U.S. Department of Energy
Office of Science

U.S. DEPARTMENT OF ENERGY

Basic Energy Sciences Update

Eric Rohlfing
Director; Chemical Sciences, Geosciences, and Biosciences Division
Office of Basic Energy Sciences

- **FY 2009 Budget Update**
- **Energy Frontier Research Centers**
- **FY 2010 Budget Proposal**

Office of Science FY 2009 Budgets

BES gets a ~25% increase over FY 2008
Reduced by $8.6M for additional EPSCOR and $3.7M general reduction

	FY 2008 Enacted Approp.	FY 2008 Current Approp	FY 2009 Base Appropriation: Request to Congress	House Mark	Senate Mark	Final Approp	FY 2009 Recovery Act Approp.
SCIENCE							
Basic Energy Sciences	1,283,402	1,252,756	1,568,160	1,599,660	1,415,378	1,571,972	
Advanced Scientific Computing Research	351,173	341,774	368,820	378,820	368,820	368,820	
Biological & Environmental Research	544,397	531,063	568,540	578,540	598,540	601,540	
High Energy Physics	720,317	702,845	804,960	804,960	804,960	795,726	
Nuclear Physics	434,226	423,671	510,080	517,080	510,080	512,080	
Fusion Energy Sciences	302,048	294,933	493,050	499,050	493,050	402,550	
Science Laboratories Infrastructure	64,861	66,861	110,260	145,760	110,260	145,380	
Science Program Direction	177,779	177,779	203,913	203,913	186,695	186,695	
Workforce Development for Teachers & Scientists	8,044	8,044	13,583	13,583	13,583	13,583	
Safeguards & Security	75,946	75,946	80,603	80,603	80,603	80,603	
Small Business Innovation Research/Tech. Transfer	—	92,997	—	—	—	—	
Subtotal, Science	3,962,193	3,968,669	4,721,969	4,821,969	4,581,969	4,678,949	
Advanced Research Projects Agency-Energy	—	—	—	15,000	—	15,000	
Congressionally-directed projects	123,623	120,161	—	39,700	58,500	93,687	
SBIR/STTR (transfer from other DOE offices)	—	47,241	—	—	—	—	
Subtotal, Science	4,085,816	4,136,071	4,721,969	4,876,669	4,640,469	4,787,636	
S&S (reimb. chg.)	-5,605	-5,605	—	—	—	—	
Rescission of prior year Congressionally-directed proj.	-44,569	-44,569	—	—	—	—	
Use of prior year balances	—	-3,014	—	-15,000	—	-15,000	
Total, Science	4,035,642	4,082,883	4,721,969	4,861,669	4,640,469	4,772,636	+1,600,000

Recovery Act Funding

BES Program Priorities
Invest in Science to Achieve Transformational Discoveries

Expand Core Research Program

- Large Scale Research Centers/Collaborations (e.g., EFRCs)
- Single-Investigator and Small-Group Research
- Broader EPSCoR Participation ($17M in FY09)

