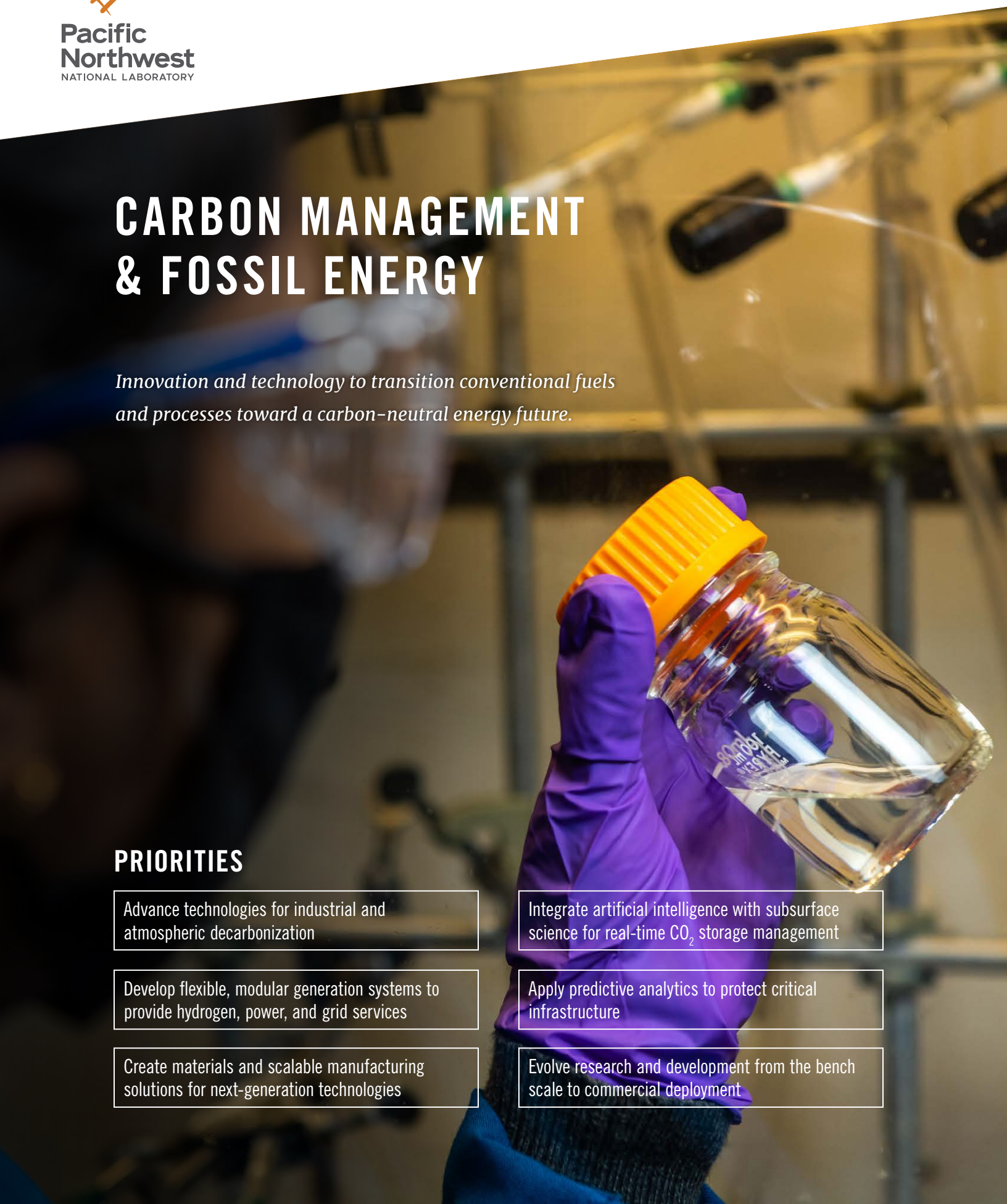
Pacific Northwest
NATIONAL LABORATORY

CARBON MANAGEMENT & FOSSIL ENERGY

Innovation and technology to transition conventional fuels and processes toward a carbon-neutral energy future.



