U.S. DEPARTMENT OF ENERGY | Office of Science

Battery Hub and R&D Integration

Batteries and Energy Storage Information Meeting

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Batteries and Energy Storage
Cross-Cutting Challenge that Impacts Energy Technologies

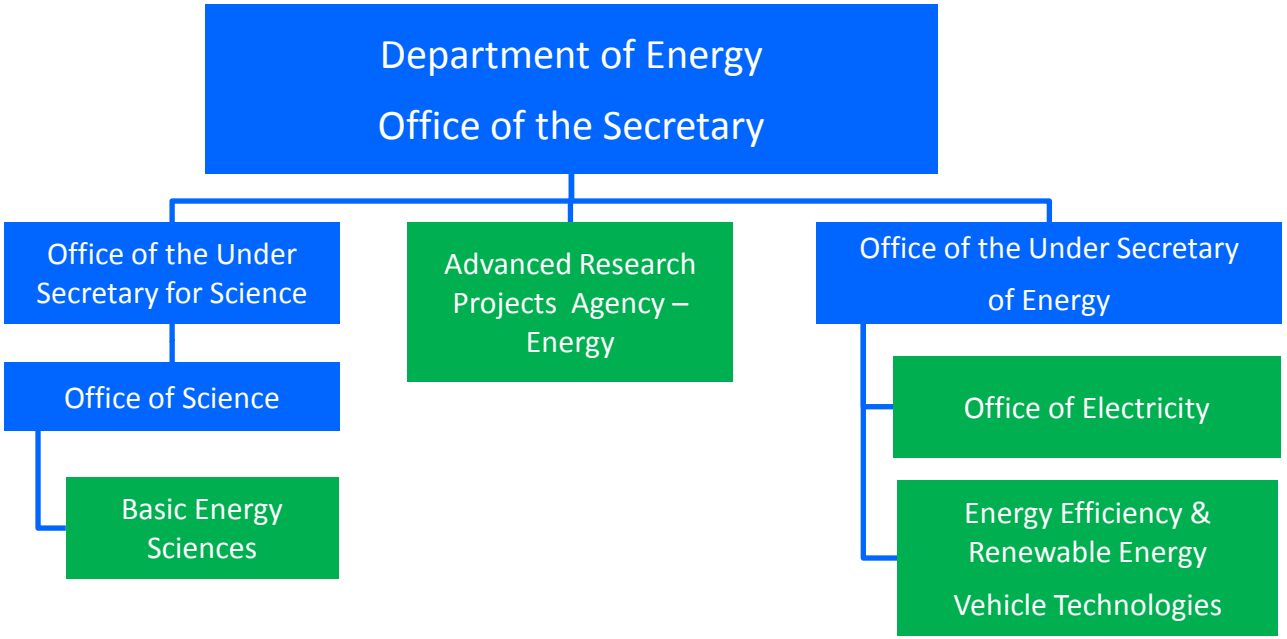
The Administration's Energy Plan has two goals that rely heavily on improvements in the science and technology of energy storage:

- Solar and wind providing over 25% of electricity consumed in the U.S. by 2025
- 1 million all-electric/plug-in hybrid vehicles on the road by 2015

- Grid stability and distributed power require innovative energy storage devices
  - Grid integration of intermittent energy sources such as wind and solar
  - Storage of large amounts of power
  - Delivery of significant power rapidly

- Enabling widespread utilization of hybrid and all-electric vehicles requires:
  - Substantially higher energy and power densities
  - Lower costs
  - Faster recharge times

Energy Storage R&D: Relevant Program Offices are Coordinating Research and Development Activities



- **Office of Science/Basic Energy Sciences (BES):** Fundamental research to understand, predict, and control matter and energy at electronic, atomic, and molecular levels.
- **Advanced Research Projects Agency-Energy (ARPA-E):** High-risk, transformational research with potential for significant commercial impact.
- **Energy Efficiency and Renewable Energy (EERE) Vehicle Technologies (VTP):** Applied battery R&D to enable a large market penetration of electric vehicles.
- **Office of Electricity Delivery and Energy Reliability (OE) Energy Storage**: Energy storage technology R&D, integration, system demonstrations and deployment on the grid.

