



September 28, 2023

Carbon Capture & Sequestration

Air & Waste Management Association

Southern Section 2023 Annual Meeting & Technical Conference

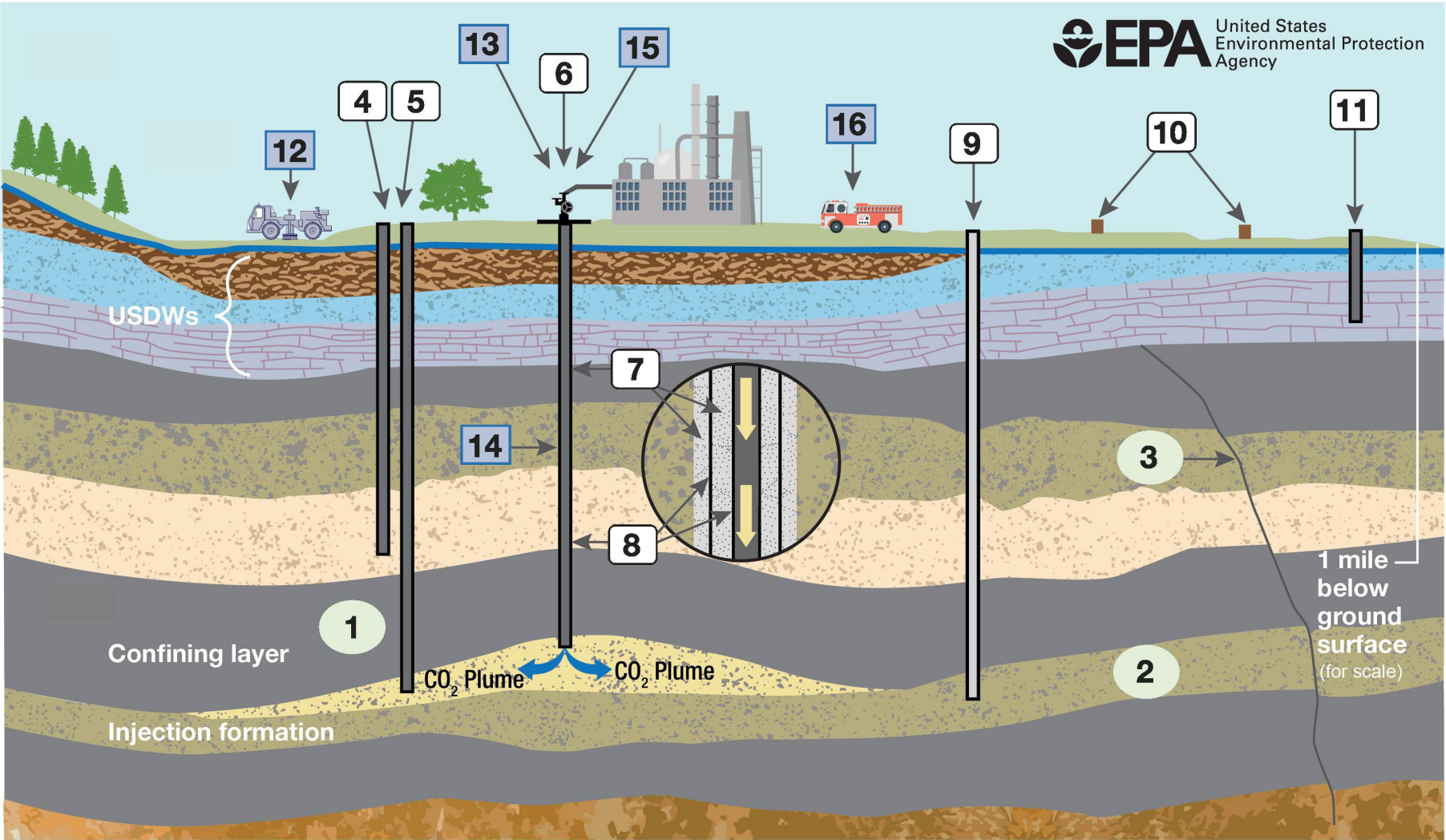
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TECHNICAL ASPECTS

