Energy Security

Secure and expand the supply and delivery of affordable, clean energy with technologies that are resilient to evolving natural and adversarial risks.

Secure and Resilient Energy

Lawrence Livermore National Laboratory (LLNL) is exploring ways to ensure access to diverse, domestic energy resources through efficient and reliable energy generation, storage, and delivery systems.

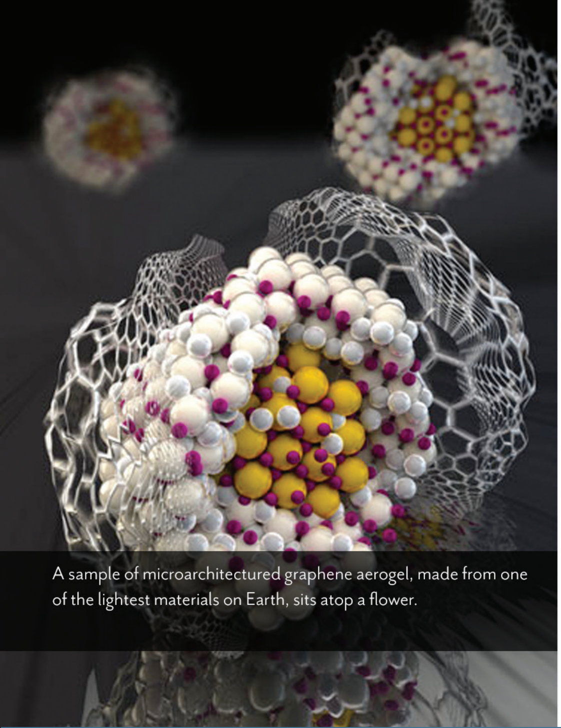
The Laboratory is also exploring novel ways to capture and recycle carbon dioxide (CO_2) into value-added products, and to store CO_2 indefinitely in terrestrial, soil, and geologic systems to reduce the concentration of atmospheric CO_2 and other greenhouse gases.

LLNL's researchers are also pioneering development of new energy sources to meet the needs of a future focused on renewables and carbon reduction goals.

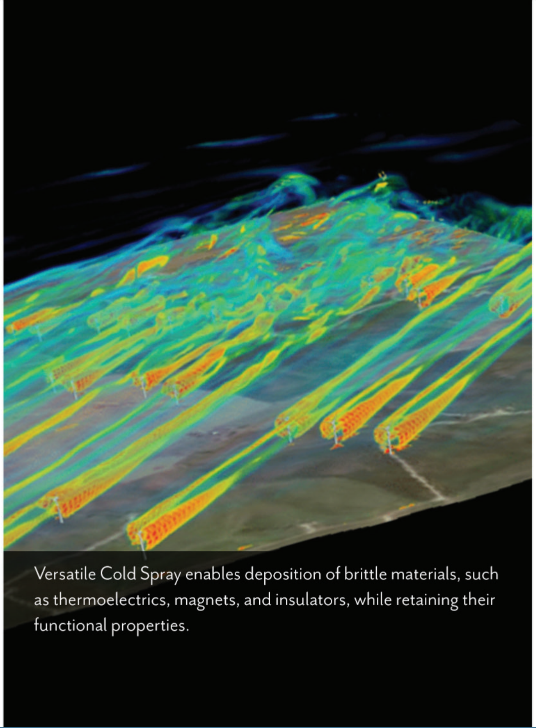
Accomplishments

Today's energy security mission at LLNL has a broad scope. Researchers are developing technologies to expand the use of low-carbon energy and identifying new clean energy resources. By exploring how to make energy-intensive processes more efficient, scientists are developing innovative technologies to sequester carbon underground, extract minerals by using less energy, and desalinate and detoxify water more efficiently. This expanded focus has produced the following accomplishments:

