DOE Energy Innovation Hub – Batteries and Energy Storage

JCESR | Joint Center for Energy Storage Research

Major advances in battery and energy storage technologies play a vital role in the efforts to transform our nation's energy economy and reduce our dependence on fossil fuels in the years ahead.

Advances in energy storage are critical to modernizing the nation's aging electrical grid—and integrating clean, renewable energy sources such as wind and solar power into our electricity supply. Breakthroughs in battery technology are also needed to reduce our dependence on petroleum through expanded electrification of vehicles.

Across our energy economy, effective storage of energy holds the key to the flexible energy sourcing and delivery required to diversify our energy portfolio, renovate our energy infrastructure, and alleviate the growing environmental costs and risks of continued reliance on fossil energy as our primary energy source.

Enabling new technologies

Fundamental research at our national laboratories and universities has yielded significant improvements in batteries and energy storage over the past 20 years. But we are still far short of comprehensive solutions for the grid and transportation.

The goal of the Joint Center for Energy Storage Research (JCESR), a DOE Energy Innovation Hub, is ambitious: to pursue advanced scientific research to understand electrochemical materials and phenomena at the atomic and molecular scale, and to use this fundamental knowledge to discover and design next-generation energy storage technologies.

We seek new technologies that move beyond lithium-ion batteries and store at least five times more energy than today's batteries at one-fifth the cost—and to achieve this objective within five years. By combining the research firepower of national laboratories and universities with industry's skill at bringing new products and technologies to market, JCESR is well-equipped to pursue the transformative scientific and technological advances essential to meet this goal.

Fundamental research

JCESR's core task is basic research—using a new generation of nanoscience tools that enable us to observe, characterize, and control matter down to the atomic and molecular scales.

This enhanced ability to understand materials and chemical processes at a fundamental level will enable us to reinvent electrical storage and achieve major improvements in battery performance at reduced cost.

Our industrial partners will help guide our efforts to ensure that research leads toward practical solutions that are competitive in the marketplace.

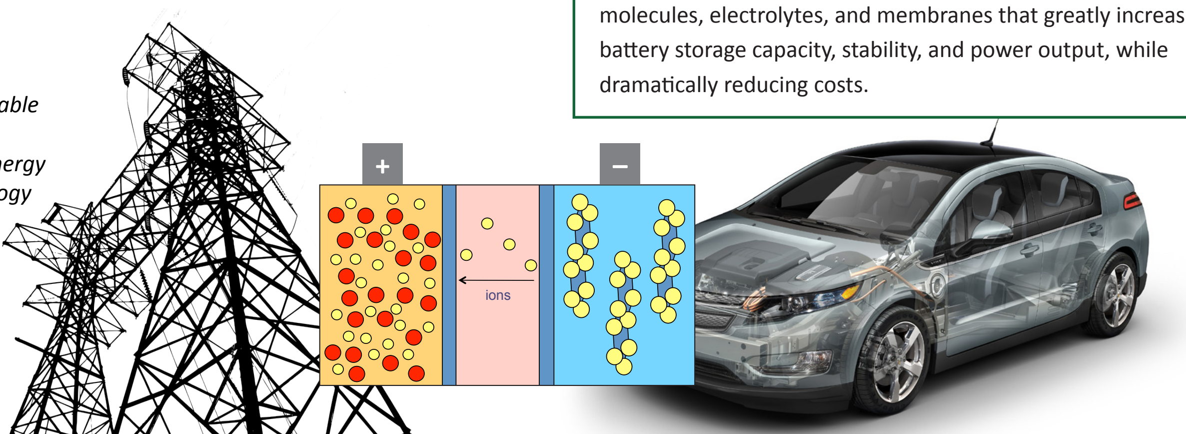
Core Scientific Challenges

JCESR's core challenges fall into three broad scientific categories:

Increasing charge density: Can we replace the singly charged lithium ion with a doubly or triply charged ion such as magnesium or aluminum to double or triple the energy density of batteries? Use of multiply charged ions leads to fundamental questions of the speed with which they move through liquids, across interfaces between battery materials, and into solids where they store and release energy. Success with this process, called **multivalent intercalation**, coupled with improvements in battery electrodes, could lead to high-capacity, high-voltage batteries that store five times more energy in the same space as today's batteries.

Storing energy in chemical bonds: Can we discover new electrode materials that store and release electricity by making and breaking high-energy chemical bonds? These discoveries in **chemical transformation** can lead to new battery materials and architectures with highly reversible charge and discharge cycles, dramatically increased storage capacities, longer battery lifetimes, and lower system costs.