DOE's Integration Activities for Basic and Applied R&D for Electrical Energy Storage

- DOE formed a team to focus on batteries for vehicles:
  - EERE, ARPA-E and BES coordination to strategically align DOE R&D
  - DOE seminar series to highlight activities of each organization
- Quadrennial Technology Review (Transportation)
  - Participation by BES and EERE
- US-European Union workshop and research coordination on electrical energy storage for the grid
  - Joint organization and participation by BES, OE and ARPA-E
- Planning for the proposed Energy Innovation Hub
- Joint workshops/PI meetings and participation in reviews among all offices

What are Energy Innovation Hubs?

- Energy Innovation Hubs are major multidisciplinary, multi-investigator, multi-institutional integrated research centers
  - Modeled after the centralized scientific management characteristics of the Manhattan Project, Lincoln Lab at MIT that developed radar, and AT&T Bell Laboratories that developed the transistor
  - Bring together top researchers from academia, industry and the government laboratories spanning multiple scientific and engineering disciplines
  - Create an integrated, multidisciplinary systems approach to overcoming critical barriers to advances in energy technology
- Hubs advance U.S. global leadership and are focused in areas that have exceptional potential to reduce our dependence on imported oil and greenhouse gas emissions

Holistic Approach for Hub Research

- Effective integration of basic and applied research
  - Interdisciplinary, both science and engineering perspectives
- Address critical scientific, engineering, and technological challenges
- Strong leadership, management, and systems approach to the research challenges
  - Create a culture of strong collaboration among all participants
- Robust ties to existing R&D activities, including industry, to accelerate innovation and movement of these advances to the marketplace
- Ultimate goal – enable new technologies that overcome current technical limits
  - Development to the point that the risk level is low enough for industrial deployment of Hub innovations

DOE Energy Innovation Hubs

Hubs funded in FY 2010:

- Fuels from Sunlight (SC) – Caltech and LBNL
- Energy Efficient Building Systems Design (EERE) – Penn State
- Modeling and Simulation for Nuclear Fuel Cycles and Systems (NE) - ORNL

Each Hub has a world-class, multi-disciplinary, and highly collaborative research, development and deployment team

Strong scientific leadership is located at the primary location of the Hub

- Clear organization and management plan for achieving the HUB goal
- “infuses” a culture of empowered central research management

DOE proposed three additional Hubs, including one for Batteries and Energy Storage, in the FY2012 budget request

Drivers for a Hub-level Effort in Electrical Energy Storage - 1

- Large team, multidisciplinary Hub research would link fundamental science and engineering research to technology and production needs, resulting in rapid and meaningful advances across the spectrum
- Scientific challenges go beyond research addressed by efforts currently supported, including Energy Frontier Research Centers
- Different energy storage technologies have similar underlying scientific challenges but diverse engineering and technology issues
  - Hub would ensure communication across the research-to-technology spectrum and among different technology sectors
- A Hub would strengthen the links from basic science all the way to industrial development
  - Hub would support fundamental science and engineering research through prototype demonstration of Hub scientific advances
  - Hub would have robust ties to the broad research and development community, including industry

Drivers for a Hub-level Effort in Electrical Energy Storage - 2

- The proposed Hub can provide the transformational, game-changing science and engineering research required for the next generation of electrochemical energy storage
  - The Hub could serve as a focus for other DOE research activities, complementing ongoing research and development activities
  - The Hub could benefit from, and provide benefit to, the balance of community research activities
  - The Hub can foster new energy storage architectures and designs that begin with a “clean sheet of paper” – and are based on innovation and advances by the Hub

Key Scientific and Engineering Challenges - 1

- Efficacy of structure in energy storage:
  - New approaches combining theory and synthesis for the design and optimization of materials architectures including self-healing, self-regulation, failure-tolerance, and impurity-sequestration; and based on abundant materials and low-cost manufacturing processes.
- Charge transfer and transport:
  - Molecular scale understanding of interfacial electron transfer, and electrolytes -- electrolytes with strong ionic solvation, yet weak ion-ion interactions, high fluidity, and controlled reactivity.
- New battery architectures and systems
  - Integration of materials and components from nano- to macro-scales to improve system performance

Key Scientific and Engineering Challenges - 2

- Novel approaches to fabrication and processing:
  - Innovation to reduce complexity and cost driven by understanding of the systems and tied to material and chemical processing advances
- Understanding energy storage chemistry and physics at all time and length scales:
  - Analytical tools capable of monitoring changes in structure and composition at interfaces and in bulk phases with spatial resolution from atomic to mesoscopic levels and temporal resolution down to femtoseconds.
  - Multi-scale modeling and computational tools to understand the complex physical and chemical processes that occur in electrical energy storage from the molecular to system scales

