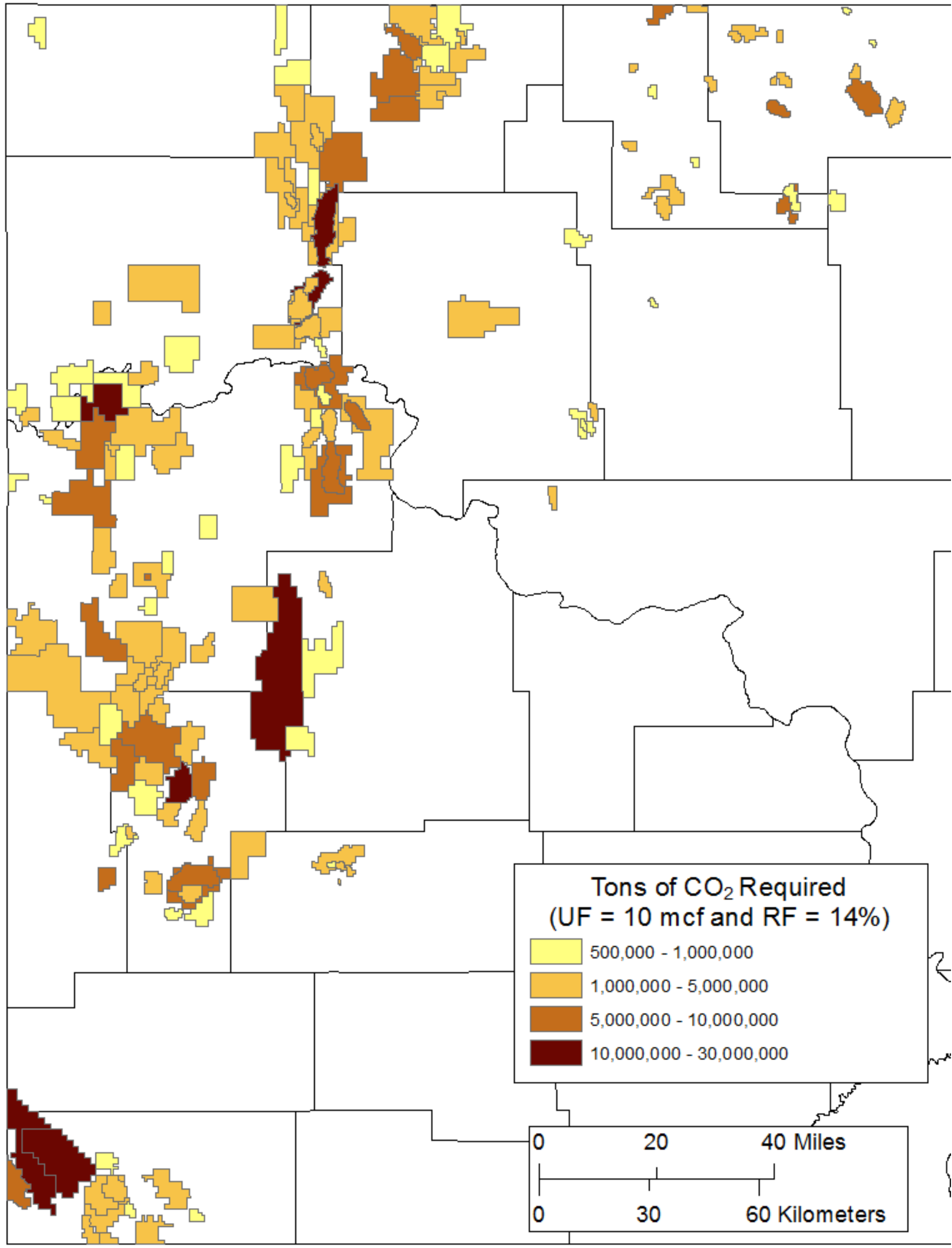
- CO_2 EOR Field Development
  - Determine the following:
    - ♦ Costs associated with developing the necessary infrastructure for CO_2 EOR.
    - ♦ Costs associated with implementing monitoring, verification, and accounting (MVA) strategies for verification of CO_2 EOR storage.
    - ♦ The magnitude of increased energy needs necessary to deploy CO_2 EOR operations.
    - ♦ Evaluate economic impacts to North Dakota, including potential impacts of tax incentives.

