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Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

SUBTASK 1.3 – INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

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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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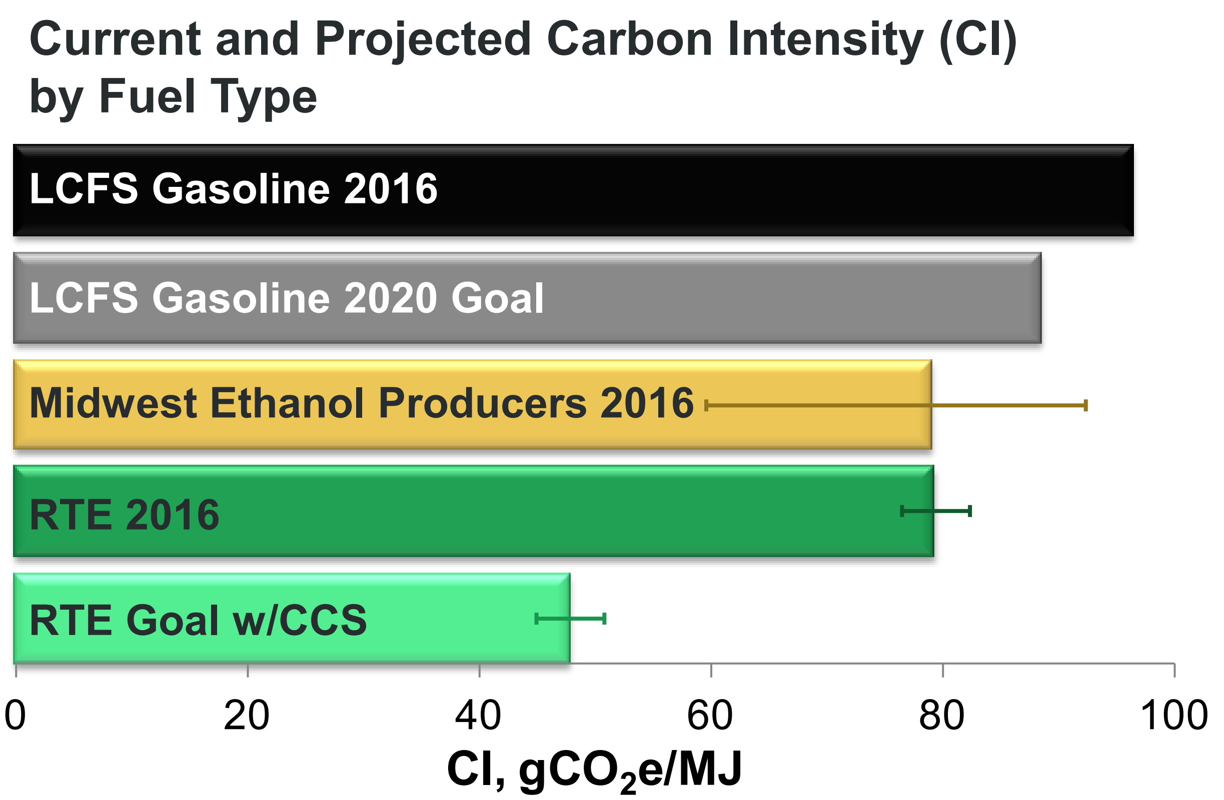
Critical Challenges. **Practical Solutions.**

PRESENTATION OUTLINE

- Technical Status
  - Background
  - Scope of work
  - Activity results
- Accomplishments to Date
- Lessons Learned
- Synergy Opportunities
- Project Summary

Image Credit: Red Trail Energy

TECHNICAL STATUS – BACKGROUND



Source: California Air Resources Board (July 2016)

- Carbon capture and storage (CCS) can maximize CI-based carbon credits.
- Pacific Coast carbon markets:
  – California's Low Carbon Fuel Standard (LCFS) Program
  – Oregon's Clean Fuels Program (CFP)
  – British Columbia's Renewable and Low Carbon Fuel Requirements Regulation

TECHNICAL STATUS – CASE STUDY

- Red Trail Energy, LLC (RTE)
  - Ethanol facility in western North Dakota
  - Current distribution to Pacific Coast
- Carbon capture potential
  - 163,000 tonnes of CO_2 annually from fermentation
  - Nearly pure CO_2 stream
- Geologic storage potential
  - Broom Creek Formation
  - 6400 ft directly below RTE facility, ~300 ft thick