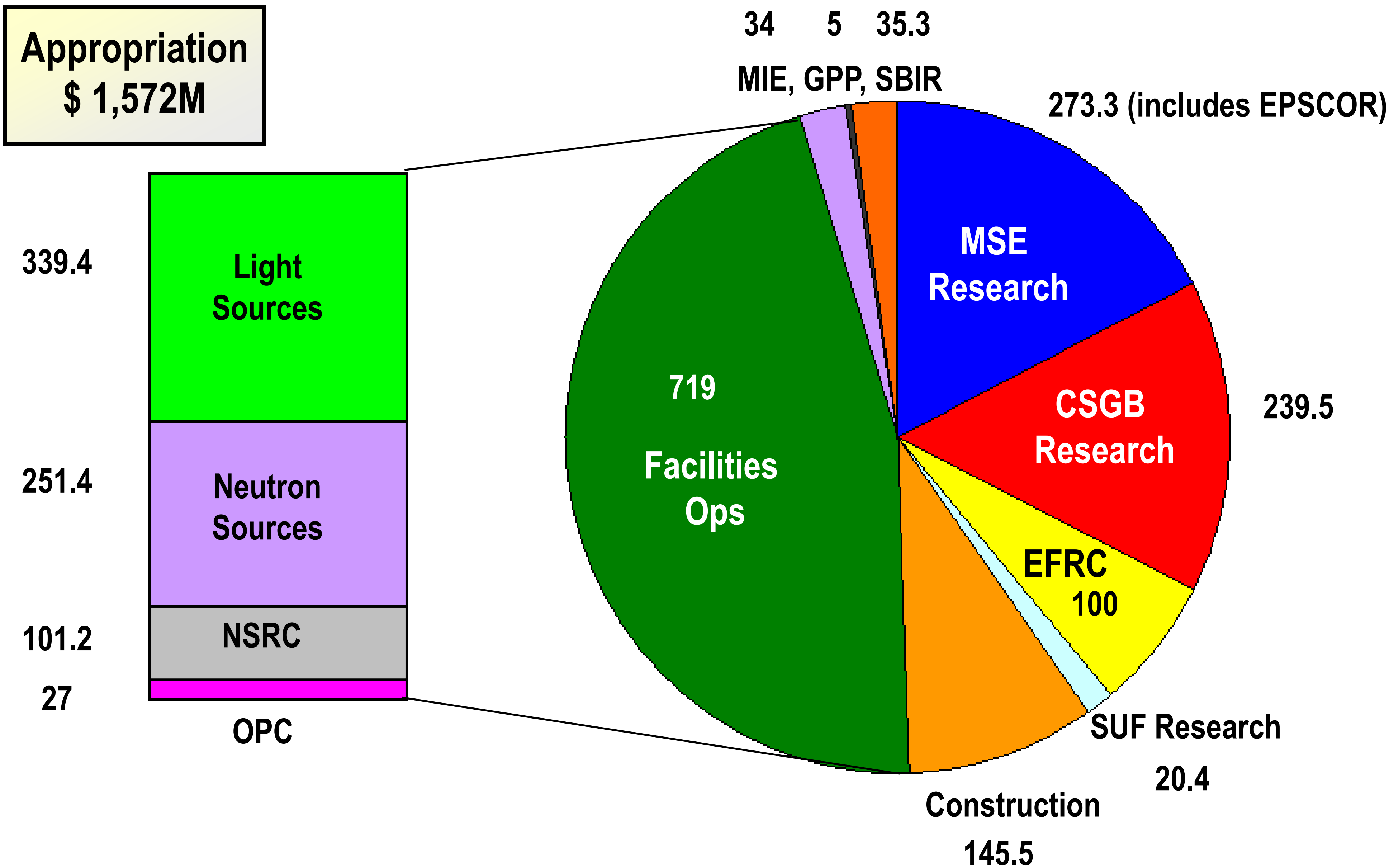
Support World-class Scientific User Facilities

- Synchrotron light sources
- Neutron scattering facilities
- Electron microcharacterization facilities
- Nanoscale Science Research Centers

New Construction and Instrumentation

- National Synchrotron Light Source-II
- Linac Coherent Light Source + Linac operations + instruments
- Advanced Light Source User Support Building
- Spallation Neutron Source instruments
- PULSE Building

FY 2009 BES Budget



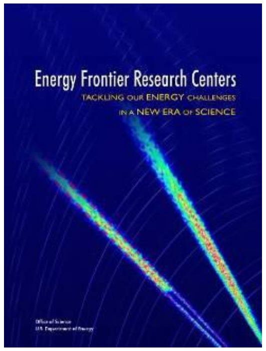
BES will invest $555.4 million of Recovery Act funding in seven activities:

