U.S. DEPARTMENT OF ENERGY | Office of Science

Grid Storage and the Energy Frontier Research Centers

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Division of Materials Sciences and Engineering

Office of Basic Energy Sciences

US-EU Workshop on Grid Storage

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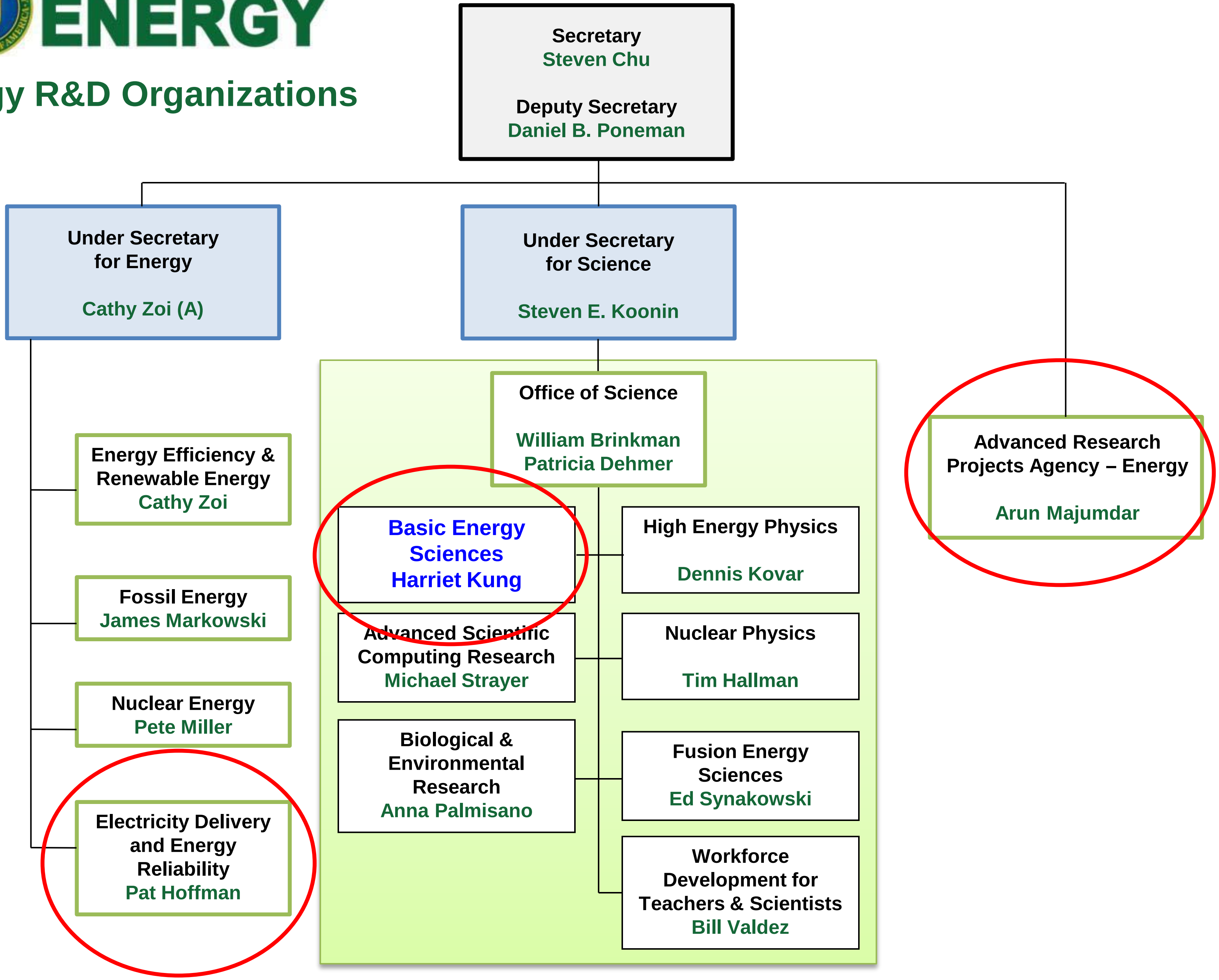
U.S. DEPARTMENT OF ENERGY