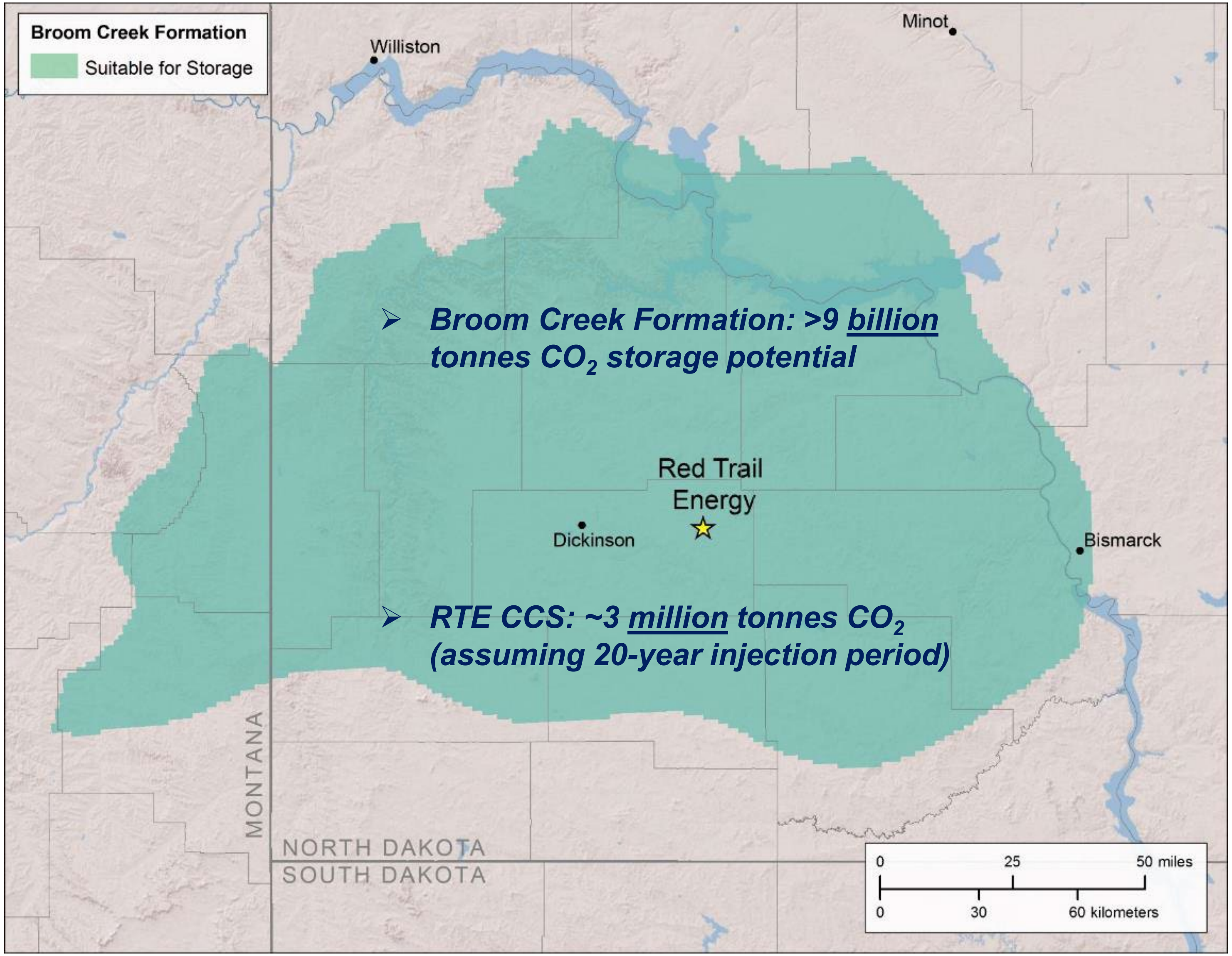
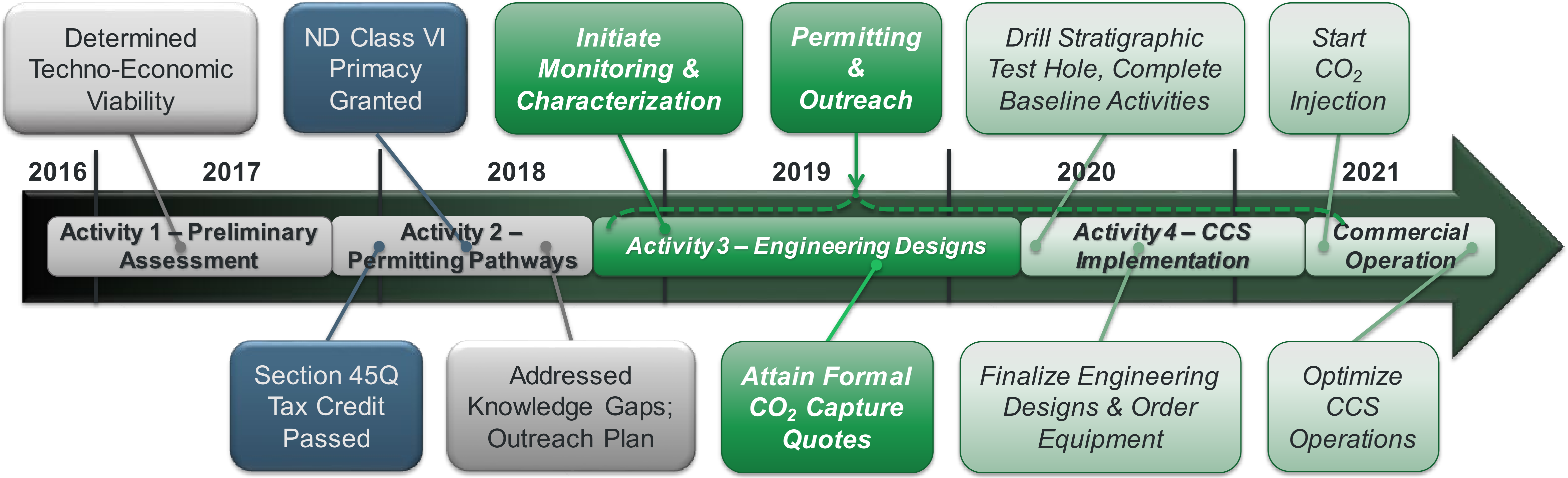


