

Capturing Carbon

Research focus to remove greenhouse gases for cleaner air

Quick read

Technology helps capture carbon dioxide. The goal? Meet energy needs, reduce global warming and protect the planet.

How do you simultaneously power and protect the planet? Eighty-six percent of the world's energy comes from fossil fuels, a cause of global warming. While reducing fossil fuel use may ultimately be the answer to many of the world's energy and environmental problems, removing pollution from the air decelerates climate change. Global emissions of carbon dioxide (CO₂), a fossil fuel byproduct that absorbs and emits heat, average 27 billion metric tons annually. Activities such as deforestation or the burning of coal and gas have increased atmospheric concentrations of CO₂ 35 percent since the Industrial Revolution, according to the Environmental Protection Agency (EPA). Carbon capture and storage is becoming a popular technique to fight global warming. Los Alamos National Laboratory (LANL) researchers developed a myriad of technologies to decrease greenhouse gases, including turning emissions into fuel and development of a comprehensive risk-assessment program to ensure safe and effective containment.

Capturing and storing (sequestering) CO₂ prevents it from reaching the atmosphere. While multiple methods exist, such as storing the gas in plants, the best current sequestration method is geologic: bury it.

In the sequestration process, CO₂ is contained at the industrial source, compressed and converted to a fluid and injected deep underground into porous rock. There are many risks to be factored, including potential chemical reactions, toxic gases escaping through faults or fractures, freshwater contamination, pollution of nearby natural gas deposits, and ecosystem changes. Selecting, engineering, and regulating geologic sites requires informed decision making.

"There's uncertainty in how fast CO₂ can be injected into a given hole, how fast it will move through porous rock, how fast it will mineralize, and how fast it might leak up through different pathways," said Los Alamos hydrogeologist Philip Stauffer. "We're trying to reduce those uncertainties so decision makers can act on a known level of risk."

Implementing carbon sequestration on a grand scale is a daunting challenge. The method has been used for decades but not at the magnitude needed to affect climate change. Global carbon dioxide storage capacity estimates range up to 10 trillion tons and officials worldwide are opting for this solution to the climate crisis. In 2008, the EPA proposed regulation to create a framework for safe CO₂ capture.

The Lab scientists are looking to the future-hundreds of years-to perfect CO₂ storage; most importantly, making sure it is secure. Increasing the time stored and volume of sequestration multiplies risks, so Los Alamos researchers (also experts at hazardous waste storage) are applying varied capabilities to tackle the carbon sequestration challenge and keep the world safe.

Lab scientists developed a framework and working computer model called CO₂-PENS (Predicting Engineered Natural Systems), as well as complex parallel computer codes, to evaluate potential problems and optimize site selection and techniques. This system combines theory, field and laboratory experiments, observation, and computation to predict earth materials' responses (underground and terrestrial) to CO₂ storage. While individual predictions were made for various subsurface processes before this technology existed,

there was no accurate way to compile and analyze all the complex data that is dynamically linked-until now.

LANL's sequestration analysis technologies quantify prediction uncertainty and report when more data (e.g., experiments, additional site sensors) is required to increase accuracy, leading to safer results. Additionally, the program analyzes hard-to-define economic risks for particular sequestration plans.

Fossil fuel emissions are a major focus for Los Alamos. Researchers are tackling monumental challenges, from developing world-class monitoring techniques to developing environmentally friendly, nonpolluting energy sources-even turning CO2 into renewable fuels with the Lab's new lauded technology, Green Freedom. An innovator in science, technology, and engineering, Los Alamos is creating a myriad of methods that lead the way to save our environment and secure our future.

Pushing Frontiers

In the second half of 2008, Los Alamos National Laboratory made significant advances in its primary mission: safeguarding the U.S. nuclear deterrent and pushing the frontiers of science on multiple fronts.

The national stockpile stewardship program achieved a major milestone in September with the production of the first life-extended W76-1 ballistic missile warhead for Trident submarines. The achievement culminated more than a decade of work by scientists and engineers at Los Alamos and across the nuclear weapons complex-including two crucial experiments conducted by the Laboratory's Hydrodynamic Experiments Division.

Another highlight: Roadrunner reached a new performance record of 1.105 petaflops, keeping it atop the list of the world's fastest supercomputers. Built by IBM for the Lab, Roadrunner was the first computer to crack the petaflop barrier: one thousand TRILLION operations per second. Initial applications will range widely: studying in great detail the evolution of HIV... exploring deeply the formation—as well as deformation—of metallic nanowires...and-toward producing biofuels more efficiently-unraveling the processes by which bacteria break down cellulose.

Safety and environmental stewardship were again a major theme for our work in the latter half of 2008. In November, the last group of unvented high-activity drums left Los Alamos for the Waste Isolation Pilot Plant near Carlsbad. That shipment fulfilled a commitment to the Defense Nuclear Facilities Safety Board to prioritize disposal of the highest-activity transuranic wastes stored at the Lab.

Los Alamos also strengthened security, ensuring that nearly six dozen classified and unclassified computing systems are managed and operated securely. The Lab has now complied with all 14 security actions mandated two years ago by the Department of Energy. And, through our program to recruit cognizant systems engineers, we met the crucial need for sufficient numbers of engineers to keep vital mechanical and electrical safety systems functioning properly in our nuclear facilities.

