

The background of the page is a grayscale photograph of a laboratory. On the left, there is a large piece of scientific equipment with a fan. In the center, a person is walking through a hallway lined with glass-walled laboratory rooms. On the right, another person is walking towards the camera. The image is overlaid with a large blue semi-transparent rectangle that contains the title text.

**THE ARGONNE
COLLABORATIVE CENTER
FOR ENERGY
STORAGE SCIENCE**



**ACCESS
YOUR
POTENTIAL.**





The ability to store energy—harness it now, use it later—opens so many possibilities, it must be considered truly revolutionary. Stored energy gives the world potential—the potential to be energy secure; the potential to create highly resilient electrical grids; and the potential to address global climate disruption through increased adoption of renewable energy and electric vehicles.

The U.S. Department of Energy's Argonne National Laboratory has built itself into one of the key global centers of this revolution with years of cutting-edge research in energy storage technology, leading the way through multiple generations of batteries used in vehicles and the grid to breakthroughs beyond lithium-ion.

The Argonne Collaborative Center for Energy Storage Science (ACCESS) is a collaboration of scientists and engineers from across Argonne that solves energy storage problems through multidisciplinary research.

ACCESS is the key that unlocks the potential of energy storage, helping public and private-sector customers turn science into solutions.

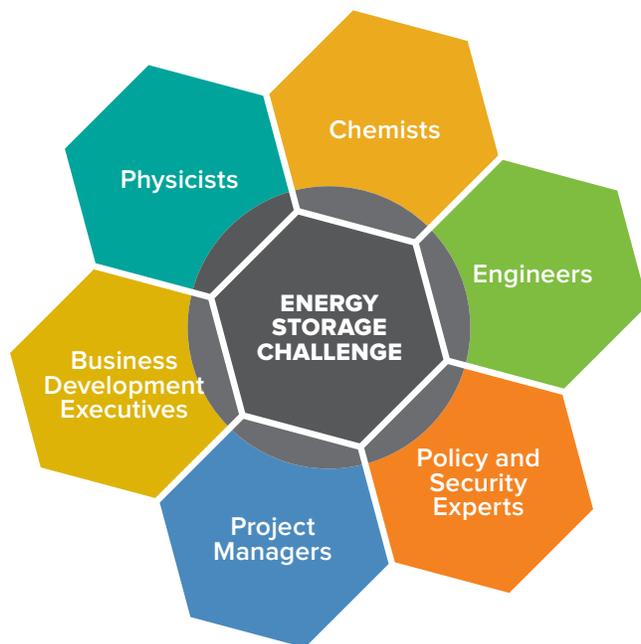


Lithium-ion battery cells are prepped for testing. With Argonne's state-of-the-art, custom-built equipment, simulations are performed to provide information on battery characteristics such as cycle life and calendar life.

A man in a white lab coat and safety glasses is working in a laboratory. He is looking down at something in his hands. The background shows laboratory equipment and pipes. A blue semi-transparent box covers the middle of the image, containing text. A green vertical bar is on the left side of the blue box.

ACCESS A UNIQUE COLLABORATIVE CENTER.

ACCESS brings to bear on the challenges of energy storage a unique combination of resources not found anywhere else. The potential of ACCESS lies in talent, time, and technical capabilities.



ACCESS the Talent.

ACCESS tackles each unique energy storage challenge with an ideal collaborative team assembled from Argonne's 1,400 award-winning and internationally recognized scientists and engineers. This enormous personnel potential represents dozens of disciplines including chemical sciences and engineering, high-energy physics, materials science, mathematics and computer science, nanoscience and technology, and X-ray science.

ACCESS the Time.

From the very first experiments on high-temperature lithium-sulfur batteries in the late 1960s to today's development of new technologies that move beyond lithium-ion, the road to energy storage innovation has led through Argonne. The collaborative work of Argonne researchers has invigorated the U.S. battery manufacturing industry, aided the transition of the U.S. automotive fleet toward plug-in hybrid and electric vehicles, and enabled greater use of renewable energy.