PRIORITIES

- Advance technologies for industrial and atmospheric decarbonization
- Develop flexible, modular generation systems to provide hydrogen, power, and grid services
- Create materials and scalable manufacturing solutions for next-generation technologies
- Integrate artificial intelligence with subsurface science for real-time CO_2 storage management
- Apply predictive analytics to protect critical infrastructure
- Evolve research and development from the bench scale to commercial deployment

MISSION

Our innovations support the transition from today's mix of conventional fuels and processes toward a lower-carbon energy future, including technologies for more sustainable production and use of fossil fuels. Integrating capabilities across multiple scales and domains, we bring solutions across the entire fossil energy value chain, from resource exploration and production to transport, conversion, and end use.

WHAT WE DO

Pacific Northwest National Laboratory's (PNNL) Carbon Management and Fossil Energy portfolio is focused on research and development (R&D) for the increasingly efficient, sustainable production and use of fossil resources. Leveraging capabilities and expertise from the atomic scale to field deployment, we create technologies to support the transition toward a lower-carbon energy future.

To develop new technologies needed for capturing carbon dioxide (CO_2) and permanently isolating it from the atmosphere, we integrate fundamental and applied chemistry, sensing, Earth and materials sciences, and process engineering. In partnership with industry, this integrated approach allows us to create and commercialize technologies that more efficiently convert hydrocarbons into power, fuels, and chemicals—all critical to the environmentally and economically viable production and use of fossil energy.

KEY PROJECTS

- Refinement and testing of CO_2-Binding Organic Liquids (CO2BOLS)
- Science-Informed Machine Learning to Accelerate Real-Time Decisions (SMART) Initiative
- Integrated Capture and Conversion of CO_2 to Methanol (ICCCM)
- High efficiency air separations for oxy-fuel power generation
- National Risk Assessment Partnership (NRAP)
- Regional Carbon Sequestration Initiatives and CarbonSAFE
- Reversible solid oxide fuel cells for power and hydrogen
- Extreme Materials National Laboratory Consortium (XMAT)

FACILITIES & EQUIPMENT

CO_2 Solvent Optimization Laboratory	High Throughput Center for Materials Synthesis, Screening, and Testing	Solid Phase Processing Demonstration Facility
Environmental Molecular Sciences Laboratory	Magnetocaloric Solid State Cryogenics	Geophysical Acquisition, Inversion, Modeling, and Decision Support
Switchable Fuel Cell Fabrication and Testing Facility	Modular Hydrothermal Liquefaction System	Artificial Intelligence-(AI) Integrated Real-Time Sensing

CO_2 capture and conversion

- Advanced solvents
- Integrated capture and conversion
- Computational optimization

Materials for extreme environments

- Solid phase processing
- Cold spray
- Embedded sensors

Predictive analytics for critical infrastructure

- Natural gas pipelines
- Fossil power generation
- Fuel cells

Geologic CO_2 storage

- Reservoir simulation
- Integrated sensing
- AI-enabled forecasting

Integrated hydrogen and power technologies

- Switchable solid oxide technology
- Gas separation and liquefaction
- Advanced hydrocarbon conversion

Industry collaboration and deployment

- Solutions-focused innovation
- Process integration and engineering
- Piloting & commercialization

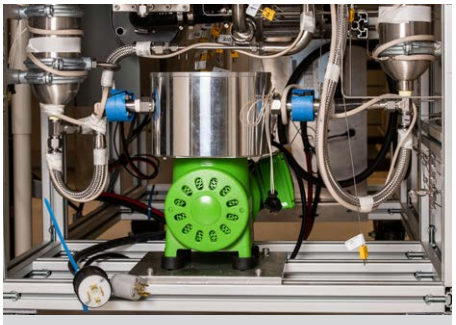
ACCOMPLISHMENTS

Industrial & Atmospheric CO_2 Capture

PNNL hosts the U.S. Department of Energy's (DOE) flagship, industry-partnered CO_2 capture solvent development and demonstration program, which recently broke the critical $50/tonne threshold. Our expertise and strong partnerships allow us to affect the commercial readiness of today's capture solvents, including a successful pilot-scale testing of our advanced solvents at the Technology Centre Mongstad in Norway, in partnership with Fluor.