- CO₂ can be stored as supercritical fluid
 - Temperature > 31.1°C / 88°F
 - Pressure ≥ 72.9 atm (~1,057 psi)
 - Dense (like a liquid) but viscous (like a gas)
- Trapping:
 - Structural – physical trapping in rock
 - Residual – pore space
 - Solubility – brine water in pore spaces
 - Mineral – reaction of dissolved CO₂ in brine to minerals in the rock

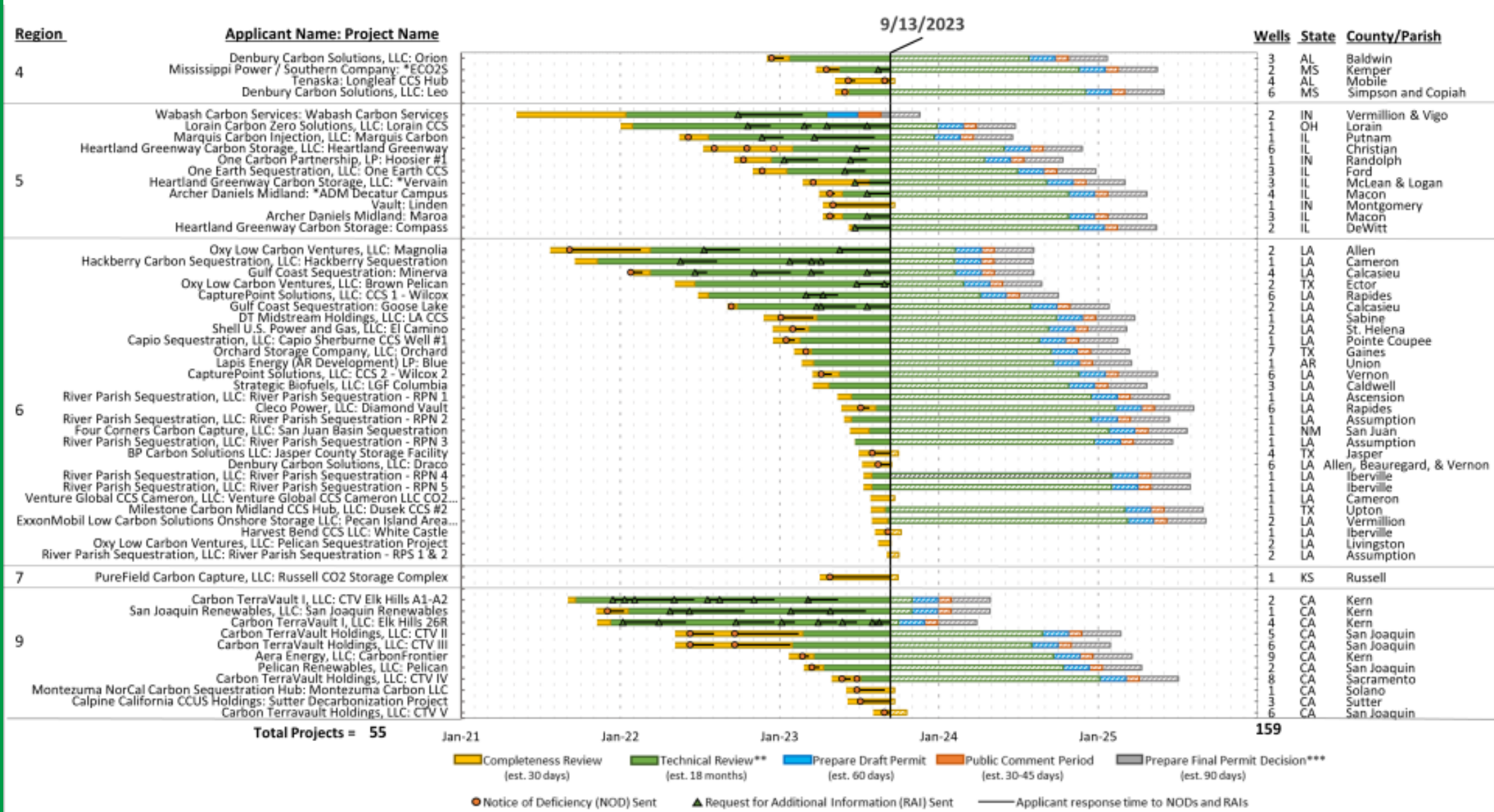
UIC CLASS VI WELLS



Through the Underground Injection Control (UIC) program, EPA protects underground sources of drinking water (USDWs) by regulating the construction, operation, permitting, and closure of injection wells that are used for the underground storage or disposal of fluids. Class VI wells are specifically used to inject carbon dioxide (CO₂) into deep rock formations. The UIC permitting authority reviews Class VI permit applications to ensure that injected CO₂ will remain within deep, isolated formations, protecting human health and the environment.