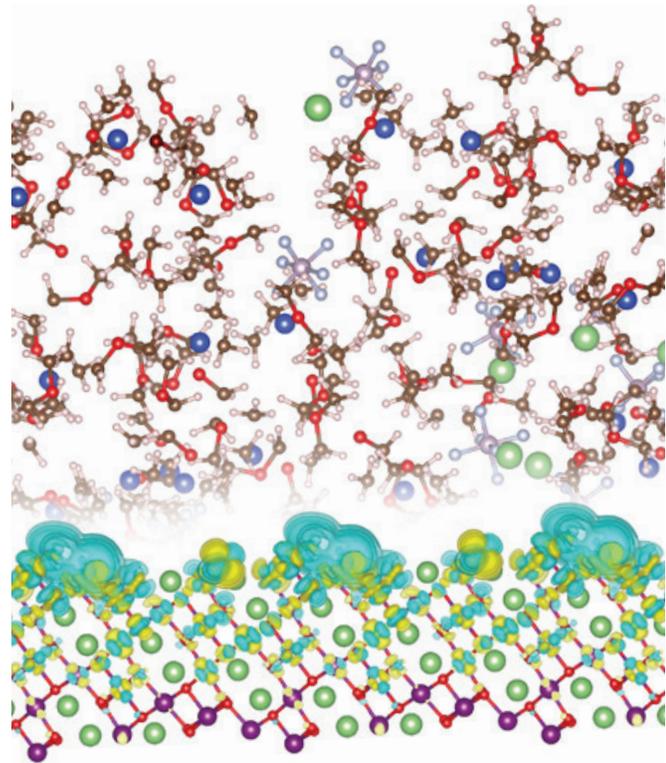
Argonne researchers perform an *in situ* X-ray spectroscopy study of a lithium-ion battery system at the Advanced Photon Source.



An Argonne researcher prepares a surface area analyzer for the characterization of battery materials.

ACCESS THE TECHNICAL CAPABILITIES.

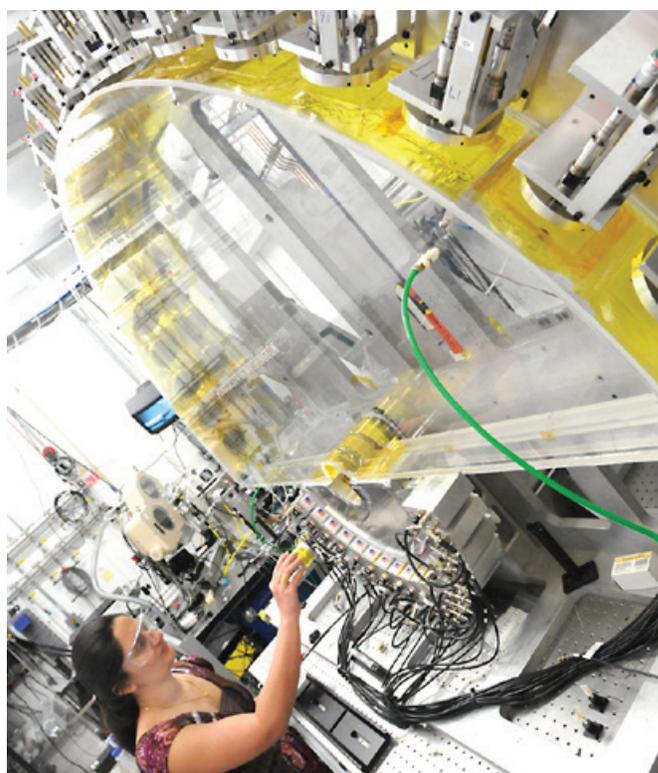
Argonne's energy storage proficiency captures every point on the spectrum from invention to commercialization. Whatever your unique challenge, Argonne has a range of processes to help you imagine and design, analyze and compare, question and answer, reject and accept.



DISCOVERY

Research on new materials—electrolytes, electrodes, interfaces—is the first step in developing next-generation energy storage. Argonne researchers make breakthrough discoveries, such as new materials for lithium-ion and beyond lithium-ion battery chemistries, using a number of Argonne's world-class facilities.

Model of the interface between an electrolyte (darker, above) and an electrode (green crystal structure, below) inside a lithium-ion battery.



MATERIALS CHARACTERIZATION

Leveraging Argonne's Advanced Photon Source, the Argonne Leadership Computing Facility and other world-class resources, Argonne researchers predict the properties of materials with extreme accuracy.

An Argonne physicist loads a lithium-ion battery into the low-energy resolution inelastic X-ray (LERIX) system for *in situ* measurements at the Advanced Photon Source. This multi-element X-ray scattering instrument is helping Argonne researchers to understand the fundamental mechanisms that limit the performance of batteries.