Energy R&D Organizations

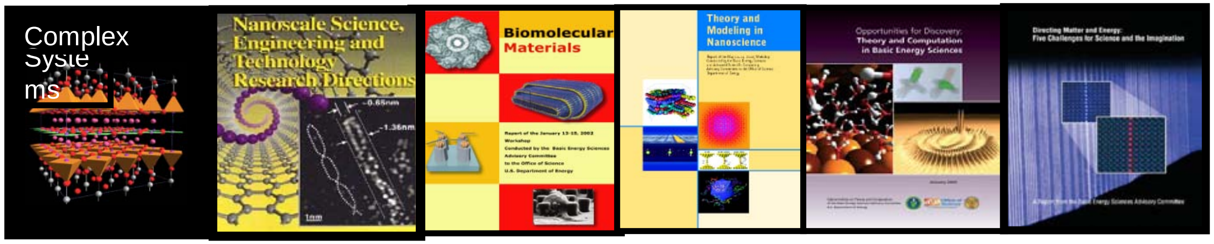


Priority: Science and Discovery
Invest in science to achieve transformational discoveries

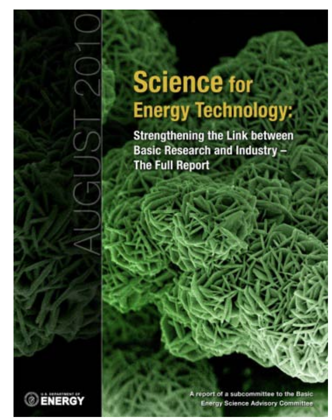
- **Focus on transformational science**
  - Connect basic and applied sciences
  - Embrace a degree of risk-taking in research
  - Create an effective mechanisms to integrate university, national laboratory, and industry activities
- **Develop science and engineering talent**
  - Train the next generation of scientists and engineers
  - Attract and retain the most talented researchers
- **Collaborate universally**
  - Partner globally
  - Support the developing world
  - Build research networks across departments, government, nation and the globe

BESAC & BES Strategic Planning Activities

- *Science for Discovery*



- *Science for National Needs*



Newly Published!

Newly Published!

BES Research — Science for Discovery & National Needs
Three Major Types of Research Thrusts

increasing progression of scientific scope and level of effort

- **Core Research**

  Support single investigator and small group projects to pursue their specific research interests.

  - Enable seminal advances in the core disciplines of the basic energy sciences—materials sciences and engineering, chemistry, and aspects of geosciences and biosciences. Scientific discoveries at the frontiers of these disciplines establish the knowledge foundation to spur future innovations and inventions.

- **Energy Frontier Research Centers**

  $2-5 million-per-year research centers, established in 2009, focused on fundamental research related to energy

  - Multi-investigator and multi-disciplinary centers to harness the most basic and advanced discovery research in a concerted effort to accelerate the scientific breakthroughs needed to create advanced energy technologies.

- **Energy Innovation Hubs**

  $20 million+ -per-year research centers will focus on integrating basic & applied research with technology development to enable transformational energy applications

  - Hubs comprise a larger set of investigators spanning science, engineering, and other disciplines focused on a single critical national need identified by the Department; each Hub is expected to become a world leading R&D center in its topical area to develop a complete energy system.

Energy Frontier Research Centers

Tackling Our Energy Challenges in a New Era of Science

- To engage the talents of the nation's researchers for the broad energy sciences
- To accelerate the scientific breakthroughs needed to create advanced energy technologies for the 21st century
- To pursue the fundamental understanding necessary to meet the global need for abundant, clean, and economical energy

46 centers awarded ($777M over 5 years), representing 102 participating institutions in 36 states and D.C.