KEY PROJECT ACTIVITIES

- Data Integration
  - Integrate results from this project with those from concurrent and complementary carbon capture and storage (CCS) economic investigations at the EERC.
- Business Case Scenario Analysis
  - Supported by North Dakota Department of Commerce

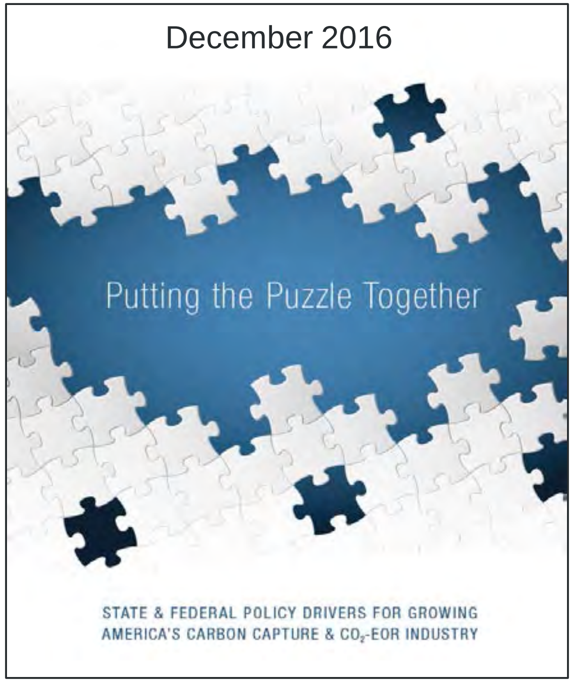
BASIC APPROACH

- Exploring scenarios:
  - Use nearly all non-Bakken oil fields (minor screening) criteria.
    - ♦ Assume a fixed annual capture amount.
    - ♦ Sequence the fields/phases to maximize tons CO_2/yr.
    - ♦ Integrate 45Q on the EOR and dedicated aspects of CO_2 storage.
    - ♦ Represents upper limit of potential for conventional fields.



FEDERAL AND STATE INCENTIVES

- 45Q ($35/tonne tax credit)
- Section 43 (EOR tax credit)



State CO_2 EOR Deployment Work Group

Reductions in:

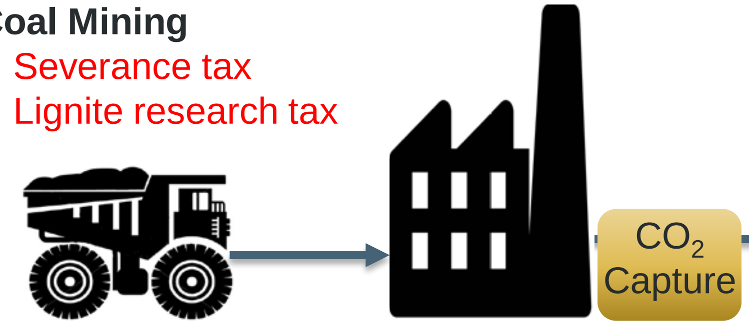
- Sales taxes on carbon capture or CO_2 EOR equipment.
- Property taxes associated with capture or CO_2 EOR.
- Oil taxes, such as production and/or severance taxes.

NORTH DAKOTA CO_2 VALUE CHAIN

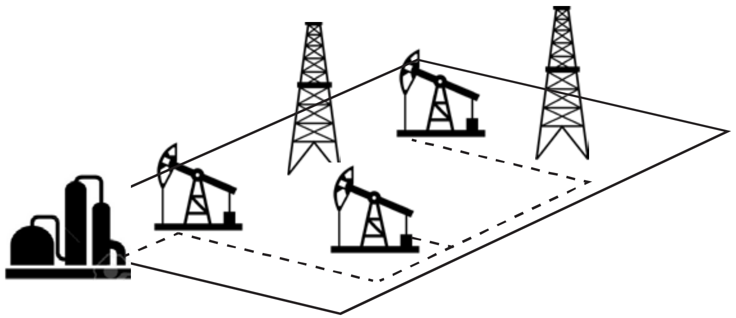
45Q tax credit
- Who gets it?
- How does it get used?
- Who pays for MVA?

Section 43 EOR tax credit

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.



CO_2 Capture
- Coal conversion tax: tax reduction with CO_2 capture (up to 50%).
- No sales tax on capture-related infrastructure.
- No sales tax on CO_2 sold for EOR.

Field Development/Operation
- New wells (injection and production).
- Rework existing wells.
- CO_2 separation/recycle/compression infrastructure: No sales tax on CO_2 EOR infrastructure.