KEY			
●	Site geology	1	Thick, impermeable confining layer prevents CO ₂ from leaking upward
2	Injection, monitoring, and other wells	3	Permeable injection formation will hold injected CO ₂
4	Drinking water resource protection practices	5	Testing shows that the fault is inactive and sealed against movement of CO ₂
—	Water table	6	Water quality is tracked in the permeable formation above the confining layer using a monitoring well
		7	Pressure and CO ₂ in the injection formation are tracked using a monitoring well
		8	CO ₂ injection well is permitted for safe operation with many safeguards
		9	Cementing prevents CO ₂ from moving outside of the well
		10	Well materials are corrosion-resistant
		11	Properly plugged and abandoned well prevents CO ₂ movement between formations
		12	Seismic activity is monitored using surface equipment as needed
		13	Safe CO ₂ injection pressure avoids damaging the injection formation
		14	Shallow groundwater well is isolated from the injection formation by multiple impermeable layers
		15	Regular testing confirms the physical integrity of the well
		16	Injection pressure and flow are continually monitored
			Emergency response plan is in place and ready to be implemented

CLASS VI PERMITS UNDER REVIEW AT EPA





Greenhouse Gas Protocol

The global standard for companies and organizations to measure and manage their GHG emissions and become more efficient, resilient and prosperous.

[Launch Platform ↗](#)