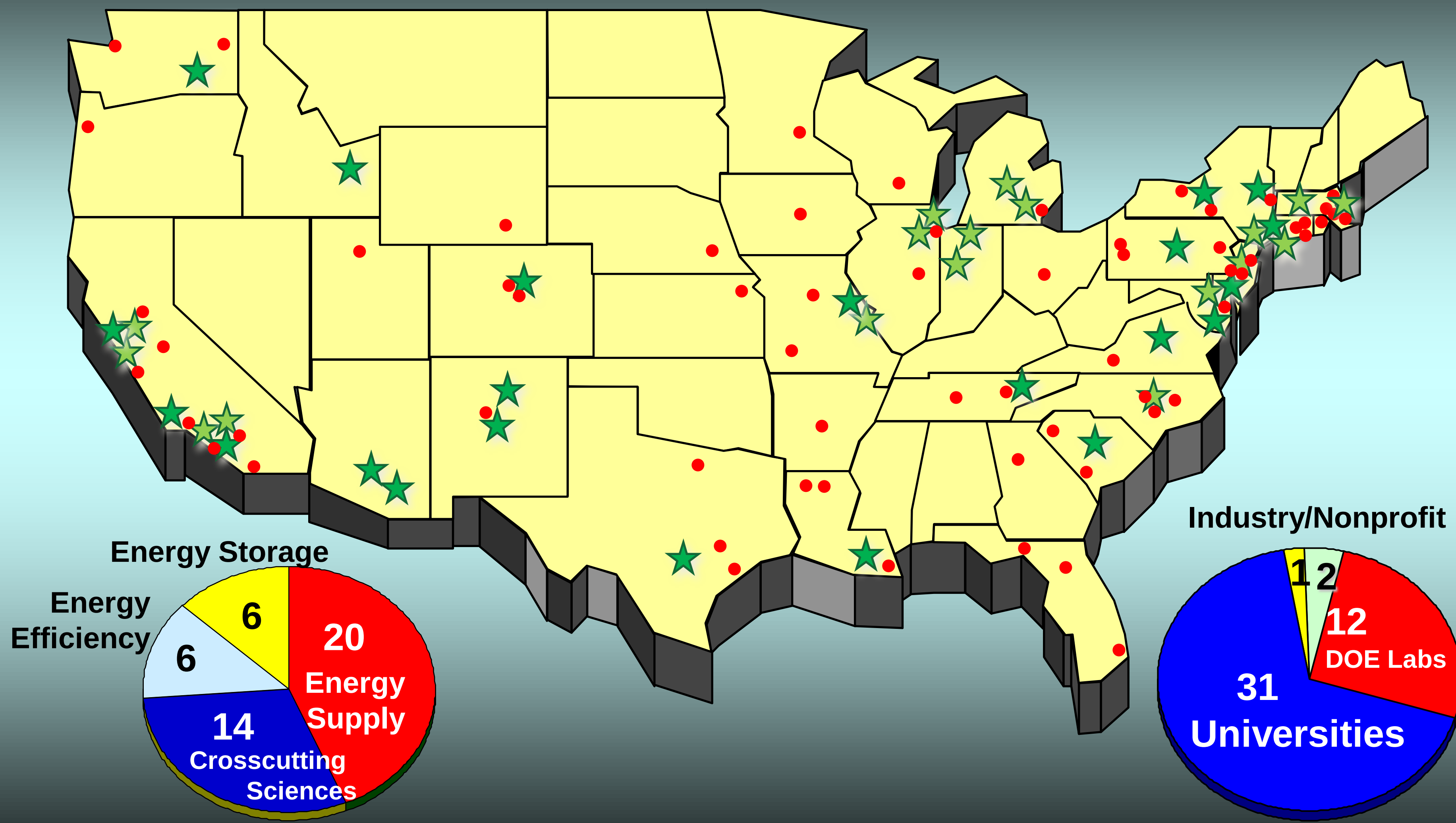
Pursue *collaborative* basic research that addresses both energy challenges and science grand challenges in areas such as:

- Solar Energy Utilization
- Combustion
- Bio-Fuels
- Catalysis
- Energy Storage
- Solid State Lighting
- Geosciences for Energy Applications
- Superconductivity
- Advanced Nuclear Energy Systems
- Materials Under Extreme Environments
- Hydrogen

Energy Frontier Research Centers

46 centers awarded, representing 102 participating institutions in 36 states plus D.C

Energy Frontier Research Center Locations (★ Leads; • Participants)



By Topical Category

By Lead Institution

Energy Frontier Research Centers directly related to Energy Storage

project period 08/01/09 – 07/31/14

Michael Thackeray, ANL

Center for Electrical Energy Storage

Grigorii Soloveichik, General Electric Global Research

Center for Electrocatalysis, Transport Phenomena, and Materials (CETM) for Innovative Energy Storage

Héctor Abruña, Cornell Univ.