Integrated CO_2 Separations & Synthesis

Combining our leadership in CO_2 capture R&D with discoveries and expertise in advanced separations and catalysis—stewarded under DOE's Basic Energy Sciences program—we are developing the next generation of technologies to integrate CO_2 capture and CO_2 utilization into a more efficient, cost-effective process. PNNL is partnering with SoCal Gas to commercialize a process to directly convert CO_2 captured from a gas-fired power plant into methanol.



Solid Oxide Fuel Cells

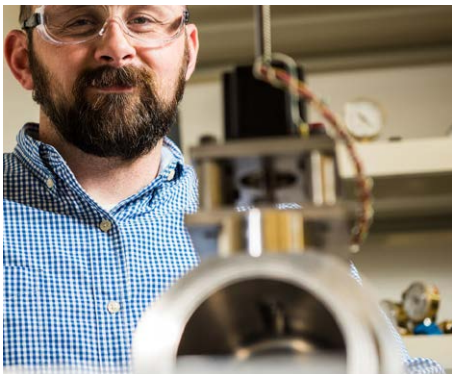
Stewarding over a decade of DOE investment in solid oxide fuel cell technologies, researchers at PNNL are working to develop and commercialize reversible systems capable of producing power when demand for electricity is high, and hydrogen when surplus electricity is available for electrolysis. This work combines expertise in materials development, characterization, and computational modeling to help identify opportunities to improve the efficiency and cost effectiveness of fuel cell technologies.

Modular Gas Separation & Liquefaction

Leveraging PNNL's expertise in magnetocaloric liquefaction and microchannel distillation, we are developing modular, scalable air separations systems to provide cost-effective oxygen separations to improve efficiency and reduce CO_2 capture costs for small and distributed power generation facilities. On the way to liquefying air, the team also demonstrated the solid-state system to liquefy methane, offering an opportunity to capture and transport fossil and renewable natural gas that might otherwise be vented or flared.

CO_2 Mineralization in Basalts

A decade after early laboratory results suggested basalt rocks could convert CO_2 into minerals, PNNL conducted the first injection of supercritical CO_2 into a basalt reservoir. Data and samples taken from the Wallula, Washington, site two years later confirmed that the basalts converted CO_2 into minerals much more rapidly than other storage formations, offering the potential to store CO_2 in a solid form that is immobile and poses no risk of leakage.



Commercial-Scale Geologic CO_2 Storage

PNNL has 20 years of experience developing technologies to support the commercial scale adoption of the subsurface storage of captured CO_2, including technical leadership on the National Risk Assessment Partnership. Our support of multiple field demonstrations includes preparation of the CO_2 injection permit for FutureGen, the first granted under the U.S. Environmental Protection Agency's Class VI rule. Today, our researchers are leveraging the power of artificial intelligence and high-performance computing to provide operators with real-time reservoir management tools under the DOE SMART Initiative.

CONTACTS

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ABOUT PNNL

Pacific Northwest National Laboratory draws on signature capabilities in chemistry, Earth sciences, and data analytics to advance scientific discovery and create solutions to the nation's toughest challenges in energy resiliency and national security. Founded in 1965, PNNL is operated by Battelle for the U.S. Department of Energy's Office of Science. DOE's Office of Science is the single largest supporter of basic research in the physical sciences in the United States and is working to address some of the most pressing challenges of our time.

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Learn more: **pnnl.gov**