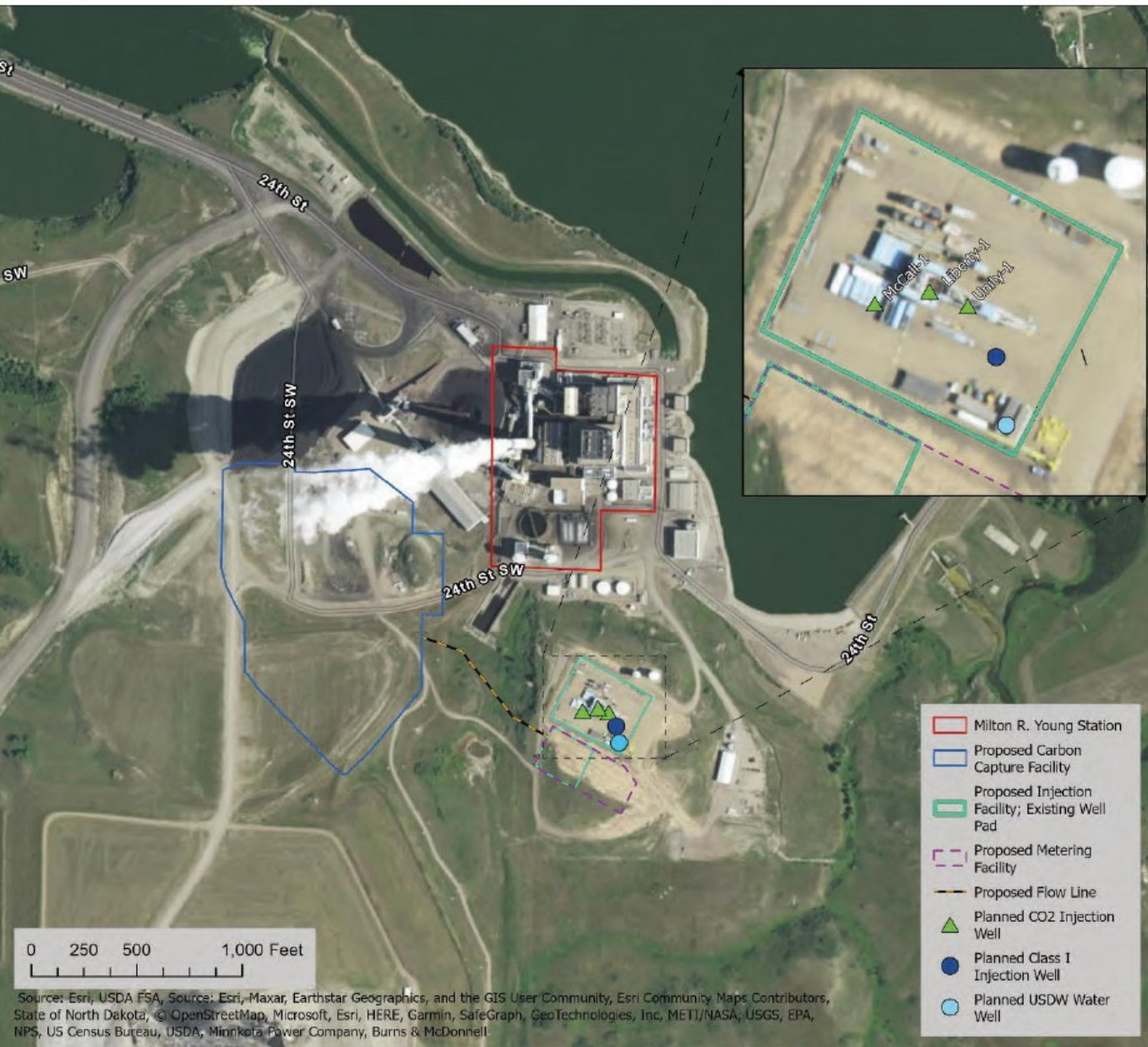
ACCOUNTING ISSUES

- Whose “requirements” apply and harmony across platforms
 - Greenhouse Gas Protocol a leading framework
 - World Resources Institute (WRI) & World Business Council for Sustainable Development (WBCSD)
- Who gets credit for capture, double-counting, etc.
 - Across Scope 1 (direct), Scope 2 (indirect), Scope 3 (up and down the value chain – indirect emissions that are not Scope 2)
- Acceptable forms of sequestration (geologic, forestry, etc.) within or across industries
- Corporate governance issues



CCS PROJECTS

Figure 2-2: Proposed Project Plan – Facility Adjacent to MRY Unit No. 1 & Unit No. 2



TUNDRA (MINNKOTA)

- Joint venture between Tundra CO2 Technologies and Minnkota
- Lignite power plant
- Porous rock layer mile deep below rock cap layers
- 4 million metric tons annually
- 252 billion tons total capacity

Project Information

Prime Performer: Minnkota Power Cooperative, Inc.

Project Duration: 10/01/2019 - 06/30/2023

Technology Area: Post-Combustion Capture

Key Technology: Solvents

Location: Grand Forks, ND

Agreement Number: FE0031845

Total Award Value: \$13,058,042

DOE Share: \$9,821,578

Performer Share: \$3,236,464

Project Description

The objective of this project is to complete a front-end engineering & design (FEED) study on the addition of a post-combustion carbon capture system based on Fluor's Econamine FG Plus™ solvent technology onto an existing power plant fueled by North Dakota lignite that will demonstrate next-generation carbon capture system feasibility and economics. Building on the findings of a pre-FEED study for Milton R. Young Station Unit 2 (MRY2), the key deliverables of this FEED study will be: 1) design, costing, and performance data needed to commence project financing activities; 2) engineering and material balances required to file for all project permits; and 3) a final project schedule. Advances included in the project to take carbon capture technology beyond the current state-of-the-art include steam cycle integration with advanced heat recovery to improve energy efficiency, a solution for aerosol emissions and solvent degradation to improve the environmental and cost profile, design of the world's largest capture facility (3.6 million tonnes/year) by two-fold to capture greater economies of scale, optimization for cold climate performance, and establishment of the lowest levelized cost of capture attempted at world scale.



Milton R. Young Station

Project Benefits

FEED studies for carbon capture systems at actual sites will provide the U.S. Department of Energy (DOE) with a more detailed understanding of carbon capture costs in a commercial application, thereby enabling DOE to better design its research and development (R&D) program to reduce those costs for similar carbon capture technologies being developed in its R&D portfolio.