Image Credit: Energy & Environmental Research Center (modified from Peck and others, 2014)

PROJECT Status (*Proposed Timeline*)



TECHNICAL STATUS – ACTIVITY 1
PRELIMINARY ASSESSMENT

1. Feasibility study
2. Field implementation plan (FIP)
3. Economics analysis
4. National Risk Assessment Partnership (NRAP) validation
5. Outcome assessment

➢ Conclusions
   - Technically viable: estimated 40%–50% net CO_2 emissions reduction.
   - May be economically viable through low-carbon fuels programs or other incentives.

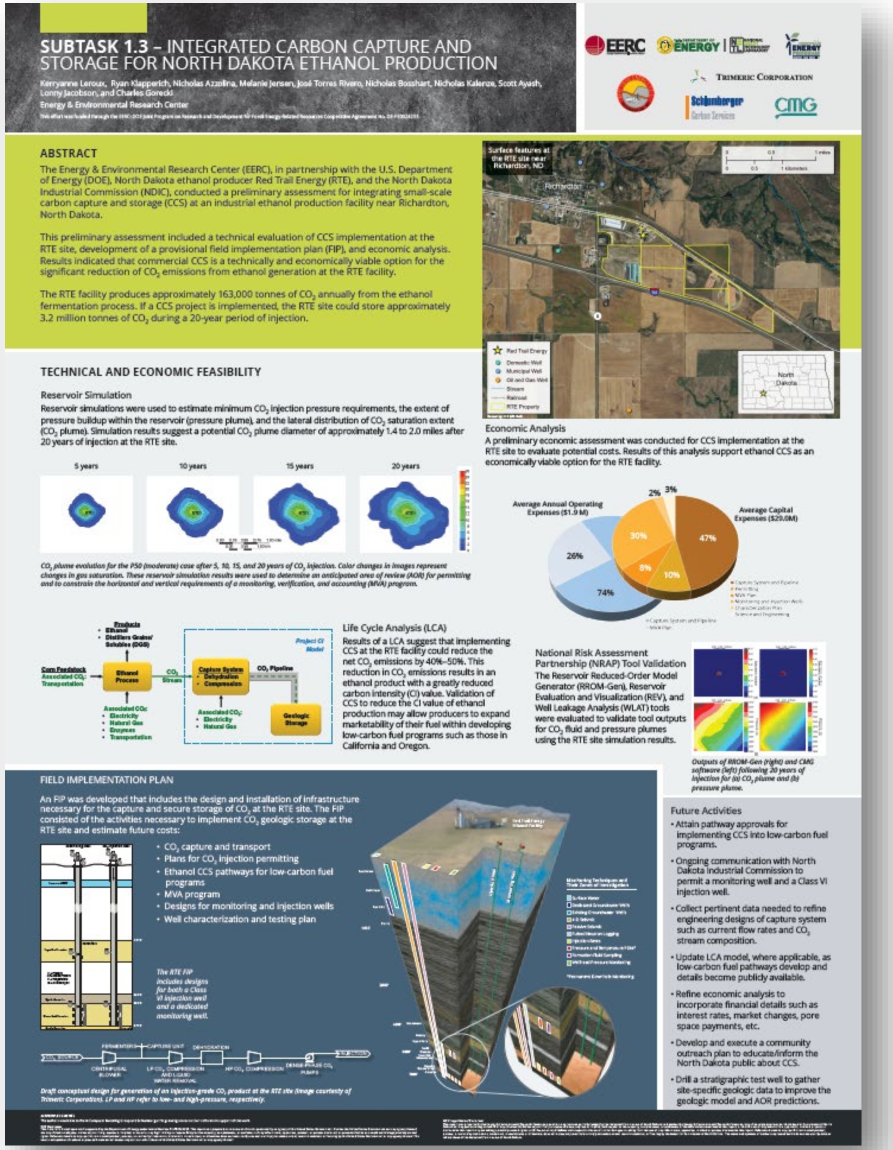


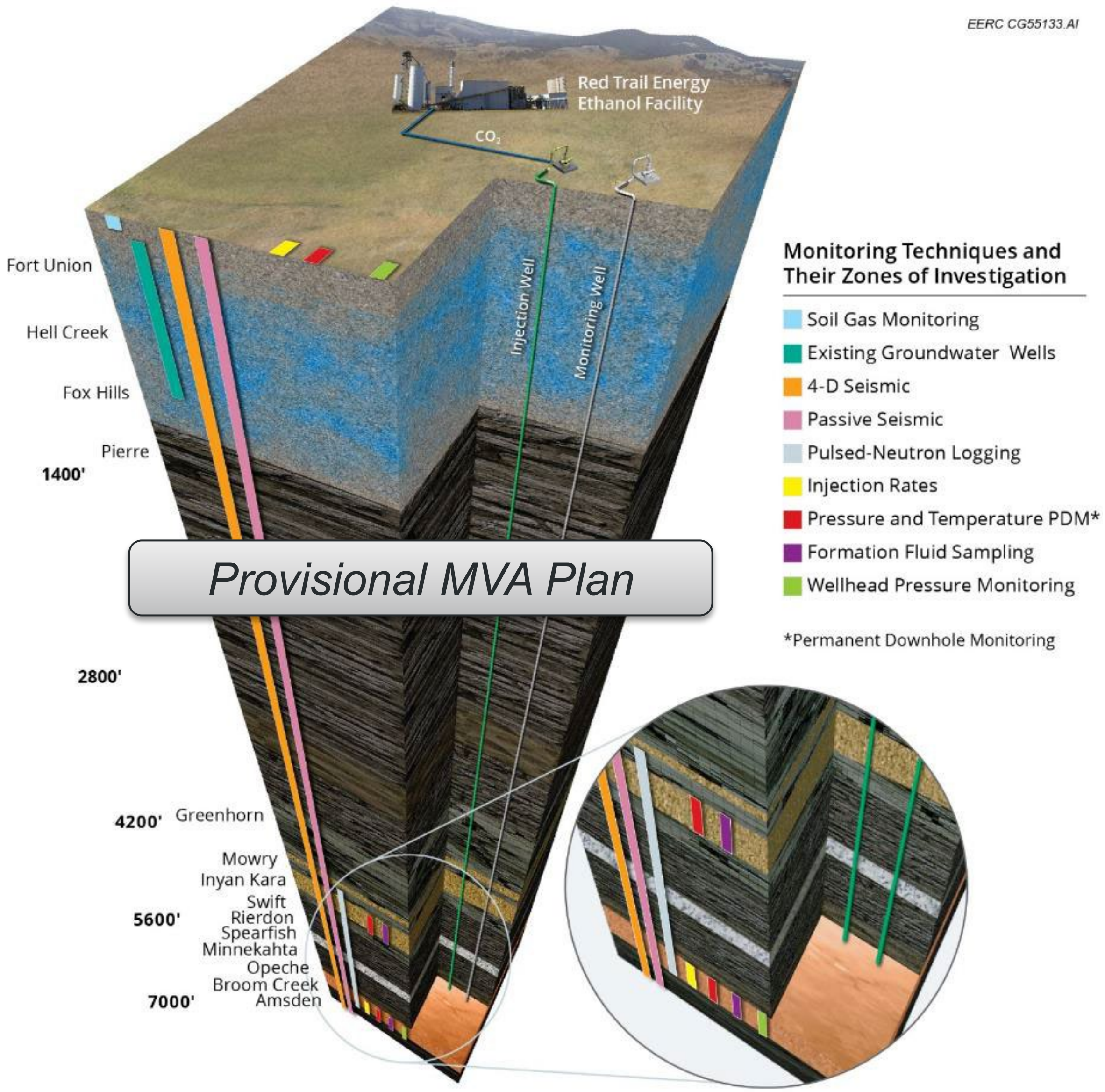
Image Credit: Energy & Environmental Research Center

TECHNICAL STATUS – ACTIVITY 2 DETAILED PATHWAY

1. Establish permitting pathways
2. Update infrastructure design
3. Update economic analysis
4. Develop community outreach plan
5. Outcomes assessment