Energy Materials Center at Cornell (EMC^2)

Clare P. Grey, Stony Brook Univ.

Northeastern Chemical Energy Storage Center

Gary Rubloff, Univ. of Maryland

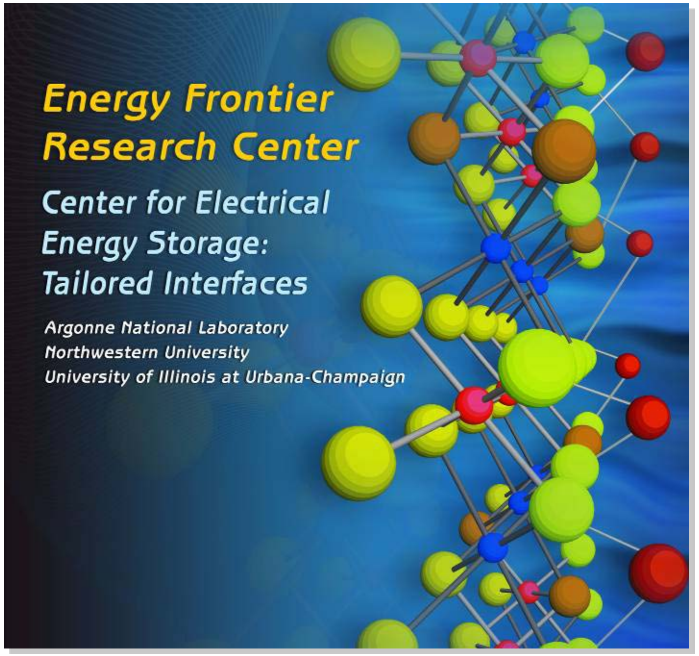
Center for Science of Precision Multifunctional Nanostructures for Electrical Energy Storage

Ken Reifsnider, Univ. of South Carolina

Heterogeneous Functional Materials (HeteroFoaM) Center

Center for Electrical Energy Storage
Michael Thackeray (Argonne National Laboratory)

The Center's overarching mission is to acquire a fundamental understanding of interfacial phenomena controlling electrochemical processes that will enable dramatic improvements in the properties and performance of electrical energy storage devices such as batteries and supercapacitors.



RESEARCH PLAN AND DIRECTIONS

Control of ionic and electronic transport and the stability of an electrified interface is central to the high energy and power output, lifetime, and safety of batteries and supercapacitors. Radical improvements will be sought through the synthesis and design of novel, stabilized architectures at the electrode-electrolyte interface and the characterization of electrochemical processes at the interface.

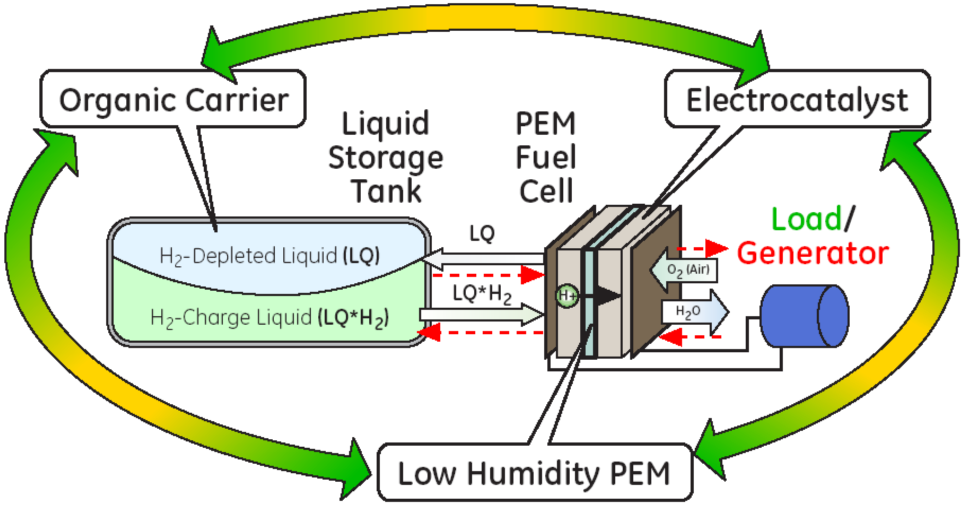
Argonne NATIONAL LABORATORY
ILLINOIS UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
NORTHWESTERN UNIVERSITY