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

STATE MOTIVATION

- Maintain/grow tax revenue from coal (~$37M/yr).
- Grow state revenue from legacy oil fields.
- Maintain/grow tax revenue from jobs associated with the coal and oil industries.
- Bolster conservation of resources (coal and oil).
- Plan for future massive CO_2 demand in the Bakken (it is coming).
- Grow state population.

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
  - Strong state support.
  - Fine balance between the state’s appetite for investment and tax reduction.

- Synergy opportunities
  - CO_2 from ethanol plants can capitalize on these findings and support state investment.
  - Significant potential for CO_2 EOR from unconventional reservoirs will support investment in CO_2 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.

CONTACT INFORMATION

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THANK YOU!


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APPENDIX

IMPROVED SEISMIC PROCESSING WORKFLOW

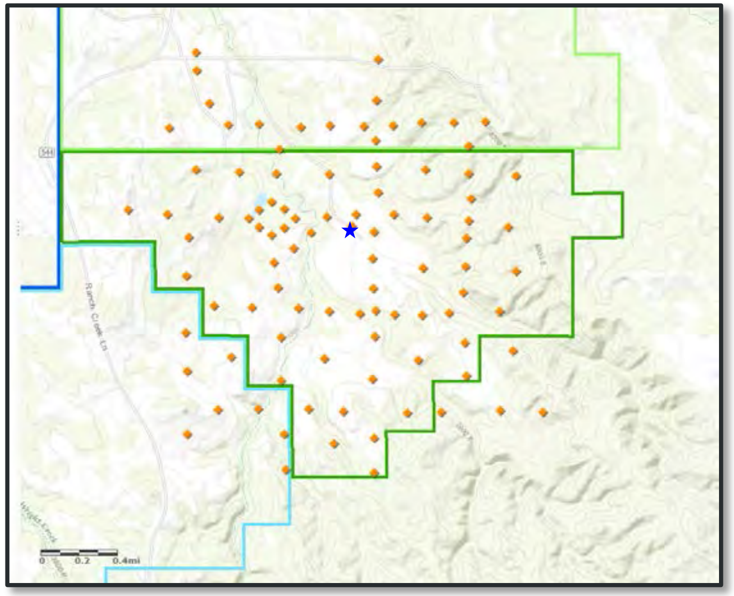
Critical Challenges. **Practical Solutions.**

INTRODUCTION

- Sparse surface array for monitoring injected carbon dioxide (CO_2): 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