The latter half of 2008 proved once again why Los Alamos is the nation's premier institution for scientific research. Capping the list of accomplishments was a new technology called MagViz that could eventually provide increased security at major airports. Based on medical MRI technology, MagViz can identify contents of bottles and other containers, distinguishing potentially hazardous liquids from the harmless shampoos and perfumes a traveler might carry onboard a jet. MagViz was demonstrated successfully in December at Albuquerque's airport.

We continued a long tradition of supporting U.S. space exploration. A NASA mission, launched in October to probe the far edge of the solar system from a high Earth orbit, carried a Los Alamos device called the High Energy Neutral Atom Imager. Its goal: to detect atoms emitted from a region where the outermost reaches of our solar system meet the vast interstellar space-giving us a panoramic view of this gateway to the galaxy.

Closer to home, Los Alamos continues to explore solutions to the energy needs of tomorrow. For example, scientists at the Lab hope to use tiny semiconductors called quantum dots to convert sunlight to electricity more efficiently than is possible with current solar panels-and to create new, efficient solid-state lighting.

Equally electrifying, Los Alamos materials scientists are helping unravel the mysteries of superconductivity. During the latter half of the year, LANL researchers identified entirely new mechanisms for superconductivity that could form the basis for new superconducting materials.

Underscoring the wealth of scientific talent at the Lab, Bob Albers, Paul Johnson, and Kurt

Sickafus were named Laboratory Fellows in December. These three Fellows represent diverse disciplines, including theoretical physics, energy science, and geophysics. Los Alamos may be one of the world's great technology incubators, yet we also strive to help others develop new ideas and products. In January, the Lab selected four young local companies as the newest recipients of awards from the LANS Venture Acceleration Fund. LANS, which manages and operates the Lab, supports the fund through donations from its earnings.

The Lab and LANS also teamed last September with a venture capital firm and a local venture capital fund to spin off technology developed by Lab scientists, with an emphasis on creating companies in Northern New Mexico. The Lab could contribute up to one million dollars to the initiative over the first three years.

We also are pushing to build top-flight research facilities for the future. In July 2008, workers hoisted the final steel beam atop the skeleton of what will be the Radiological Laboratory Utility Office Building, part of the Lab's Chemistry and Metallurgy Research Replacement Project. Once completed, the CMRR nuclear facility will house several of the Lab's mission-critical projects, including analytical chemistry, materials characterization, and actinide research and development capabilities. They'll be relocated from their current location in the historic—yet antiquated—Chemical and Metallurgy Research building at Technical Area 3.

In December, Los Alamos welcomed hundreds of employees who transferred from KSL, the subcontractor whose work the Lab brought in-house. The move was geared to improve efficiency and reduce costs associated with site-support services, including maintenance, waste removal, and custodial work.

Throughout the Lab's history, Los Alamos has helped play a vital role in the surrounding communities, and in 2008, that tradition continued. Lab employees pledged a million dollars, and LANS matched one hundred percent: a record Los Alamos contribution to United Way of TWO MILLION dollars. Contributions from the Lab and LANS also helped fund dozens of nonprofit organizations and scholarship programs, including a LANS donation of \$500,000 to a LANL Foundation scholarship named for former long-time New Mexico Senator Pete Domenici.

These accomplishments and many more added up to a strong year. Our customer, the National Nuclear Security Administration, reached the same conclusion in its very favorable assessment of the Lab's performance for fiscal year 2008. It's unmistakable: the extraordinary talent, commitment, and creativity that Los Alamos employees dedicate every day to national security science and the betterment of their communities.

About Our Capabilities, Facilities, and Staff

"Los Alamos National Laboratory plays an indispensable role in building America as a science and technology powerhouse, and our staff are an incredible resource to the nation and the world." Michael Anastasio, Dir.

Solving Complex R&D Problems with Special Blend of Staff, Capabilities and Facilities
Now in its seventh decade, LANL is one of the few laboratories that can bring great breadth of fundamental and discovery science, technology, and engineering rapidly together to create tangible solutions for national security needs.

Our staff, working with partners throughout science and industry, must be able to deliver today's solutions while maintaining the depth of capabilities to deliver the next generation of discoveries.

Los Alamos has demonstrated a cycle of innovation where we have developed world-leading capabilities and facilities in response to urgent, unique missions. Our new discoveries continue to respond to emerging missions.

Being able to integrate and apply our capabilities rapidly to new challenges will be a key advantage in an increasingly competitive landscape.

Our Science, Technology and Engineering Priorities
Science that Matters

Information science and technology enabling integrative and predictive science
Experimental science focused on materials for the future
Fundamental forensic science for nuclear, biological, and chemical threats

How We Work

Collaborate, partner and team to make decisive contributions to our sponsors
Outstanding operational excellence for safety, security, and efficient pursuit of ST&E
for our missions

Transform Our Scientific Campus

Campus for 2020 (consistent with complex transformation)
Modern science facilities: LANSCE refurbishment, CMR replacement, Science Complex
Signature facilities

IE) and computational science (Roadrunner)