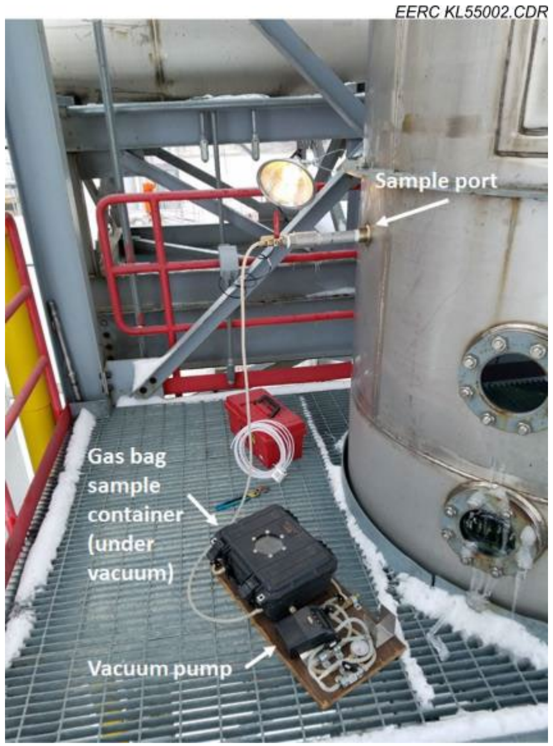
PERMITTING

- Low-carbon fuel programs
  - California LCFS, British Columbia
  - Oregon CFP, Canadian Clean Fuel Standard (proposed)
- North Dakota Class VI program
  - Primacy approved April 24, 2018
  - Discussed implementation details (e.g., pore space amalgamation)
- Updated FIP
  - Near-surface MVA (e.g., soil gas sampling/analyses)
  - Assessed California LCFS impact (e.g., ≥100 years postinjection monitoring)



UPDATE INFRASTRUCTURE

- Analyzed fermentation exhaust gases: 99.6–100% CO_2, 0–0.4% N_2, <100ppm O_2



- Capture modifications
  - Considered enhanced oil recovery (EOR) and food-grade CO_2 production systems
  - Path to commercialization
- Refined LCA
  - Injection-grade CO_2 product (with storage) = 40%–50% CI reduction
  - EOR- or food-grade CO_2 product (with storage) = 30%–40% CI reduction

UPDATE ECONOMICS

<u>Expenses</u>

- Electric upgrade for capture: 3–4 MW (nearly doubling current RTE facility)
- Pore space payment considerations: volumetric vs. pressure displacement
- California LCFS CCS requirements
  - Third-party reviews/verification
  - Expanded monitoring metrics, time frames

<u>Incentives</u>

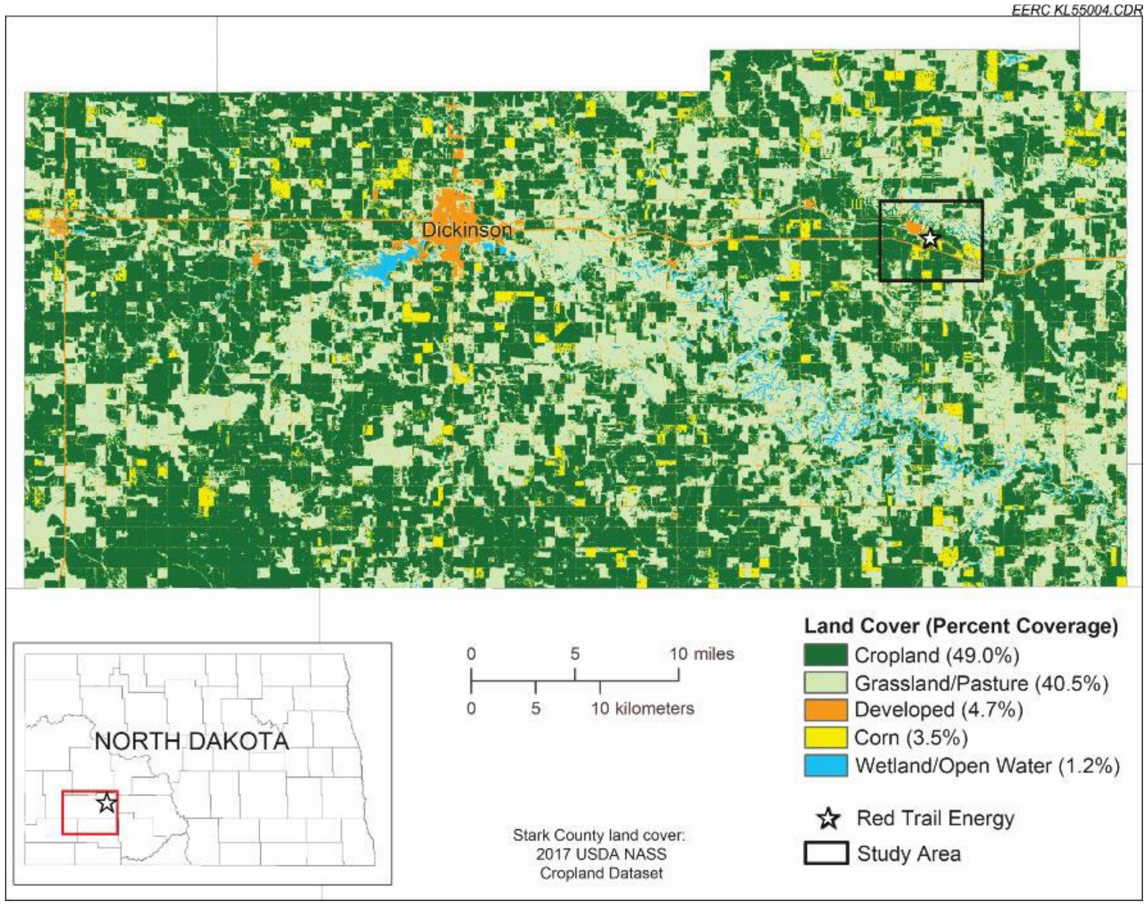
- Low-carbon fuel programs
- EOR
- Enhancement of Carbon Dioxide Sequestration Credit, a.k.a. Section 45Q

Credits, $/tonne	2020	2021	2022	2023	2024	2025	2026+
Dedicated Storage	32	35	38	41	44	47	50*
EOR	20	23	25	28	30	33	35*

* To remain constant in value for 2027 and thereafter (adjusted for inflation).