- **$150.0M** to accelerate the civilian construction of the **National Synchrotron Light Source II** (NSLS-II) at Brookhaven National Laboratory;
- **$14.7M** to complete the construction of the **User Support Building** (USB) at the Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory;
- **$33.6M** to complete the Linac Coherent Light Source (LCLS) **Ultrafast Science Instruments** (LUSI) MIE project at SLAC National Accelerator Laboratory;
- **$25.0M** for capital equipment replenishment and augmentation at the five BES **Nanoscale Science Research Centers** (NSRCs);
- **$24.0M** for four **synchrotron radiation light sources** capital equipments, AIP, other upgrades
- **$277.0M** for **Energy Frontier Research Centers** (EFRCs) – funding an additional 16 EFRCs for the full five-year initial award period.
- **$31.1M for Early Career Awards for scientists at DOE labs and universities (TBD).**

Energy Frontier Research Centers

Energy Frontier Research Centers

Tackling Our Energy Challenges in a New Era of Science



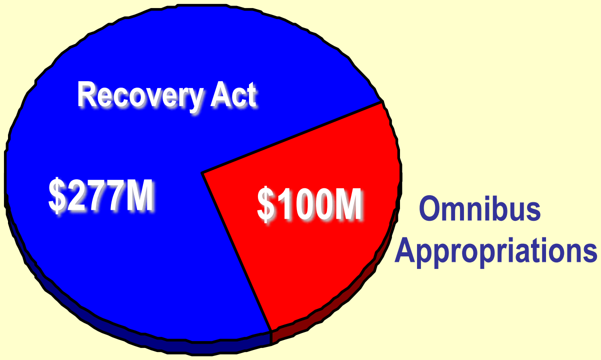
- To engage the talents of the nation's researchers for the broad energy sciences
- To accelerate the scientific breakthroughs needed to create advanced energy technologies for the 21st century
- To pursue the fundamental understanding necessary to meet the global need for abundant, clean, and economical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

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

- Solar Energy Utilization
- Geosciences for Nuclear Waste and CO_2 Storage
- Combustion
- Bio-Fuels
- Advanced Nuclear Energy Systems
- Superconductivity
- Catalysis
- Materials Under Extreme Environments
- Solid State Lighting
- Energy Storage
- Hydrogen

2003-2007	Conducted BRN workshops
August 2007	America COMPETES Act signed
Feb. 2008	FY 2009 budget roll-out
April 2008	EFRC FOA issued
Oct. 2008	Received 261 full proposals
Oct. 2008	FY 2009 Continuing Resolution started
Feb. 2009	Recovery Act of 2009 signed
March 2009	Omnibus Appropriations Act 2009 signed
April 2009	46 EFRC awards announced
August 2009	EFRC projects to start

FY 2009 EFRCs Funding Status:



Total EFRCs = $777M over 5 years

46 EFRC Awards Announced by the White House on April 27, 2009

"…in no area will innovation be more important than in the development of new technologies to produce, use, and save energy – which is why my administration has made an unprecedented commitment to developing a 21st century clean energy economy." - President Barack Obama

"These Centers will mobilize the enormous talents and skills of our nation's scientific workforce in pursuit of the breakthroughs that are essential to make alternative and renewable energy truly viable as large-scale replacements for fossil fuels." – Secretary of Energy Steven Chu