DOE/EA-2197D

**Draft Environmental
Assessment for North Dakota
CarbonSAFE: Project Tundra**

August 2023



Sierra Club and CURE Challenge Department of Energy's Approval of "Project Tundra" Carbon Capture Project

September 22, 2023

Contact

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Montevideo, MN – This week, Sierra Club and CURE submitted [comments](#) to the U.S. Department of Energy (DOE) challenging the agency's environmental analysis that expressed approval of "Project Tundra," a proposed large-scale carbon capture and storage project in North Dakota.

Project Tundra is a proposal from Minnkota Power Cooperative, a rural electric cooperative that provides power to communities in Minnesota and North Dakota. Minnkota seeks to retrofit its aging Milton R. Young coal power plant with equipment to



DIAMOND VAULT (CLECO)

Louisiana Economic Development
(4/11/22):

Cleco Corporate Holdings LLC “will invest \$900 million to significantly reduce carbon emissions at the largest of its nine electric generation units in Louisiana, Madison-3 at Brame Energy Center in Lena, La.

“Cleco Power . . . will build a [CCS] facility to remove and compress 95% or more of the CO₂ emitted by Madison-3 and permanently store it in geological formation under the site.”



Our Mission

As a neutral research facility, the National Carbon Capture Center is working to accelerate the commercialization of advanced technologies to reduce greenhouse gas emissions. Since our creation by the U.S. Department of Energy in 2009, the center has been a cornerstone of U.S. innovation in the research and development of cost-effective, technically viable carbon management technologies.

NATIONAL CARBON CAPTURE CENTER (WILSONVILLE, AL)

- Created by USDOE
- Managed and operated by Southern Company
- Tests and validates advanced CCS solutions, including—
 - post-combustion capture
 - pre-combustion capture
 - oxy-fuel combustion
 - direct air capture

NETL carbon capture team visits renowned national facility where technologies are put to the test

🕒 Posted on December 13, 2022

NETL's Point Source Carbon Capture Team visited the National Carbon Capture Center (NCCC) in Alabama. NCCC is a world-class, neutral test facility focused on accelerating the development and commercialization of next-generation carbon reduction technologies for fossil-based power plants. Since its creation by the U.S. Department of Energy (DOE) in 2009, the center has been a cornerstone of U.S. innovation in the research and development of cost-effective, technically viable carbon management technologies. NETL is a cosponsor of NCCC.



National Carbon Capture Center test facility, Wilsonville, Alabama

Managed and operated by Southern Company, the center has worked with more than 30 government, university and research organizations from seven countries. As a unique test bed for third-party developers, NCCC helps bridge the gap between laboratory research and large-scale demonstrations. The center's state-of-the-art facilities provide realistic industrial operating conditions and the infrastructure to evaluate promising technologies for scale-up and future commercial deployment.

Its scope includes post-combustion carbon capture, carbon utilization and conversion, and negative-emission technologies such as direct air capture.

The NETL delegation also toured the Westover CO₂ geological storage characterization borehole site, which is located near NCCC.

NETL project manager Andrew O'Palko, who led the team visit to NCCC, explained the relevance of the tour.

ONGOING CCS PROJECT DEVELOPMENT

- **1PointFive** (an Occidental subsidiary) and **Carbon Engineering** developing modular direct air capture projects
 - 1M tpy capacity apiece
 - 70 facilities globally by 2035
 - First to be in TX
- **Aemetis** purchased 24 acres in 2022 at the Riverbank Industrial Complex (CA), a former military base, for a CCS injection well
- **Air Products** investing \$4.5B to produce “blue hydrogen” in Louisiana and store about 5M tons per year
- **B.P.** and **Linde** developing a CCS project at a Linde property in TX to store as much as 15M tpy
- **Carbon America** partnering with Sterling Ethanol, LLC and Yuma Ethanol, LLC for CCS projects at two ethanol production facilities in Colorado to capture 95% of CO₂
- **Chevron** developing a new CCS project in San Joaquin Valley, California
- **Competitive Power Ventures** developing a 1,80MW gas-fired power plant with CCS in WV
- **Red Trail Energy LLC** capturing and storing 500 tpy at ethanol plant near Richardton, ND
- **California Resources Corp.** and **Brookfield Renewable** joint venture will invest \$500M in initial funding for projects providing 200M tons of storage
- Etc., etc., etc.

Questions?

Thank you!



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