DEVELOP OUTREACH PLAN

- Social characterization: demographics, energy development, and land cover
- Outreach plan development
  - Goals and approaches
  - Implementation guidelines
  - Project partners and audiences
  - Outreach narrative, themes, and messages
  - Audience engagement strategies
  - Materials and time line
  - Tracking and assessment



ACCOMPLISHMENTS AND NEXT STEPS

- Continuing project based on favorable results from Activity 2.0.
- Potential Activities:
  - Develop CO_2 capture process design package
  - Initiate monitoring and characterization plans
  - Prepare CCS permit application package
  - Evaluate economic viability
  - Execute public outreach plan

Image Credit: Energy & Environmental Research Center

LESSONS LEARNED

- Risks are policy/program-related, not technical.

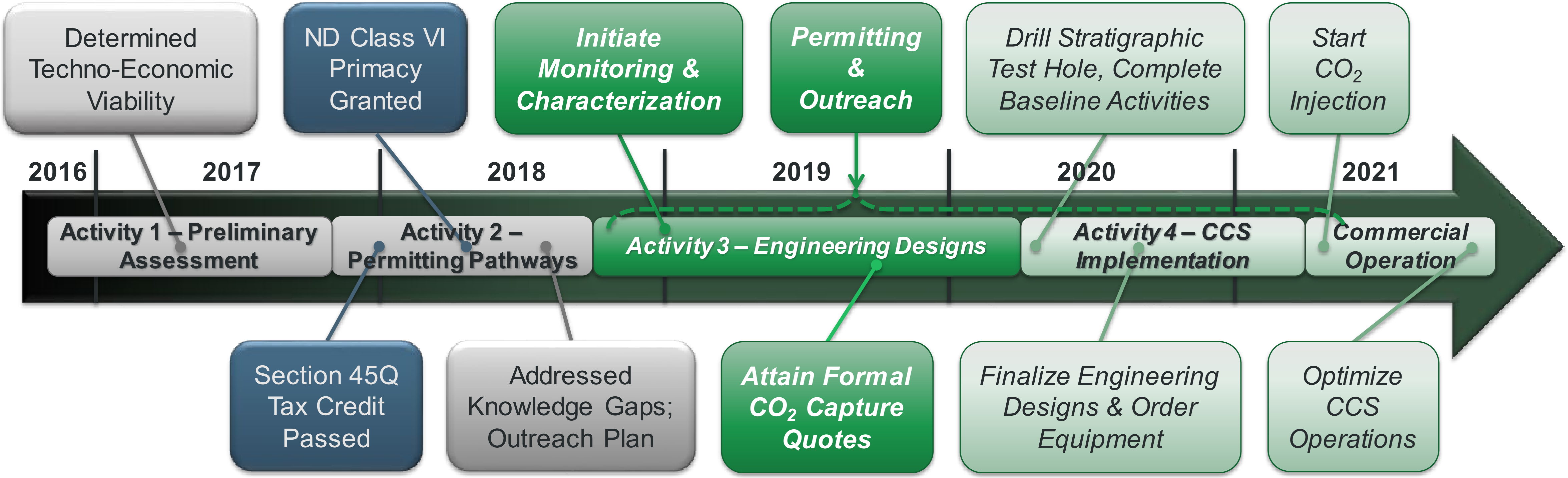
Photo by EPA

- Economic opportunities are reliant on evolving state/federal incentives.
  - Low-carbon fuel programs
    - California LCFS, Oregon CFP, etc.
  - Tax credits
    - Enhancement of Carbon Dioxide Sequestration Credit, a.k.a. Section 45Q
  - Proposed legislation
    - Carbon Utilization Act of 2018, USE IT Act

SYNERGY OPPORTUNITIES

- NETL Regional Partnerships
  - ***Plains CO_2 Reduction Partnership***
  - Midwest Geological Sequestration Consortium [Illinois State Geological Survey]
- CarbonSAFE Phase II
  - ***North Dakota Integrated Carbon Storage Complex Feasibility Study***
  - Integrated Midcontinent Stacked Storage Hub [Battelle Memorial Institute]
  - Integrated Commercial Carbon Capture and Storage Feasibility Study at Dry Fork Station [University of Wyoming]
- ***Techno-Economic Assessment of Regional Carbon Utilization Scenarios and Attendant Monitoring Technology***
- Developing and Validating Pressure Management and Plume Control Strategies in the Williston Basin Through a Brine Extraction and Storage Test (BEST)

PROJECT SUMMARY (*Potential Activities*)



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THANK YOU!