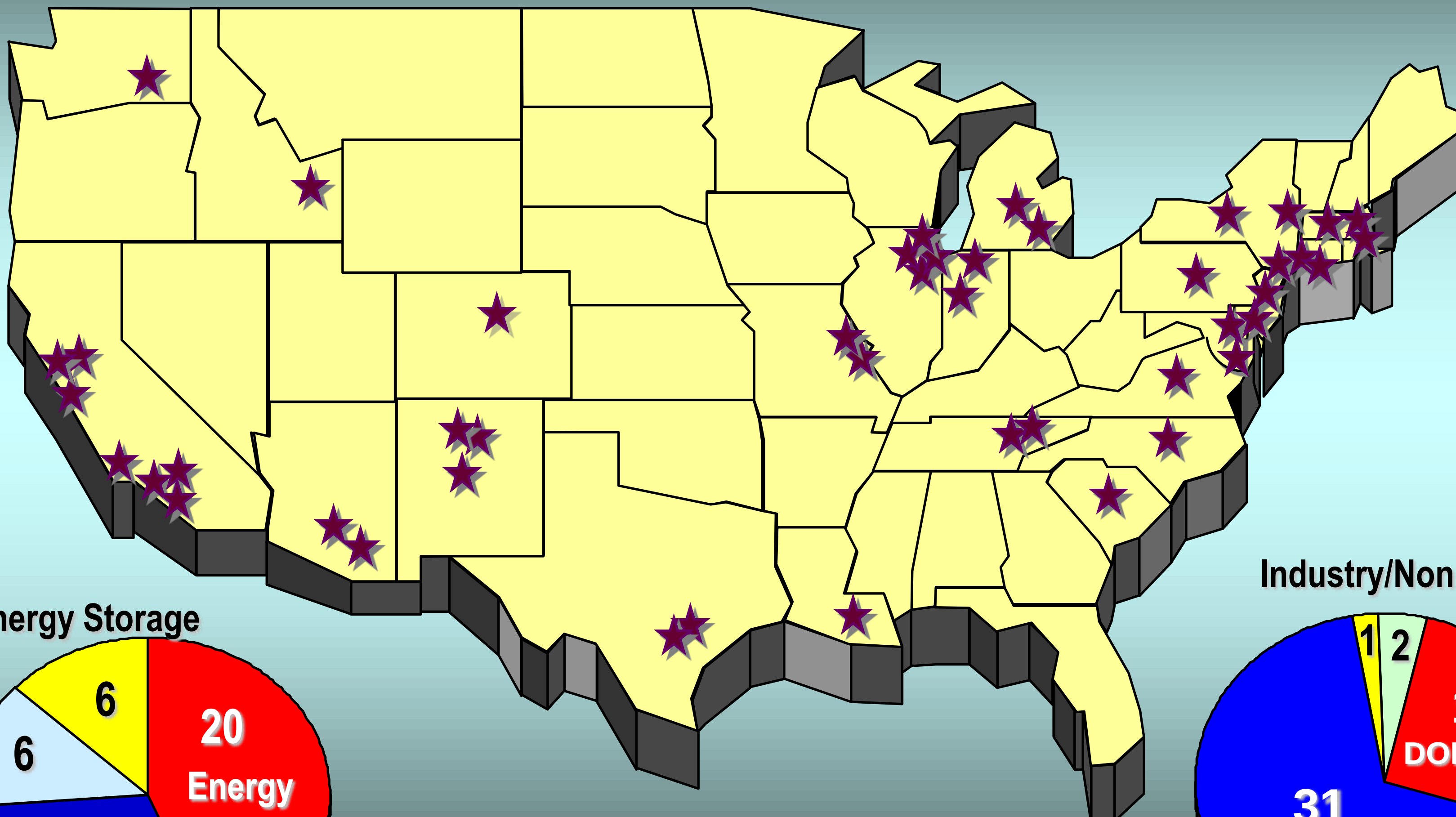
- **In his speech before the Annual Meeting of the National Academy of Sciences, President Obama described "A Historic Commitment to Research and Education."**
- **Included in the White House fact sheet under "Sparking the Clean Energy Revolution" was the announcement of the 46 EFRC awards.**