U.S. DEPARTMENT OF ENERGY

Center for Electrocatalysis, Transport Phenomena, and Materials for Innovative Energy Storage

Dr. Grigorii Soloveichik (GE Global Research)

Electrocatalysis, transport phenomena and membrane materials research aimed to three novel components of an entirely new high-density energy storage system combining the best properties of a fuel cell and a flow battery: organic carriers, electro(de)hydrogenation catalysts, and compatible PEM



RESEARCH PLAN AND DIRECTIONS

Challenges: - Effective electrocatalysts for (de)hydrogenation of organic carriers
- Transport of protons and electrons
- Compatibility of cell components

Approaches: combination of modeling, synthetic chemistry and electrochemistry

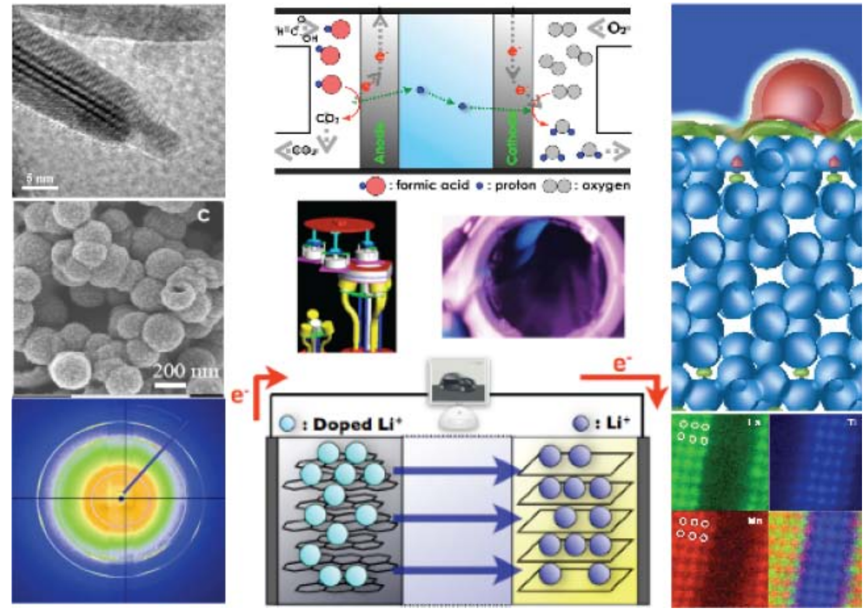
Unique aspects: using PEM fuel cell with organic carriers instead hydrogen gas

Potential outcome: high-density mobile and stationary energy storage systems

GE   BERKELEY LAB   Yale UNIVERSITY   STANFORD UNIVERSITY

Energy Materials Center at Cornell (EMC^2)
Héctor D. Abruña (Cornell University)

Summary statement: We aim to achieve a detailed understanding, via a combination of synthesis of new materials, experimental and computational approaches, of how the nature, structure, and dynamics of nanostructured interfaces affect energy generation, conversion and storage with emphasis on fuel cells and batteries.



RESEARCH PLAN AND DIRECTIONS

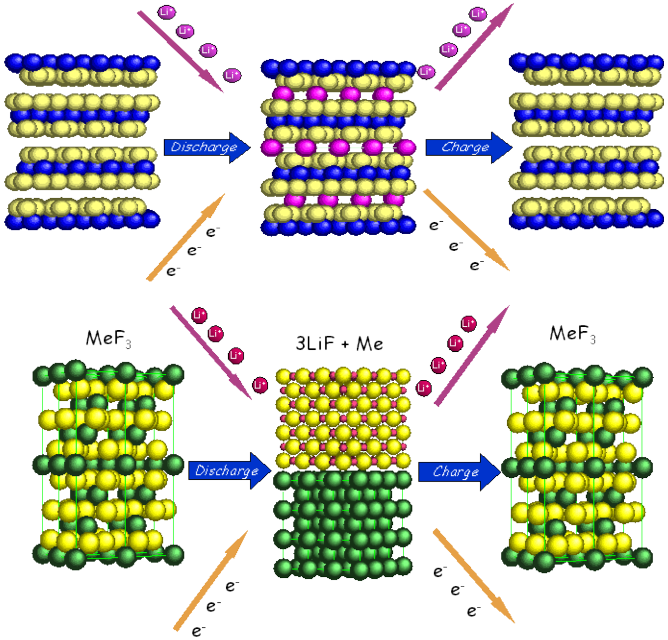
The major challenges relate to materials performance in energy generation, conversion and storage technologies especially fuel cells and batteries. To address these, we will prepare and characterize novel nanoscale materials including ordered intermetallic phases and "atomically engineered" complex oxides. These will be characterized through novel experimental tools and computational platforms.