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BENEFIT TO THE PROGRAM

To progress toward full-scale CCS deployment, the feasibility of a small- to medium-scale commercial (<1,000,000 metric tons of CO_2 emitted annually) geologic storage complex for CO_2 must be established. Activities outlined in the proposed approach will gather data to address both the technical and nontechnical challenges associated with establishing feasibility. The results derived from implementation of the proposed project will provide a significant contribution to DOE's Carbon Storage Program goals. Specifically, this project will support DOE Goals 1 and 2 by validating technologies that will improve reservoir storage efficiency, ensure containment effectiveness, and/or ensure storage permanence by collecting and generating fundamental geologic data from the subbasinal characterization of a potentially ideal CO_2 storage complex (Broom Creek Formation). This proposed project also includes efforts to validate risk assessment tools developed by NRAP. Goal 3, the ability to predict CO_2 storage capacity in geologic formations to within ±30%, will be addressed by integrating characterization data derived from the proposed project into geocellular and dynamic reservoir models for a commercial-scale geologic storage complex. In addition, this project will support Goal 4 by producing information that will be useful for inclusion in DOE best practices manuals focusing on monitoring, verification, accounting, and assessment; site screening, selection, and initial characterization; public outreach; well management activities; and risk analysis and simulation.

PROJECT OVERVIEW
GOALS AND OBJECTIVES

- Goal: Implementation of a small-scale (<200,000 metric tons CO_2 per year) commercial CCS system at an industrial fuel production facility to generate a reduced-carbon ethanol fuel applicable for low-carbon fuel programs.
- Objectives
  - Develop a FIP for small-scale CCS.
  - Determine the full carbon life cycle of an industrial fuel production facility with CCS.
  - Determine the validity and pathway of using CCS to meet LCFS.
  - Validate the Broom Creek Formation, an Aeolian reservoir, as a regional target for CCS.

PROJECT OVERVIEW
SUCCESS CRITERIA

- Key activities will signify successful completion of the subtask's goals:

Project Activity	Key Milestones	Subsequent Step
1 – Preliminary Assessment for Integrated Small-Scale CCS at an Industrial Fuel Production Facility.	FIP (M1) and LCA (M2)	Pathway for CCS implementation
2 – Detailed Pathway for Integrated Small-Scale CCS at an Industrial Fuel Production Facility.	Permitting Pathways (M3)	CCS system designs
3 – Engineering Designs for Integrated Small-Scale CCS System.	Site Design (M6)	CCS implementation
4 – Implementation of CCS at an Industrial Fuel Production Facility.	Permitting (M7)	Commercial operation

- Subtask will be considered successful as measured by the following:
  - Generates data that provide cost-effective value to the efforts of commercial deployment of integrated small-scale CCS systems and provide a template for implementation of similar-sized industrial CO_2 sources.
  - Described and communicated to DOE and the CCS industry along with appropriate site-specific challenges and lessons learned.

ACCOMPLISHMENTS TO DATE

Completed Deliverables

- Quarterly reports [*D2, D4–8]