Storing energy in liquids: Can we replace conventional solid electrodes with inexpensive liquid solutions or nanoparticle suspensions that charge and discharge as they flow through the next-generation battery? This knowledge of what experts call **non-aqueous redox flow** will help us design new molecules, electrolytes, and membranes that greatly increase battery storage capacity, stability, and power output, while dramatically reducing costs.



Basic materials research will enable next-generation batteries and energy storage technology for the grid and electric vehicles.

Joint Center for Energy Storage Research

The JCESR team

DOE National Laboratories
- Argonne National Laboratory
- Lawrence Berkeley National Laboratory
- Pacific Northwest National Laboratory
- Sandia National Laboratories
- SLAC National Accelerator Laboratory

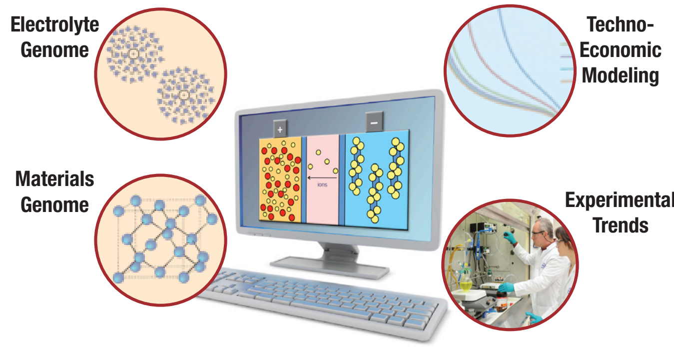
Universities
- Northwestern University
- University of Chicago
- University of Illinois, Urbana-Champaign
- University of Illinois, Chicago
- University of Michigan

Industry
- Dow Chemical Co.
- Applied Materials, Inc.
- Johnson Controls Inc.
- Clean Energy Trust

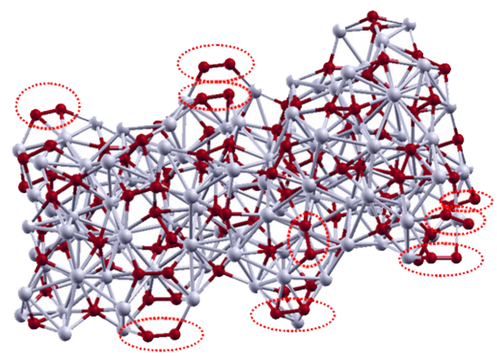
Individual Members' Home Institutions
- Massachusetts Institute of Technology
- University of Waterloo

Argonne leads JCESR
Headquartered at Argonne National Laboratory, the JCESR Energy Innovation Hub brings together many of the world's leading battery researchers around a common objective of overcoming fundamental challenges to improving energy systems. With up to $120 million in funding from the U.S. Department of Energy's Office of Science for an initial five-year period, subject to availability of funds, the project's large scale and close collaborations with industry in all stages of the R&D pipeline are unprecedented for battery research programs.

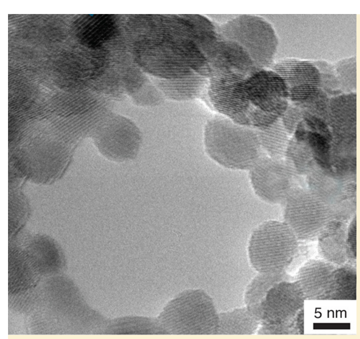
Economic benefits
JCESR's discoveries will provide the advanced R&D to give our nation the foundation to manufacture competitive, high-performance products for years to come. Innovations that improve sustainable transportation and electric grid storage will also benefit the many industries that rely on products that use rechargeable batteries, such as construction, electronics, utilities, medicine, aerospace, and defense.



Computer modeling: *JCESR's advanced computational tools are key to streamlining next-generation materials discovery and battery design and development. Materials genome techniques will discover and evaluate tens of thousands of advanced candidate electrodes. JCESR's innovative electrolyte genome opens access to broad new classes of "soft" energy storage materials unconstrained by crystal structure. Techno-economic modeling translates these materials discoveries to systems level operation, projecting the performance and cost of candidate battery systems before they are prototyped.* Image courtesy of Argonne National Laboratory.



Predictive design of battery materials: *Computer-generated model of the reactions at the cathode in a lithium-air battery. High-performance computing is critical for achieving the fundamental scientific breakthroughs needed to create next-generation batteries.* Image courtesy of Argonne National Laboratory.



Nanoscale processing control for improved battery structure: *Controlling the nanoscale design of host materials allow controlled electrochemical reactions. By controlling the creation and location of pores that become reaction zones, scientists can dictate where electrochemical reactions occur.* Image courtesy Lawrence Berkeley National Laboratory.