Cornell University

BERKELEY LAB

Northeastern Chemical Energy Storage Center (NECESC)

Clare P. Grey, Director (Stony Brook University)



Summary statement: A fundamental understanding of how key electrode reactions occur, and how they can be controlled will be developed, so as to identify critical structural and physical properties that are vital to improving battery performance; this information will be used to optimize and design new electrode materials.

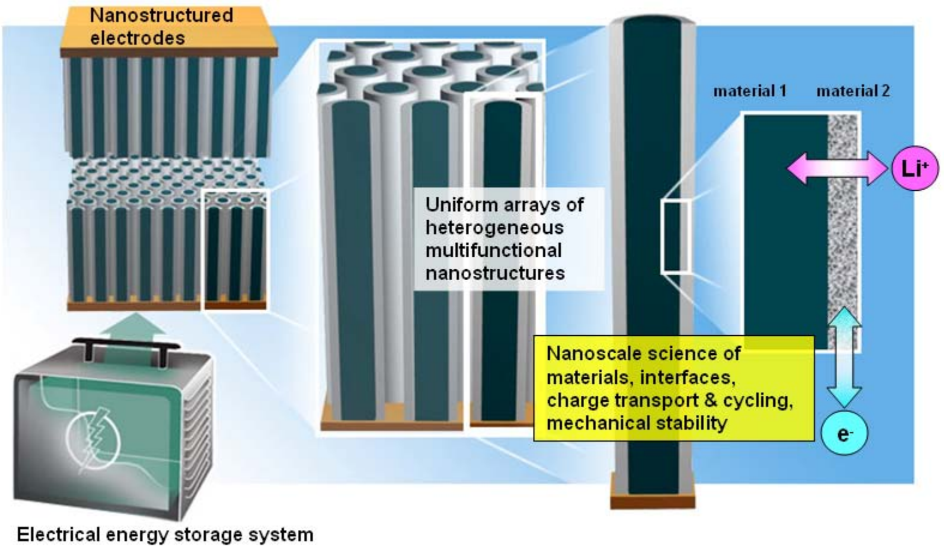
RESEARCH PLAN AND DIRECTIONS

The processes that occur in batteries are complex, spanning a wide range of time and length scales. The assembled team of experimentalists and theorists will make use of, and develop new spectroscopy, scattering, imaging and theoretical methodologies to determine how electrodes function in real time, as batteries are cycled.

Center for Science of Precision Multi-functional Nanostructures for Electrical Energy Storage
Gary Rubloff (University of Maryland)

The EFRC will pursue multifunctional nanostructures as the basis for a next generation of high performance electrical energy storage to:

- power **electric vehicles** over long distances and recharge quickly, and
- capture, hold, and deliver energy from **renewable sources**.



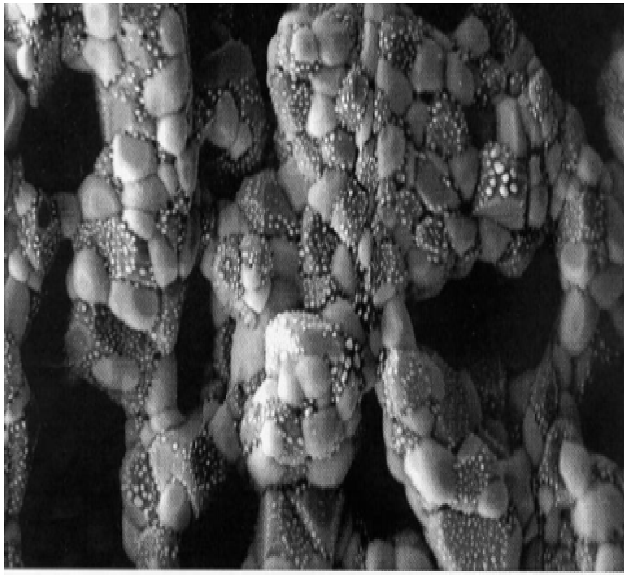
EFRC features:

- Metal oxide and silicon nanowires to hold and cycle charge
- Carbon-nanowire composite nanostructures for faster charge transport and structural stability during charge cycling
- Fundamental understanding of nanostructure synthesis, properties, and electrochemical behavior, supported by novel instruments and theory
- Uniform, predictable structures for scientific analysis and as prototypes of massive arrays in future technology

an Office of Basic Energy Sciences
Energy Frontier Research Center

Heterogeneous Functional Materials "HeteroFoaM" Center
Ken Reifsnider (University of South Carolina)

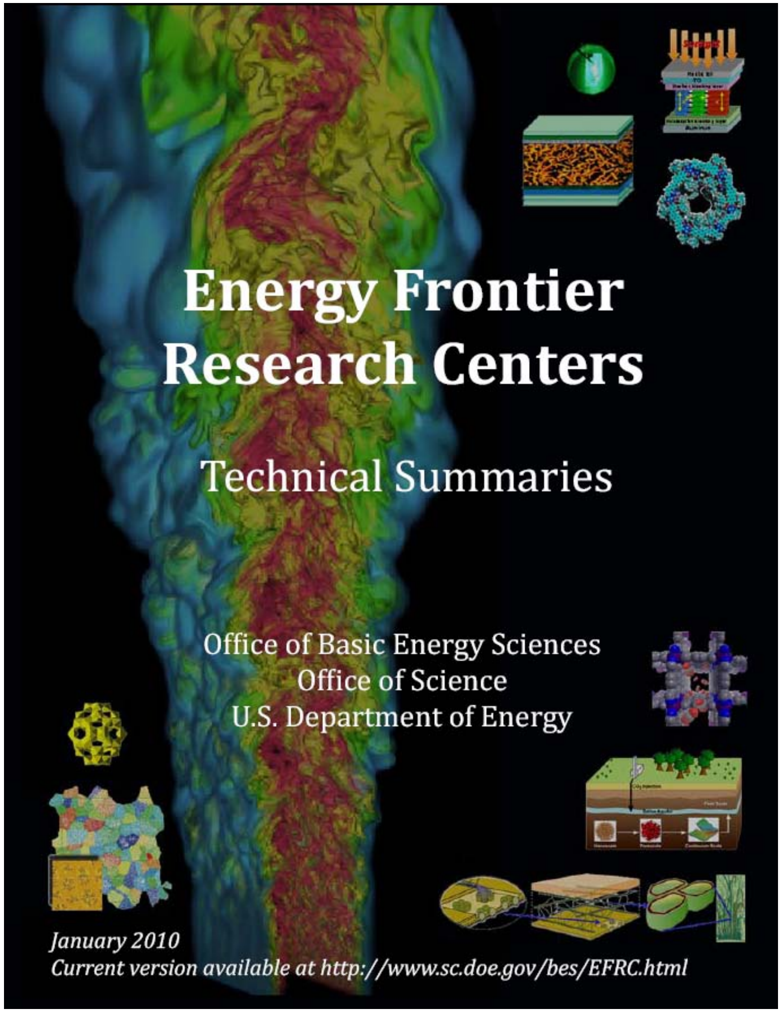
The aim of this EFRC is to establish foundations of understanding and control science that enable the prescriptive design and ordered synthesis of the local compositions, interfaces, and morphology of heterogeneous material systems for specific functional behavior and system performance.



RESEARCH PLAN AND DIRECTIONS

The greatest challenge to the creation of nano-synthesis concepts and processes that control nano-structural configurations and interfaces of active phases is to understand "what the picture should look like." We will use science to bridge the gap between multi-scale analysis and nano-synthesis methodologies to create new functional materials.

EFRCs Technical Summaries Book



Two-page technical summaries provided by EFRCs PLUS

- EFRC contact information and
- Indexed by
  - investigator, institution,
  - basic research needs,
  - grand challenges,
  - topical keywords,
  - experimental and theoretical methods

Available and downloadable on-line