**D1 quarterly not required due to final agreement delays*

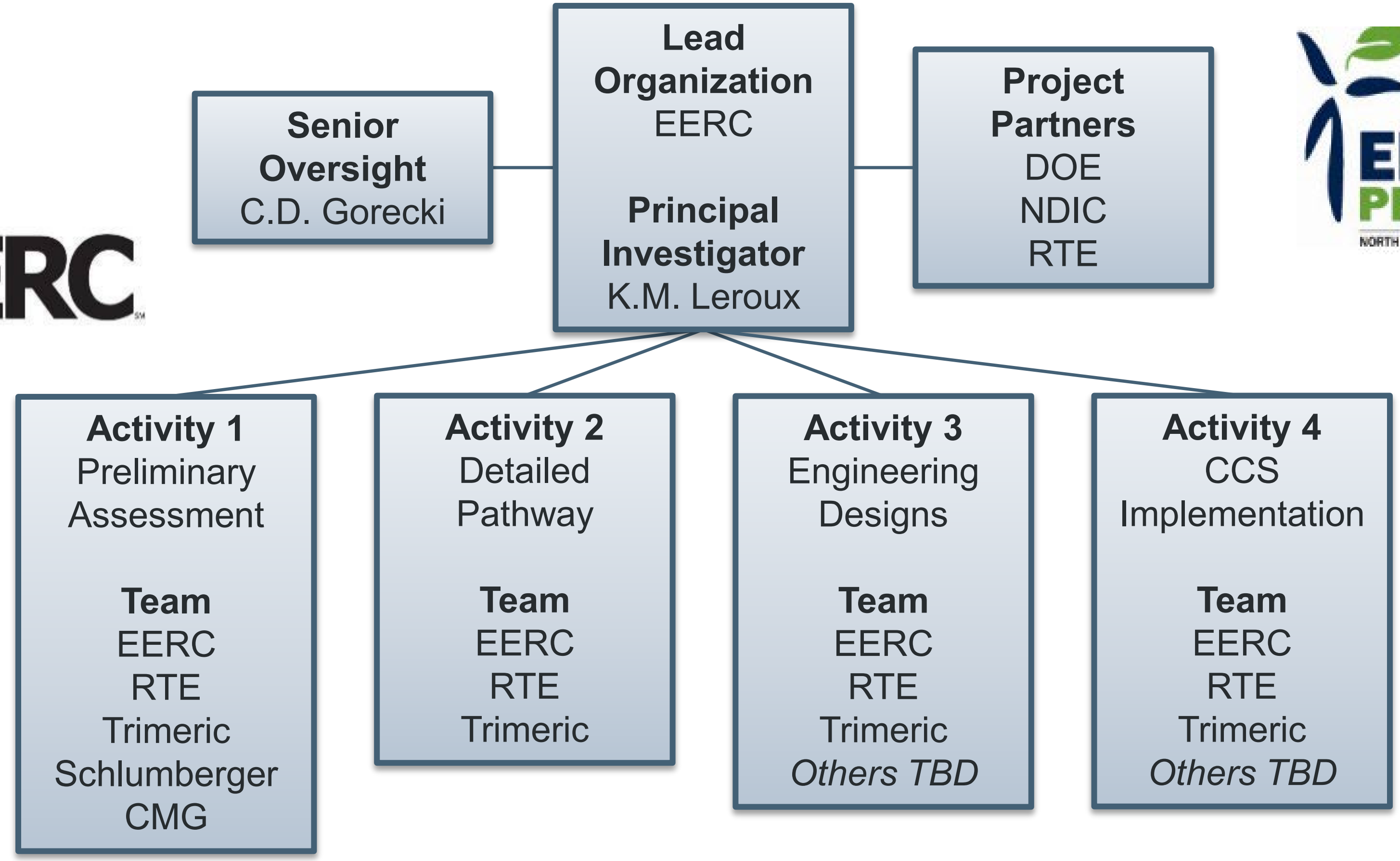
- Activity 1.0 interim report [D3]
- Activity 2.0 interim report [D9]

Image Credit: Energy & Environmental Research Center

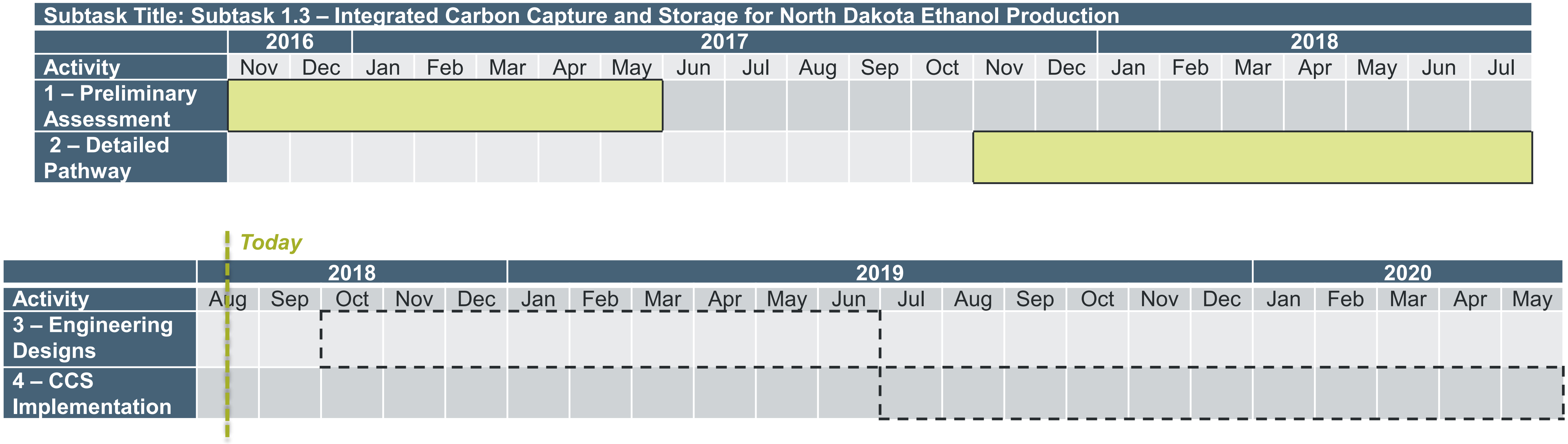
Completed Milestones

- FIP for Integrated Small-Scale CCS Completed [M1]
- Life Cycle Analysis of an Industrial Fuel Production Facility with CCS Completed [M2]
- Pathway of Using CCS to Meet Low-Carbon Fuel Standards Completed [M3]
- Updated Infrastructure Design for an Industrial Fuel Production Facility with CCS [M4]

ORGANIZATION CHART



GANTT CHART (Period of Performance: 11/1/16 – 5/31/20)



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