PROCESS SCALE-UP

After modeling to understand the charge transport process they developed in the laboratory, Argonne researchers modify the process as needed to enable economical commercial-scale production. Making this leap from bench to industrial scale represents one of the most significant hurdles in transitioning new battery materials and technologies to the market.

Argonne researchers have developed an improved, scalable process for the synthesis of a lithium-ion battery overcharge protection redox shuttle. Initial discovery amounts of battery materials are small compared to the kilogram-scale amounts needed for validation of new battery technologies.

PROCESS AND SYSTEMS MODELING

Again drawing upon the Argonne Leadership Computing Facility and other resources, Argonne scientists perform multiscale modeling of charge transport processes in energy storage materials. Argonne's modeling capability for battery systems predicts performance and costs through the battery pack scale. Argonne scientists and engineers are also world leaders in modeling entire grid and vehicle systems, helping to determine how storage technology will enable the systems of the future.

Argonne scientists use state-of-the-art simulation software to model the performance of electric vehicles and their batteries.



CELL FABRICATION

Argonne scientists keep the discovery-to-industry pipeline moving by fabricating commercial grade full-size prototype battery cells (pouch and 18650 cells) and battery electrodes necessary to test energy storage materials.

To make a prototype lithium-ion battery, an Argonne chemical engineer lines up positive and negative electrodes on a winder. The two electrodes are then wound together with a separator to create a structure called a "jellyroll."



PERFORMANCE TESTING

Fulfilling the promise of advanced battery systems requires understanding every battery failure—Argonne scientists find the answers by dissecting, harvesting, and analyzing materials from used and previously tested battery cells.

Hybrid and advanced electrical propulsion systems are among the systems tested in the precise laboratory environment of Argonne's Advanced Powertrain Research Facility.



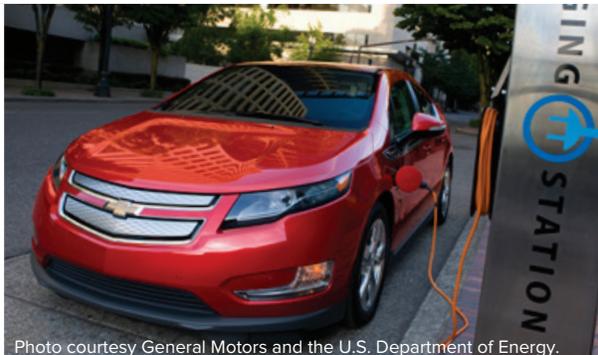


Photo courtesy General Motors and the U.S. Department of Energy.



Photo courtesy of U.S. Army National Guard, Staff Sgt. Roby Di Giovine.

INDUSTRY

Argonne's ultimate goal is to transfer battery innovations to the marketplace, providing processes, materials, performance testing data, and finished cells to industries including transportation, consumer electronics, and materials manufacture and supply. Customers working with ACCESS—be they small, medium, or large companies; government agencies; national security interests; or entrepreneurs—can realize their potential to bring transformational energy storage to the world.

ACCESS ONE-OF-A-KIND FACILITIES.

Argonne researchers collaborate on a combination of complementary facilities and scientific equipment unmatched in energy storage R&D.



The reaction calorimeter gives Argonne researchers the ability to precisely measure how much heat is generated by a chemical reaction.



A 500-square-foot dry room plays a critical role in the assembly and performance of a finished battery cell.



Information on important battery characteristics such as cycle life and calendar life come from simulations on state-of-the-art, custom-built equipment.

Materials Engineering Research Facility (MERF)

Enables development of manufacturing processes for producing advanced battery materials in sufficient quantity for industrial testing. MERF helps bridge the gap between benchtop science and industrial production by using cutting-edge tools to scale up production of newly discovered materials.

Cell Analysis, Modeling and Prototyping Facility (CAMP)

Designs, fabricates, and characterizes high-quality prototype cells using high-energy anode and cathode battery materials. CAMP-manufactured cells enable realistic, consistent, and timely evaluation of candidate chemistries in a close-to-realistic industrial format.

Electrochemical Analysis and Diagnostics Laboratory (EADL)

Provides battery developers with reliable and independent performance evaluations of their cells, modules, and battery packs. EADL has the capability to conduct 240 concurrent advanced battery studies under operating conditions that simulate electric vehicle and hybrid electric vehicle, plug-in hybrid electric vehicle, utility load-leveling, and standby/uninterruptible power source applications.