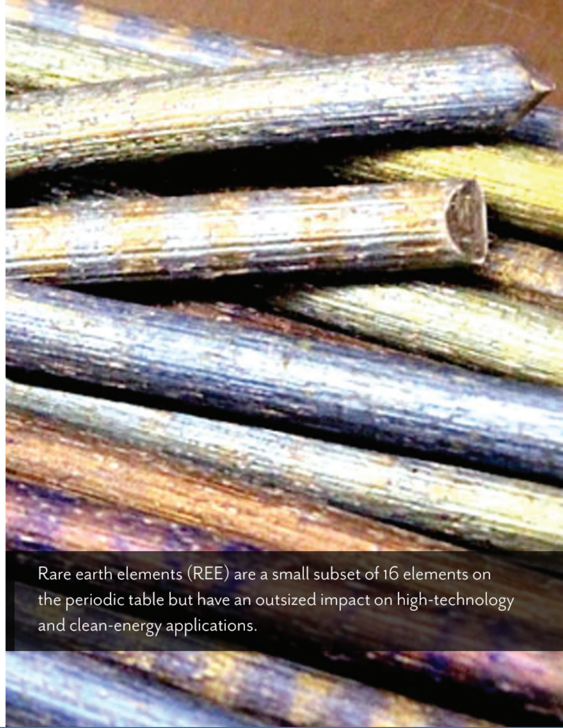
- Developed GEOSX, an open-source simulation platform that illustrates the mechanical, hydrologic, and geochemical response of subsurface reservoirs to carbon storage.
- Leveraged the power of high-performance computing to model and evaluate ways to better harness the potential of geothermal energy as a clean power source.
- Explored new composite materials with ionic conductivity for increased voltage, capacity, and stability—providing new options for fast-charging, lightweight batteries.
- Pioneered a new additive manufacturing technique to create thermoelectric generators that can harvest heat that would otherwise be lost and use it as an energy source.
- Demonstrated how biocatalysts that use live microbes can more efficiently convert carbon sources into valuable end-product chemicals, including biofuels.
- Developed new lightweight aluminum alloys that are structurally stable up to the melting point for improved energy efficiency in cars and trucks.
- Bioengineered a protein that can extract rare earth elements from electronic waste and purify it for use in clean energy applications, using a one-step, environmentally friendly process.
- Contributed to Getting to Neutral: Options for Negative Carbon Emissions in California report, exploring the capacity and costs of carbon capture on a national scale.



A sample of microarchitectured graphene aerogel, made from one of the lightest materials on Earth, sits atop a flower.



Versatile Cold Spray enables deposition of brittle materials, such as thermoelectrics, magnets, and insulators, while retaining their functional properties.



Rare earth elements (REE) are a small subset of 16 elements on the periodic table but have an outsized impact on high-technology and clean-energy applications.

Scientific Underpinnings

Energy security research at LLNL draws on the Laboratory's strengths in geoscience, atmospheric science, chemistry, physics, bioscience, materials science, engineering, advanced manufacturing, data science, and high-performance computing. In this multidisciplinary research environment, teams leverage a suite of unique experimental and computational resources to drive innovation.

- LLNL's high-performance computing resources enable scientists to model complex systems and optimize the energy efficiency of production.
- Advanced materials science and additive manufacturing research enables less-wasteful production while developing new materials for energy efficient and resilient technology.
- Earth and atmospheric science expertise is used to improve the detection and extraction of energy resources and the use of renewable energy, including wind and solar energy.
- Bioscience experts collaborate with chemists to develop catalysts capable of generating biofuels and microbes that can extract rare earth elements from electronic waste.
- High-energy-density science research and laser physics at the National Ignition Facility advance the quest for clean energy through inertial confinement fusion.
- LLNL collaborations accelerate solutions. The DOE's Energy Materials Network focuses on research involving national laboratories, industry, and academia.

The Future

LLNL's long-term vision for the U.S. energy system relies on low-carbon sources. To achieve this aim, we must ensure a secure, sustainable, resilient, and reliable national energy infrastructure.

Tomorrow's power grid will utilize smart technology and storage and distribution channels that fully incorporate renewable energy. Hydrogen continues to be a low-carbon fuel option, as scientists explore solutions for production, solid-state storage, and subsurface storage in geologic formations.

We will develop new ways to balance supply and demand in a diversified energy delivery system based on a decentralized network that shares sensor data, validates remote commands, and decreases vulnerabilities.

LLNL researchers improve our capability to predict and mitigate chemical degradation, oxidation, and corrosion of energy production and delivery infrastructure. Thermally resistant power turbines, radiation-tolerant material for nuclear power plants, and corrosion-resistant pipelines are crucial components of current and future energy systems.

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