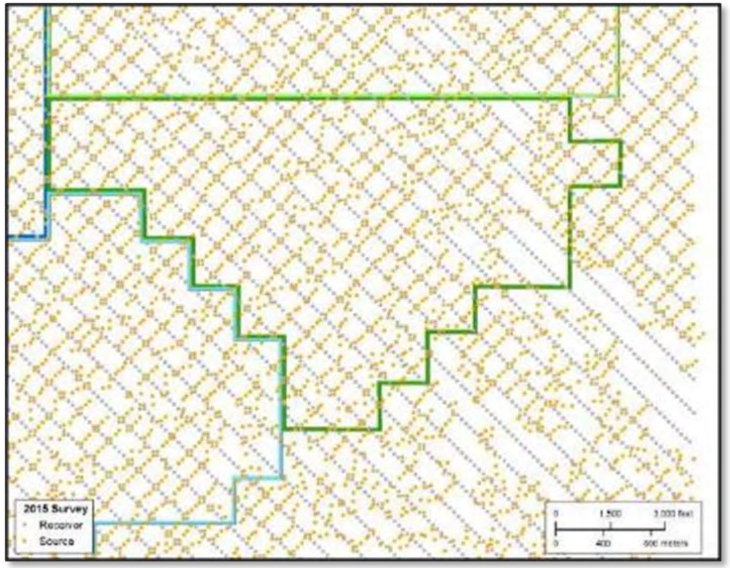
Sparse Array

★ Source
◆ Receiver



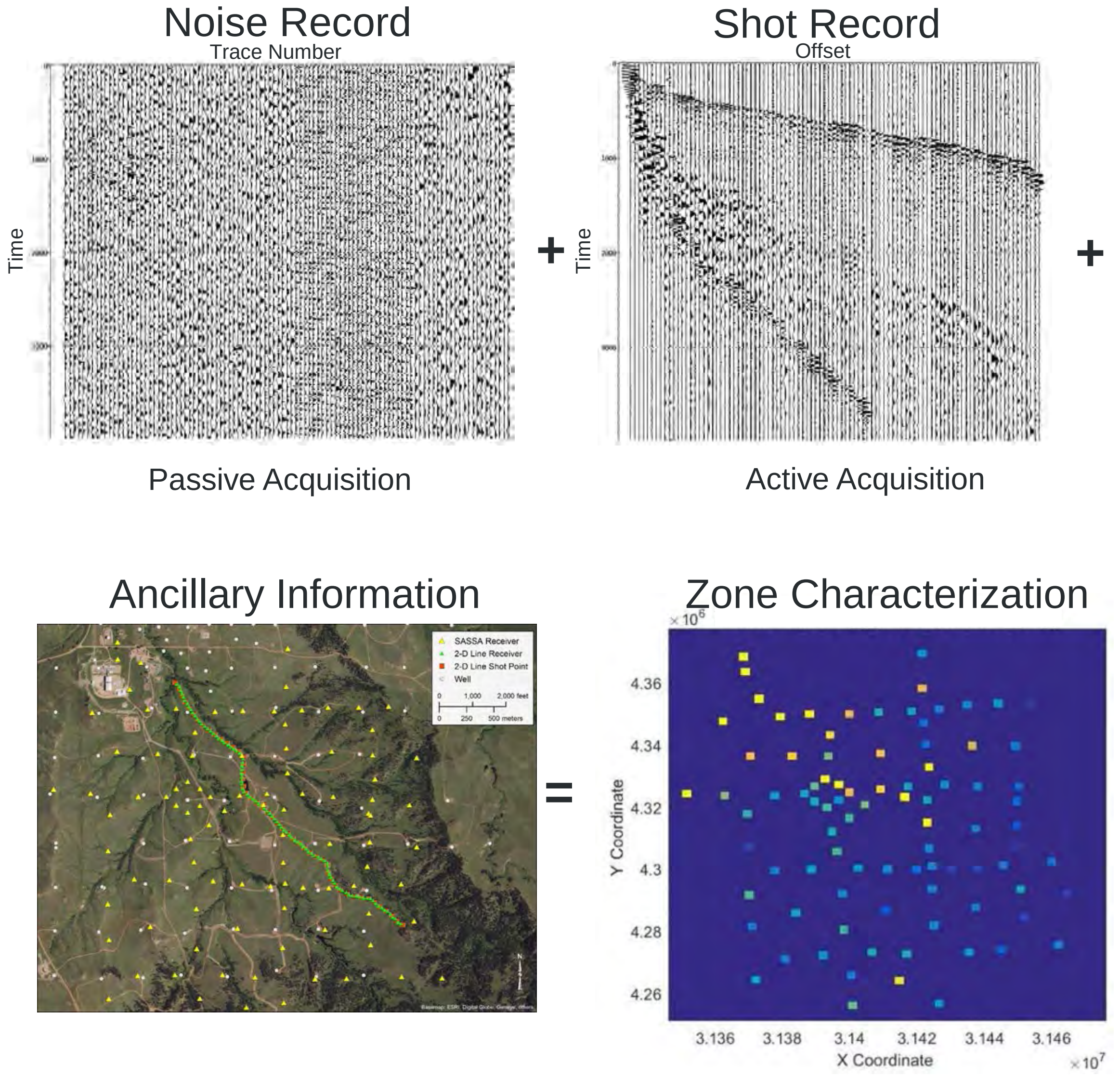
Conventional Array

● Source
● Receiver



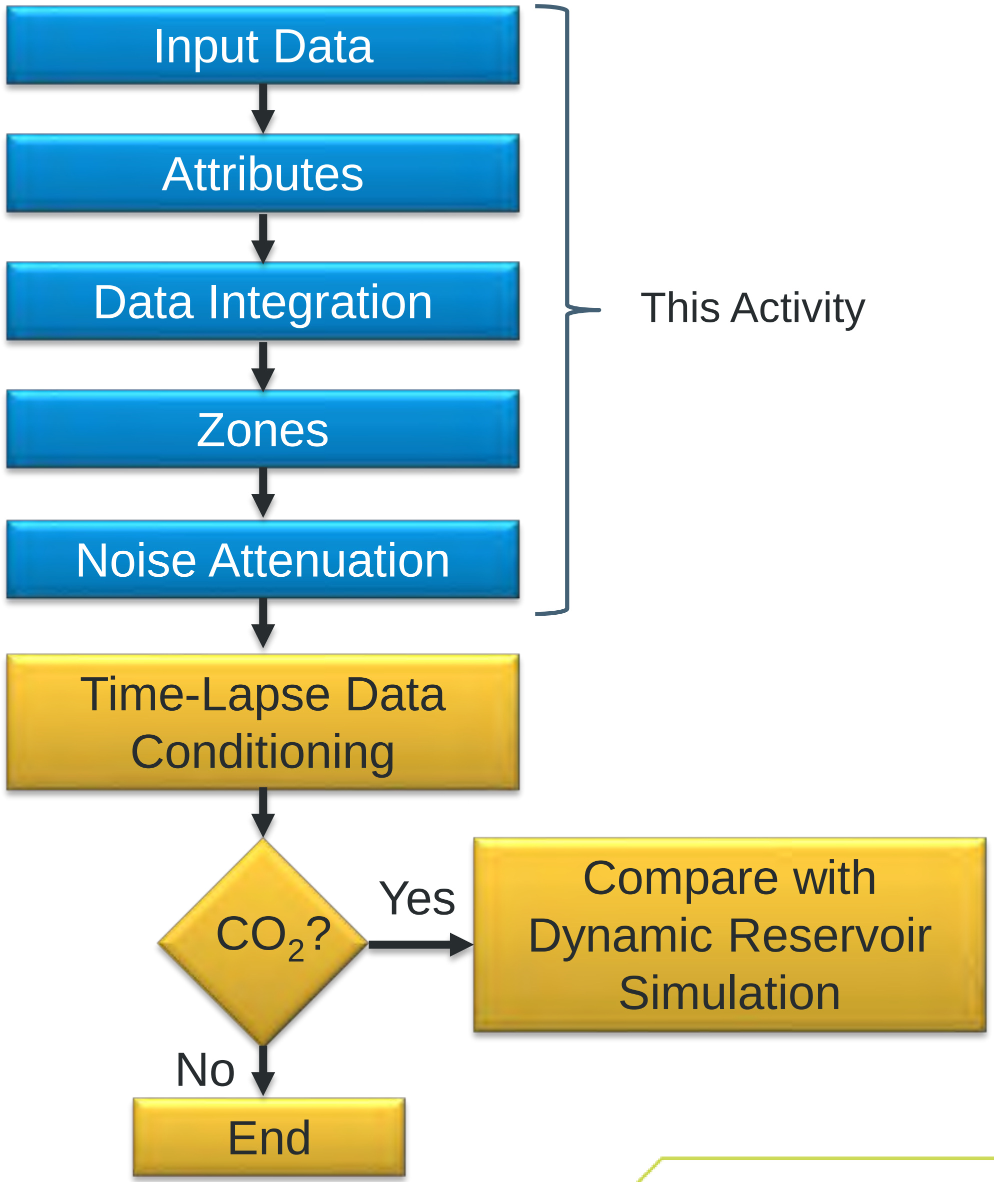
APPROACH

- 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
  - CO_2 storage projects with permanent or semipermanent receiver arrays: Aquistore, Otway, Tomakomai
  - CO_2 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 CO_2 STORAGE RESOURCE IN RESIDUAL OIL ZONES (ROZs)

RESIDUAL OIL ZONES: CONSIDERATION OF RECOVERY AND UTILIZATION FACTORS

- Recovery factor (RF) for conventional tertiary CO_2 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 CO_2 storage. An approach to define potential storage and incremental oil will provide additional leverage to develop a broader CO_2 EOR industry.
- Project summary
  - Next steps
    - ♦ Continue to work with DOE and the team to establish a method for estimating CO_2 storage and incremental oil from ROZs.

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 CO_2 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 CO_2 injection wells and MVA technologies in the context of the CO_2 life cycle associated with CO_2-based EOR.

PROJECT OVERVIEW

GOALS AND OBJECTIVES

- Assess the regional techno-economic life cycle of CO_2 EOR in North Dakota, quantify prospective CO_2 storage resource in ROZs, and develop new techniques for monitoring geologic CO_2 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 CO_2 EOR in North Dakota will be developed and reported to stakeholders.
  - The steps needed to define a prospective CO_2 storage resource method applicable to ROZs will be established.
  - New seismic processing workflows capable of improving the time-lapse detection of CO_2 from sparse seismic array acquisitions will be disseminated.

ORGANIZATION CHART

Funding Partners
- DOE
- North Dakota Department of Commerce

Lead Organization
Energy & Environmental Research Center

Subrecipients
- University of Wyoming
- North Dakota State University

Activity 1: Techno-Economic Assessment
Mr. Wesley Peck

Activity 2: DOE Collaboration on ROZs
Mr. Wesley Peck

Activity 3: Improved Seismic Processing Workflow
Dr. César Barajas-Olalde

GANTT CHART

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.