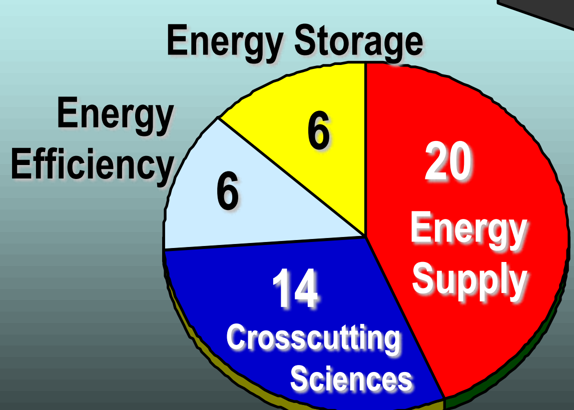
  http://www.whitehouse.gov/the_press_office/Fact-Sheet-A-Historic-Commitment-To-Research-And-Education/

Energy Frontier Research Centers

Invest in Cutting-edge Scientific Research for Transformational Discoveries

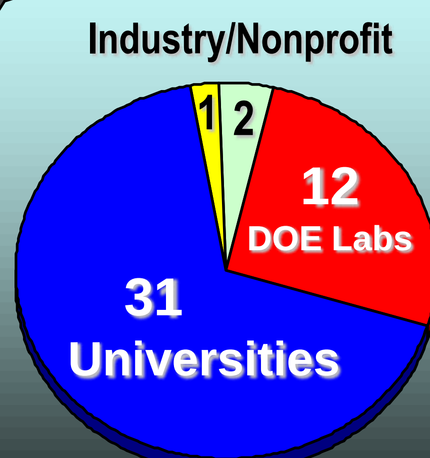
46 centers awarded in FY 2009 for five years
Representing 110 participating institutions in 36 states plus D.C.





By Topical Category

For a complete award information, see:
http://www.sc.doe.gov/bes/EFRC.html



By Lead Institution

Department of Energy
Energy Frontier Research Centers (EFRCs)

Institution	Location	State	EFRC Name	EFRC Director	EFRC Objective
Arizona State University*	Tempe	AZ	EFR Center for Bio-Inspired Solar Fuel Production	Gust, J. Devens	Adapt the fundamental principles of natural photosynthesis to the man-made production of hydrogen or other fuels from sunlight.
University of Arizona*	Tuscon	AZ	Center for Interface Science: Hybrid Solar-Electric Materials (CIS:HSEM)	Armstrong, Neal R.	Enhance the conversion of solar energy to electricity using hybrid inorganic-organic materials.
California Institute of Technology	Pasadena	CA	Light-Material Interactions in Energy Conversion	Atwater, Harry	Tailor the properties of advanced materials to control the flow of solar energy and heat.
Lawrence Berkeley National Laboratory	Berkeley	CA	Center for Nanoscale Control of Geologic CO_2	DePaolo, Donald	Establish the scientific foundations for the geological storage of carbon dioxide.
Stanford University	Stanford	CA	Center on Nanostructuring for Efficient Energy Conversion	Prinz, Fritz	Design, create, and characterize materials at the nanoscale for a wide variety of energy applications.
University of California, Berkeley	Berkeley	CA	Center for Gas Separations Relevant to Clean Energy Technologies	Smit, Berend	Design and synthesize new forms of matter with tailored properties for gas separations in applications including carbon capture and sequestration.
University of California, Los Angeles	Los Angeles	CA	Molecularly Assembled Material Architectures for Solar Energy Production, Storage, and Carbon Capture	Ozolins, Vidvuds	Acquire a fundamental understanding and control of nanoscale material architectures for conversion of solar energy to electricity, electrical energy storage, and separating/capturing greenhouse gases.
University of California, Santa Barbara*	Santa Barbara	CA	Center on Materials for Energy Efficiency Applications	Bowers, John	Discover and develop materials that control the interactions between light, electricity, and head at the nanoscale for improved solar energy conversion, solid-state lighting, and conversion of heat into electricity.
University of Southern California*	Los Angeles	CA	Emerging Materials for Solar Energy Conversion and Solid State Lighting	Dapkus, Paul Daniel	Simultaneously explore the light absorbing and emitting properties of hybrid inorganic-organic materials for solar energy conversion and solid-state lighting.
National Renewable Energy Laboratory	Golden	CO	Center for Inverse Design	Zunger, Alex	Replace trial-and-error methods used in the development of materials for solar energy conversion with an inverse design approach powered by theory and computation.

