JCESR
Next-Generation Batteries

JOINT CENTER FOR ENERGY STORAGE RESEARCH

BUILT FROM THE BOTTOM UP, ATOM BY ATOM... MOLECULE BY MOLECULE

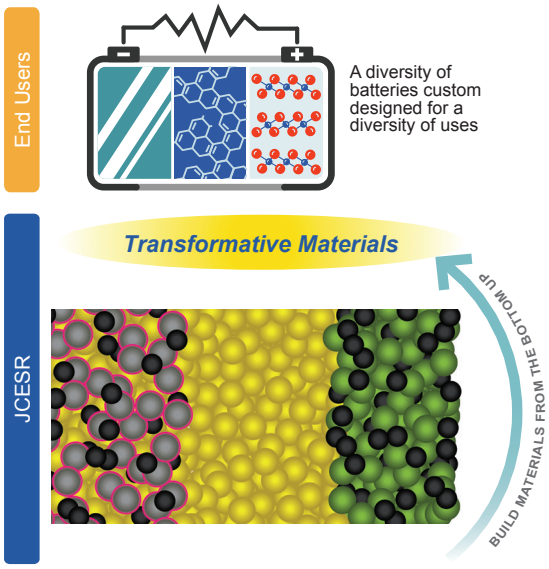
Imagine a world where energy storage transforms the electricity grid with new levels of reliability and resilience while using wind and solar power as primary energy sources; where cars run on batteries with no toxic emissions, travel more than 400 miles on a single charge, are much safer and cost less. Achieving these transformational changes requires a diversity of next-generation batteries with superior performance, purpose-designed for specific uses.

JCESR is a DOE Energy Innovation Hub designed to leapfrog current battery technology. In its first five years, JCESR uncovered atomic and molecular origins of battery-level performance using advanced tools of materials simulation and multimodal electrochemical characterization, and evaluated innovative battery systems using techno-economic modeling. Our frontier scientific advances included a comprehensive simulation of cathodes for multiply-charged ion systems and solid-state electrolytes, and used machine learning for discovery of new redox-active polymer materials (”redoxmers”).

We promised a prototype each for the grid and transportation, and delivered four, one of which is being commercialized by a JCESR startup. However, even if all four of the prototypes reached commercialization, it would not satisfy the rapidly growing demand for a diversity of purpose-designed batteries for the grid and transportation.

In our second five years JCESR shifts its emphasis from specific battery systems to transformational materials that can be mixed and matched to build a diversity of next-generation batteries purpose-designed to specific applications. To accomplish our vision, JCESR has identified three fundamental challenges that underpin battery science and broadly impact the field of electrochemistry. JCESR is introducing a new bottom-up constructionist approach for designing materials at the atomic and molecular level that will provide the foundation for transforming the battery landscape:

1. Enable fast, high-power charging and discharging by understanding the motion of ions in battery materials
2. Introduce resilient behavior to active battery materials to enable, for example, self-healing, through an exhaustive knowledge of materials synthesis and operational dynamics
3. Introduce deliberate defects and imperfections in battery materials to significantly improve their performance



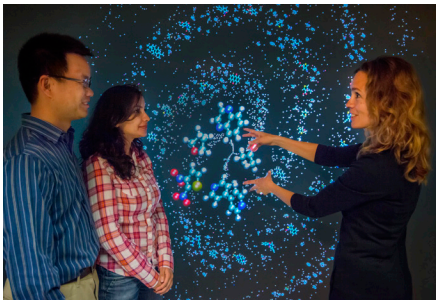
In its first five years, JCESR researchers identified the atomic and molecular origins of battery-level performance for energy density, safety, performance, lifetime and cost. In the next five years, JCESR will provide the knowledge base to build the battery from the bottom up, with each atom or molecule playing a prescribed role in producing targeted transformational materials behavior.

The JCESR team consists of 150 researchers across 18 institutions, spanning fundamental material science and chemistry to engineering, who follow a common science strategy.

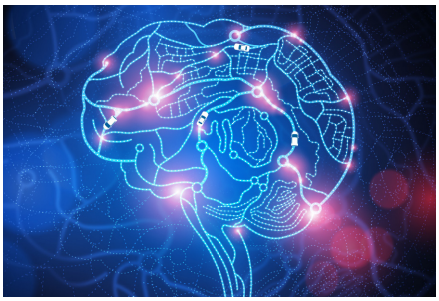
"This is a storage moment. Electric cars, grid storage, consumer electronics, and the promise of battery-powered flight are creating a battery market that is exploding. While delivering four prototypes during our first five years, we learned that revolutionizing the battery landscape requires a deeper understanding of battery materials–many of which do not exist in nature. In the next five years, JCESR researchers will design materials from the bottom up, getting us that much closer to the U.S. leading this important market transformation."

– George Crabtree

JCESR TOOLS



Materials Project and Electrolyte Genome. By providing the materials community with open source atomic and molecular level information required to approach design more effectively, the Materials Project and the Electrolyte Genome accelerate the discovery of new battery electrodes and electrolytes.



Machine learning enables systems to learn automatically, based on patterns in data, and make better searches, decisions, and predictions about new materials before they are made in the laboratory. JCESR applies machine learning to accelerate discovery of transformational materials that will enable next-generation batteries.

Multimodal Characterization. JCESR has created and integrated a collection of signature research tools that characterize and model electrode surfaces and interfaces chemically, structurally, and electronically, enabling our holistic, molecular-based design strategy.

JCESR BY THE NUMBERS

JCESR's 150+ researchers have published 450+ papers, submitted 70 invention disclosures, built 4 prototypes, and launched 3 commercial startups. Our community includes 100+ affiliates in 26 states and 4 countries.

JCESR's 100+ alumni span graduate students, postdocs, and mid-career researchers who represent our legacy in universities, national laboratories, and private industry. This human capital is one of our most impactful and enduring contributions to the energy storage community.

U.S. DEPARTMENT OF ENERGY
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See the JCESR website for more information on these and other success stories.
http://www.jcesr.org | 630.252.8801

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