U.S. DEPARTMENT of ENERGY | Office of Science

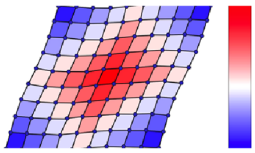
DOE Energy Innovation Hubs

The Basic Energy Sciences (BES) program of the Office of Science (SC) manages DOE Energy Innovation Hubs that focus on collaborative research to overcome key scientific barriers for major energy challenges. The research activities are centered on fundamental science whose impact is demonstrated by development and evaluation of integrated energy systems, a critical step toward implementation of scientific innovation in transformative energy technologies. The Hubs funded and managed by SC/BES bring together teams of experts from multiple disciplines to focus on two grand challenges in energy: (1) Fuels from Sunlight and (2) Batteries and Energy Storage.

The **Fuels from Sunlight Hub** program currently consists of two multidisciplinary research centers that address emerging new directions as well as long-standing challenges in liquid solar fuels generation via artificial photosynthesis approaches. Scientists in each center are employing new approaches to understand, design, and develop chemical processes and new materials for directly converting sunlight into storable fuels using only water and carbon dioxide.

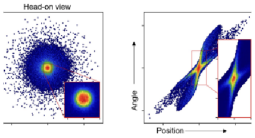
The Liquid Sunlight Alliance (LiSA), established in 2020 and led by the California Institute of Technology in close partnership with Lawrence Berkeley National Laboratory, is pursuing a "co-design" strategy to make the many complex steps in solar fuels generation work more efficiently both individually and in concert with each other. Enhanced understanding of these processes at the molecular-level are targeted through a combination of advanced computational methods and sophisticated characterization tools such as ultrafast x-ray and optical spectroscopy. LiSA partner institutions also include the National Renewable Energy Laboratory, SLAC National Accelerator Laboratory, the University of California Irvine, the University of California San Diego, and the University of Oregon.

Highlights



Hot on the Trail of a Thermoelectric Material with High-Conductivity but Slow Thermal Transfer

A "neutron camera" device reveals how a thermoelectric material maintains an overall crystalline structure despite local dynamic disorder



Harnessing Distortions for Denser

The Center for Hybrid Approaches in Solar Energy to Liquid Fuels (CHASE), established in 2020 and led by the University of North Carolina at Chapel Hill, seeks to develop hybrid photoelectrodes for fuel production that combine semiconductors for light absorption with molecular catalysts for selective chemical conversion. CHASE is blending experiment with theory to understand and establish new design principles that can enable the integrated light-driven synthesis of liquid fuels through multi-catalyst cascades. CHASE partner institutions are Brookhaven National Laboratory, Yale University, the University of Pennsylvania, North Carolina State University, and Emory University.

Both centers build on important scientific understandings of natural photosynthesis and related chemical processes that have been achieved through decades of fundamental research by single principal investigators, small groups, and large multi-institutional teams, including the first Fuels from Sunlight Hub, the Joint Center for Artificial Photosynthesis (JCAP) that was established in 2010. Significant JCAP accomplishments include the discovery of new ways to protect light-absorbing semiconductors from corrosion; creation of innovative high throughput capabilities for synthesis, characterization, and data analysis of light absorbers and electrocatalysts; discovery of new earth-abundant catalysts with performance comparable to those based on rare-earth metals; discovery of mechanistic aspects of key factors important for tuning activity and selectivity of carbon dioxide reduction to specific carbon-based products; and implementation of fully integrated test-beds to evaluate new components and assemblies for solar fuels generators including the design and demonstration of prototypes with highly efficient solar-to-hydrogen conversion.

More information on LiSA, CHASE, and JCAP is available at the links below.

LiSA Web Site | CHASE Web Site | JCAP Web Site | Selected JCAP Tools | Selected JCAP Science Advances

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The **Batteries and Energy Storage Hub** program currently consists of two multidisciplinary research centers that address key fundamental issues in energy storage for transportation and the grid. Both exploit cutting edge synthesis, analytical tools and computational analysis to create breakthroughs in the fundamental science of materials and chemistry to better understand and control critical phenomena that underpin efficient, cost-effective and environmentally friendly energy storage systems.

Particle Beams

The intra-beam repulsion that typically degrades electron beam quality can now be used to improve it

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The Aqueous Battery Consortium (ABC) was established in September 2024 with a mission to generate fundamental breakthroughs to enable aqueous batteries for long-duration energy storage with a potential of 10x cost reduction compared to lithium-ion batteries while ensuring excellent safety and scalability for global energy storage. The Hub will exploit electrodeposition and stripping as the charge-storage mechanism for both metal anodes and metal oxide cathodes, affording bigger opportunities than the ion intercalation mechanism. ABC is led by Stanford University with significant partnership with SLAC National Accelerator Laboratory and twelve other institutions representing wide-ranging expertise and experience from leaders in their fields as well as promising young scientists.

The Energy Storage Research Alliance (ESRA) was established in September 2024 with the goal to provide the scientific underpinning to address some of the nation's most pressing battery challenges, including safety, high-energy density, and long-duration batteries made from inexpensive, abundant materials. The Hub includes transformative scientific thrusts and crosscutting themes that allow researchers to design materials with atomic and molecular level precision in liquids, soft, and condensed matters; to observe and quantify ion and charge transport; and to build architectures with materials and their interphases to achieve superior properties. ESRA's strategy is based on the team's ability to gain precise control over ion-matter interactions, leveraging world-leading computational and experimental capabilities that are enabled by recently emerged tools and by creating a dynamic and collaborative working environment. ESRA is led by Argonne National Laboratory (ANL) with thirteen national laboratory and university partners.

Both new Hubs build off research from other BES-funded activities, including the Joint Center for Energy Storage Research (JCESR) Hub that was led by ANL and funded from 2013 – 2023. JCESR made several major contributions to battery science. These include the combining data science and simulation to accelerate the discover of battery materials, developing and refining two powerful analytical techniques (electrophoretic NMR and X-ray photon correlation spectroscopy) to elucidate the role of molecules in ion transport, and establishing a comprehensive understanding of divalent battery materials.