* Funded under the *American Recovery and Reinvestment Act of 2009.*

Department of Energy
Energy Frontier Research Centers (EFRCs)

Institution	Location	State	EFRC Name	EFRC Director	EFRC Objective
Carnegie Institute of Washington	Washington	DC	Center for Energy Frontier Research in Extreme Environments (Efree)	Mao, Ho-Kwang	Accelerate the discovery of energy-relevant materials that can tolerate transient extremes in pressure and temperature.
University of Delaware*	Newark	DE	Rational Design of Innovative Catalytic Technologies for Biomass Derivative Utilization	Vlachos, Dionisios	Design and characterize novel catalysts for the efficient conversion of the complex molecules comprising biomass into chemicals and fuels.
Idaho National Laboratory	Idaho Falls	ID	Center for Materials Science of Nuclear Fuel	Wolf, Dieter	Develop predictive computational models, validated by experiments, for the thermal and mechanical behavior of analogues to nuclear fuel.
Argonne National Laboratory	Argonne	IL	Institute for Atom-Efficient Chemical Transformations (IACT)	Marshall, Christopher	Discover, understand, and control efficient chemical pathways for the conversion of coal and biomass into chemicals and fuels.
Argonne National Laboratory	Argonne	IL	Center for Electrical Energy Storage: Tailored Interfaces	Thackeray, Michael	Understand complex phenomena in electrochemical reactions critical to advanced electrical energy storage.
Northwestern University	Evanston	IL	Argonne-Northwestern Solar Energy Research (ANSER) Center	Wasielewski, Michael	Revolutionize the design, synthesis, and control of molecules, materials, and processes in order to dramatically improve conversion of sunlight into electricity and fuels.
Northwestern University*	Evanston	IL	Center for Integrated Training in Far-From-Equilibrium and Adaptive Materials (CITFAM)	Grzybowski, Bartosz	Synthesize, characterize, and understand new classes of materials under conditions far from equilibrium relevant to solar energy conversion, storage of electricity and hydrogen, and catalysis.
Purdue University*	West Lafayette	IN	Center for Direct Catalytic Conversion of Biomass to Biofuels (C3Bio)	McCann, Maureen	Use fundamental knowledge about the interactions between catalysts and plant cell walls to design improved processes for the conversion of biomass to energy, fuels, or chemicals.
University of Notre Dame*	Notre Dame	IN	Materials Science of Actinides	Burns, Peter C.	Understand and control, at the nanoscale, materials that contain actinides (radioactive heavy elements such as uranium and plutonium) to lay the scientific foundation for advanced nuclear energy systems.
Louisiana State University	Baton Rouge	LA	Computational Catalysis and Atomic-Level Synthesis of Materials: Building Effective Catalysts from First Principles	Spivey, James	Develop computational tools to accurately model catalytic reactions and thereby provide the basis for the design of new catalysts.

* Funded under the *American Recovery and Reinvestment Act of 2009*.

Department of Energy

Energy Frontier Research Centers (EFRCs)

