NATIONAL ENERGY TECHNOLOGY LABORATORY

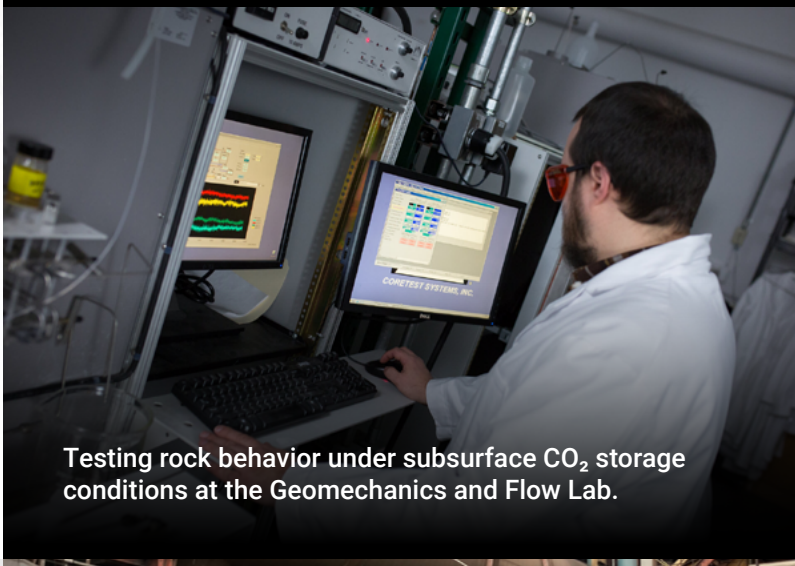
Carbon Management

NETL conducts research to advance carbon management technologies that reduce emissions from domestic power generation and industrial sources. This work supports the continued use of U.S. fossil energy resources, enhances energy reliability, and ensures economic competitiveness. NETL develops technologies and decision-making tools that improve carbon capture; enable productive use of captured carbon dioxide (CO_2); and expand safe, permanent storage options. NETL's capabilities in this area include materials design and testing, integrated systems modeling, techno-economic and life cycle analysis, and field deployment.

R&D Applications

- Point Source Carbon Capture
- Direct Air Capture
- Carbon Conversion and Utilization
- AI-Driven Materials Development
- Geologic Storage and Infrastructure Development
- Wellbore Integrity and Subsurface Infrastructure
- Subsurface Modeling and Data Integration
- Monitoring, Verification and Accounting
- Risk Assessment and Decision Support Tools
- Techno-Economic and Life Cycle Analysis

Developing advanced materials for efficient CO_2 capture at the Polymer Synthesis Lab.



Testing rock behavior under subsurface CO_2 storage conditions at the Geomechanics and Flow Lab.

Mobile Carbon Capture Unit at U.S. Steel Plant

NETL deployed its mobile membrane test unit to U.S. Steel's Edgar Thomson plant to evaluate advanced polymer membranes under real blast-furnace gas conditions. The membrane showed superior carbon and nitrogen selectivity and stability in humid environments, supporting industrial-scale capture options that preserve U.S. manufacturing strength.

Research Highlights

Industry-Supported Direct Air Capture (DAC) Test Center

NETL is leading the development of an industry-supported test center for DAC technologies. Current work includes establishing baseline techno-economic and life cycle case studies; developing protocols for measurement, reporting and verification; and modeling material performance and degradation. These efforts enable consistent evaluation of DAC systems and provide a technical foundation for future field validation in collaboration with industry partners.

Advancing CO_2 Conversion Technologies

NETL researches thermochemical, electrochemical and biological pathways to convert CO_2 into fuels, chemicals and materials. This includes work at NETL's ReACT (Reaction Analysis and Chemical Transformation) facility, which enables evaluation of CO_2 conversion systems under realistic operating conditions. Researchers use the facility to study catalyst behavior, system integration and reactor performance with simulated and actual flue gas streams. NETL also applies techno-economic and life cycle analysis to benchmark technology viability and to assess trade-offs across pathways. This combined modeling and experimental approach allows NETL to rapidly advance practical CO_2 conversion options for industrial consideration.

Carbon Storage Risk Assessment – National Risk Assessment Partnership (NRAP)

NETL serves as the lead lab for NRAP, a collaboration among five DOE national laboratories that develops and maintains open-source tools to evaluate long-term subsurface performance and manage CO_2 storage risk. Project developers and DOE programs use tools, like the NRAP Open-Source Integrated Assessment Model and the State of Stress Analysis Tool, to support data-driven decisions at commercial storage sites.

Tools and Modeling Platforms for Storage Infrastructure

NETL's tools, such as EDX4CCS and the SMART (Subsurface Modeling for Advanced Risk and Technology) Initiative, support analysis of subsurface resources and inform decisions on infrastructure development. These platforms integrate data from field programs to improve storage site characterization, performance forecasting and long-term monitoring strategies. NETL also evaluates mineralization approaches to expand CO_2 storage options and support diverse geologic settings.

Publications

- Alumbaugh, D., Gasperikova, E., Crandall, D., Commer, M., Feng, S., Harbert, W., Li, Y., Lin, Y. & Samarasinghe, S. (2023). The Kimberlina Synthetic Multiphysics Dataset for CO_2 Monitoring Investigations. Geoscience Data Journal. https://doi.org/10.1002/gdj3.191.
- Boerst, J., Pena Cabra, I., Sharma, S., Zaremsky, C., & Iyengar, A. K. (2024). Strategic Siting of Direct Air Capture Facilities in the United States. Energies, 17(15), 3755.
- Brown, M., Irish, M., Steinberg, D., Moss, T., Cherney, D. P., Shultz, T., ... & Schmitt, T. (2024). Representing carbon dioxide transport and storage network investments within power system planning models. Energies, 17(15), 3780.
- Henry, S., Schneider, N., Hughes, S., Zoelle, A., Grol, E., Fout, T., & Homsy, S. (2024). Decarbonization of the Iron and Steel sector: Challenges and Opportunities. Proceedings of the 17th Greenhouse Gas Control Technologies Conference. Available at https://ssrn.com/abstract=5070025.
- Hughes, S., Zoelle, A., Woods, M., Henry, S., Homsy, S., Pidaparti, S., Kuehn, N., Hoffman, H., Forrest, K., Sheriff, A., Fout, T., Summers, W. M., Herron, S., Mantripragada, H., Cvetic, P., & Grol, E. (2023). Cost of Capturing CO2 from Industrial Sources. https://doi.org/10.2172/2007619.

NETL is a U.S. Department of Energy (DOE) national laboratory dedicated to advancing the nation's energy future by creating innovative solutions that strengthen the security, affordability and reliability of energy systems and natural resources. With laboratories in Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania, NETL creates advanced energy technologies that support DOE's mission while fostering collaborations that will lead to a resilient and abundant energy future for the nation.