Proposed Batteries and Energy Storage Hub

Transform the Grid and Electrify Transportation

- The Hub, proposed for FY 2012, would develop electrochemical energy storage systems that safely approach theoretical energy and power densities with very high cycle life – and have the potential for fundamentally new and economic manufacturing
- These are systemic challenges requiring new materials, systems, innovative engineering, and enhanced scientific knowledge
- The proposed Hub would address key fundamental questions in electrochemical energy storage including:
  - Can we approach theoretical energy density?
  - Can we safely increase the rate of energy utilization?
  - Can we create a reversible system with minimal energy loss?
  - Can we limit the use of materials that are not earth-abundant?
  - Can we develop totally new battery architectures?
  - Can we enable truly innovative approaches to manufacturing and packaging?
- The proposed Hub would link fundamental science, technology, and end-users, and it will collaborate with relevant BES, Energy Frontier Research Centers, ARPA-E EERE, and OE activities

Budget Status of the Batteries and Energy Storage Hub

- FY 2012 Request: $34,0202,000 requested for the proposed Batteries and Energy Storage Hub
  - Includes one-time funding of $10,000,000 will be provided for Hub start-up needs, excluding new construction

- FY 2012 House Energy & Water Committee Recommendation: 20,000,000

- FY 2012 Senate Energy & Water Committee Recommendation: 20,000,000

- Continuing Resolution: On-hold pending FY 2012 appropriation or approval of the Hub as a new start

DOE Batteries and Energy Storage Program Features

	Investigators and their institutions	Diversity of Disciplines Per Award	Period of Award and Management	Annual Average Award Amount	Core Motivation, Research Focus
Core BES Program	Single or small-groups of researchers led by universities or national laboratories	Few	3 –year renewable awards	~$300k	Fundamental research to understand the underlying science of materials and chemistry issues related to electrical energy storage. Current projects focus primarily on electrode and electrolyte phenomena, including synthesis and characterization.
Energy Frontier Research Centers	Self-assembled group s of 12-20 investigators. Led by universities, national laboratories, nonprofit organizations, and industry.	Several	Initial awards in 2009 for 5-years. Managed by DOE SC-BES.	~$3M	Fundamental research on electrical energy storage with a link to energy technologies or technology roadblocks. The EFRCs address topics from among a large set of scientific grand challenges and electrical energy storage-related topics developed in BES workshop reports.
ARPA-E	Single investigator, small group, or small teams.	Few	Typically 1-3 years	$1 -7M	High risk translational research driven by the potential for significant commercial impact in the near-term. Current funding includes technologies relevant to both transportation and the electrical grid.
EERE and OE	Range of research teams, frequently involving industrial partners	Few	Varies, typically 1-3 years	Ranging from small teams ($300K+) to technology demonstrations (can be >$1M)	Developmental research and technology demonstration projects. EERE primarily focuses on mobile applications, OE on stationary and grid applications.
Proposed Batteries and Energy Storage Energy Innovation Hub	Large set of investigators spanning multiple science and engineering disciplines and possibly including other areas such as energy policy, economics, and market analysis. May be led by national labs, universities, nonprofit organizations or industry.	Many	Initial award for 5-years Managed by DOE SC-BES in close coordination with EERE, ARPA-E, and OE.	~$25 million per year for R&D	Integrate from fundamental research through potential commercialization of electrochemical energy storage advances that are relevant to transportation and the electric grid. The breadth and emphasis of activities will be influenced by the nature of the selected Hub proposal. Lead institution must provide a central location and strong scientific leadership to develop a culture of empowered central research management.

Where Could a Battery and Energy Storage Hub Take Us?

- Move science and technology for electrochemical energy storage forward at a rapid pace to enable transformative developments for reliable energy supply and transportation systems

- Provide a strong linkage between fundamental science, applied technology and end-use communities to create long- and short-term innovations that would not otherwise be achieved

Batteries and Energy Storage Hub:
A research framework for scientific discovery and transformational technologies

For more information on DOE's Energy Innovation Hubs

- Go to: http://energy.gov/hubs