Institution	Location	State	EFRC Name	EFRC Director	EFRC Objective
Massachusetts Institute of Technology	Cambridge	MA	Solid-State Solar-thermal Energy Conversion Center (S3TEC CENTER)	Chen, Gang	Create novel, solid-state materials for the conversion of sunlight and heat into electricity.
Massachusetts Institute of Technology*	Cambridge	MA	Center for Excitonics	Baldo, Marc	Understand the transport of charge carriers in synthetic disordered systems, which hold promise as new materials for conversion of solar energy to electricity and electrical energy storage.
University of Massachusetts*	Amherst	MA	Polymer-Based Materials for Harvesting Solar Energy	Russell, Thomas	Use novel, self-assembled polymer materials in systems for the conversion of sunlight into electricity.
University of Maryland	College Park	MD	Science of Precision Multifunctional Nanostructures for Electrical Energy Storage	Rubloff, Gary	Understand and build nano-structured electrode components as the foundation for new electrical energy storage technologies.
Michigan State University	East Lansing	MI	Revolutionary Materials for Solid State Energy Conversion	Morelli, Donald	Investigate the underlying physical and chemical principles of advanced materials for the conversion of heat into electricity.
University of Michigan*	Ann Arbor	MI	Solar Energy Conversion in Complex Materials (SECCM)	Green, Peter	Study complex material structures on the nanoscale to identify key features for their potential use as materials to convert solar energy and heat to electricity.
Donald Danforth Plant Science Center	St. Louis	MO	Center for Advanced Biofuels Systems	Sayre, Richard	Generate the fundamental knowledge required to increase the efficiency of photosynthesis and production of energy-rich molecules in plants.
Washington University, St. Louis	St. Louis	MO	Photosynthetic Antenna Research Center	Blankenship, Robert	Understand the basic scientific principles that underlie the efficient functioning of the natural photosynthetic antenna system as a basis for man-made systems to convert sunlight into fuels.
University of North Carolina*	Chapel Hill	NC	Solar Fuels and Next Generation Photovoltaics	Meyer, Thomas	Synthesize new molecular catalysts and light absorbers and integrate them into nanoscale architectures for improved generation of fuels and electricity from sunlight.
Princeton University	Princeton	NJ	Energy Frontier Research Center for Combustion Science	Law, Chung K.	Develop a suite of predictive combustion modeling capabilities for the chemical design and utilization of non-petroleum based fuels in transportation.
Los Alamos National Laboratory	Los Alamos	NM	The Center for Advanced Solar Photophysics	Klimov, Victor	Capitalize on recent advances in the science of how nanoparticles interact with light to design materials that have vastly greater efficiencies for the conversion of sunlight into electricity.

* Funded under the *American Recovery and Reinvestment Act of 2009.*

Department of Energy

Energy Frontier Research Centers (EFRCs)

Institution	Location	State	EFRC Name	EFRC Director	EFRC Objective
Los Alamos National Laboratory	Los Alamos	NM	Extreme Environment-Tolerant Materials via Atomic Scale Design of Interfaces	Nastasi, Michael	Understand, at the atomic scale, the behavior of materials subject to extreme radiation doses and mechanical stress in order to synthesize new materials that maintain their desired properties under such conditions.
Sandia National Laboratories	Albuquerque	NM	EFRC for Solid State Lighting Science	Simmons, Jerry	Study energy conversion in tailored nanostructures as a basis for dramatically improved solid-state lighting.
Brookhaven National Laboratory	Upton	NY	Center for Emergent Superconductivity	Davis, J.C. Seamus	By understanding the fundamental physics of superconductivity, discover new high-temperature superconductors and improve the performance of known superconductors.
Columbia University*	New York	NY	Re-Defining Photovoltaic Efficiency Through Molecule-Scale Control	Yardley, James	Develop the enabling science needed to realize breakthroughs in the efficient conversion of sunlight into electricity in nanometer sized thin films.
Cornell University*	Ithaca	NY	Nanostructured Interfaces for Energy Generation, Conversion, and Storage	Abruna, Hector	Understand and control the nature, structure, and dynamics of reactions at electrodes in fuel cells, batteries, solar photovolataics, and catalysts.
General Electric Global Research	Niskayuna	NY	Center for Electrocatalysis, Transport Phenomena and Materials for Innovative Energy Storage	Soloveichik, Grigorii	Explore the fundamental chemistry needed for an entirely new approach to energy storage that combines the best properties of a fuel cell and a flow battery.
State University of New York, Stony Brook	Stony Brook	NY	Northeastern Chemical Energy Storage Center (NOCESC)	Grey, Clare P.	Understand how fundamental chemical reactions occur at electrodes and use that knowledge to tailor new electrodes to improve the performance of existing batteries or to design entirely new ones.
Pennsylvania State University*	University Park	PA	Center for Lignocellulose Structure and Formation	Cosgrove, Daniel	Dramatically increase our fundamental knowledge of the physical structure of bio-polymers in plant cell walls to provide a basis for improved methods for converting biomass into fuels.
University of South Carolina	Columbia	SC	Science Based Nano-Structure Design and Synthesis of Heterogeneous Functional Materials for Energy Systems	Reifsnider, Kenneth	Build a scientific basis for bridging the gap between making nano-structured materials and understanding how they function in a variety of energy applications.