Argonne's energy storage researchers also benefit from access to the lab's other cutting-edge resources



An Argonne scientist analyzes results from battery sample testing that includes characterization in an inert "glovebox" and in a scanning-electron microscope for detailed, microstructural characterization.

Post-Test Facility

Assists with difficult problems related to battery failure modes. Designed to handle air-sensitive materials, such as those from lithium-based or sodium-based battery technologies, the facility uses a mixture of materials science and wet-chemistry techniques. Facility staff has direct experience evaluating pouch and hard-case cells, ranging from ~1 mAh to 20 Ah. With knowledge of the causes of performance decline and/or failure, battery developers work toward improving the life and performance of batteries.



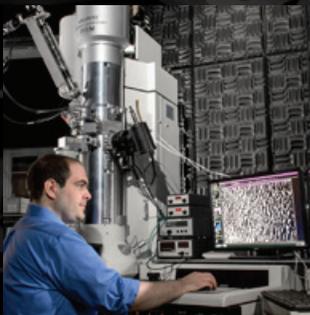
Advanced Photon Source (APS)

The APS provides the brightest storage ring-generated X-ray beams in the Western Hemisphere for research in materials science, chemistry, biology, physics, earth and planetary science, and environmental science.



Argonne Leadership Computing Facility (ALCF)

The ALCF is half of the leadership computing facility supported by the U.S. Department of Energy, and is home to Mira, the fifth-fastest supercomputer in the world. ALCF staff provides expertise and assistance to support user projects to achieve top performance of applications and to maximize benefits from the use of computing resources.



Center for Nanoscale Materials (CNM)

The Center for Nanoscale Materials develops and maintains unique capabilities for electron beam characterization and applies those capabilities to solve materials problems in three major areas: materials research, technique, and instrumentation.



ACCESS PROVEN CAPABILITY.

Argonne has demonstrated achievement in meeting a spectrum of energy storage challenges and has amassed a portfolio of more than 125 patented advanced cathode, anode, electrolyte, and additive components for lithium-ion, lithium-air, lithium-sulfur, sodium-ion, and flow batteries.

ACCESS A COMPETITIVE ADVANTAGE.

Today's changing business climate has led companies to devote research dollars to product development, with a reduced focus on basic science research.

By developing tailored teams of experienced researchers collaborating in one-of-a-kind facilities on world-class equipment, ACCESS offers companies an affordable, manageable alternative to increase their stake in scientific discovery.

The increasing complexity of scientific challenges requires access to resources that private industry—particularly small and medium-sized businesses—cannot necessarily muster. Argonne's time, talent, and tools represent billions of dollars invested in energy storage R&D; ACCESS turns this investment into a competitive advantage for any company looking to solve its unique energy storage challenge.

HOW YOUR COMPANY CAN WORK WITH ARGONNE

Argonne works with industry and governmental partners to solve their enduring R&D challenges, identify commercialization opportunities, license new applications, and introduce transformational technologies to the marketplace.

Argonne offers multiple processes for collaborating with outside groups to accommodate both small and large firms. Licensing and contractual agreements vary based on the particular situation; we will work with you to meet specific needs, including concerns about intellectual property. For additional information on how to work with Argonne, visit www.anl.gov/technology/partnerships.

Licensing agreements—with leading companies including General Motors, BASF, LG Chem, General Electric, and Toda America—to mass produce Argonne's patented materials for advanced batteries have led to construction of new plants and creation of jobs in the United States.



Representatives from the Department of Energy and Argonne joined federal, state and local officials, as well as representatives and BASF personnel for a ribbon cutting at the company's first-of-its-kind, \$50 million Elyria, Ohio, facility. Photo courtesy of BASF Corporation.



**LET ARGONNE HELP
UNLEASH THE POTENTIAL
OF YOUR ENERGY
STORAGE SOLUTION.**

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 **ACCESS**



ABOUT ARGONNE NATIONAL LABORATORY

- U.S. Department of Energy research facility
- Midwest's largest federally funded R&D facility
- Located in Lemont, IL, about 25 miles (40 km) southwest of Chicago, IL (USA)
- Conducts basic and applied research in dozens of fields
- 1,400 world-class staff scientists and engineers
- Unique suite of leading-edge and rare scientific user facilities

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