* Funded under the *American Recovery and Reinvestment Act of 2009.*

Department of Energy

Energy Frontier Research Centers (EFRCs)

Institution	Location	State	EFRC Name	EFRC Director	EFRC Objective
Oak Ridge National Laboratory	Oak Ridge	TN	Energy Frontier Center for Defect Physics in Structural Materials (CDP)	Stocks, G. Malcolm	Enhance our fundamental understanding of defects, defect interactions, and defect dynamics that determine the performance of structural alloys in extreme radiation environments.
Oak Ridge National Laboratory	Oak Ridge	TN	Fluid Interface Reactions, Structures and Transport (FIRST) Center	Wesolowski, David	Provide basic scientific understanding of phenomena that occur at interfaces in electrical energy storage, conversion of sunlight into fuels, geological sequestration of carbon dioxide, and other advanced energy systems.
University of Texas, Austin	Austin	TX	Frontiers of Subsurface Energy Security	Pope, Gary A.	Harness recent theoretical and experimental advances to explain the transport of native and injected fluids, particularly carbon dioxide, in geological systems over multiple length scales.
University of Texas, Austin*	Austin	TX	Understanding Charge Separation and Transfer at Interfaces in Energy Materials and Devices (CST)	Barbara, Paul	Pursue fundamental research on charge transfer processes that underpin the function of highly promising molecular materials for photovoltaic and electrical energy storage applications.
University of Virginia	Charlottesville	VA	Center for Catalytic Hydrocarbon Functionalization	Gunnoe, T. Brent	Develop novel catalysts and manipulate their reactivity for the efficient conversion of hydrocarbon gases into liquid fuels.
Pacific Northwest National Laboratory	Richland	WA	Center for Molecular Electrocatalysis	Bullock, R. Morris	Develop a comprehensive understanding of how chemical and electrical energy contained in fuels is exchanged, stored and released.

* Funded under the *American Recovery and Reinvestment Act of 2009.*

EFRC awards relevant to biomass conversion

Rational Design of Innovative Catalytic Technologies for Biomass Derivative Utilization

Dionisios Vlachos, Director

University of Delaware

Objective: To design and characterize novel catalysts for the efficient conversion of the complex molecules comprising biomass into chemicals and fuels.

Heterogeneous catalysts designed specifically for the energy- and atom-efficient conversion of complex biomass molecules and materials will be the core knowledge to be pursued in this EFRC. Scientists in the EFRC will launch a first-principles attack on the key chemical and materials challenges associated with biomass conversion and will devise novel analytical techniques to acquire atomistic, molecular and dynamic level information from these systems. The EFRC will emphasize multi-scale modeling to treat the natural material complexity; the discovery of processes designed to manipulate complex mixtures and their reactivity, and the development of new analytical methods for characterization of reacting media. The EFRC plans collaborations with scientists at Lehigh University, California Institute of Technology, and the Universities of Massachusetts, Minnesota, Pennsylvania, Southern California, and Stony Brook.

Institute for Atom-Efficient Chemical Transformations (IACT)

Christopher Marshall, Director

Argonne National Laboratory

Objective: To discover, understand, and control efficient chemical pathways for the conversion of coal and biomass into chemicals and fuels.

Modern experimental and computational techniques will be used to address the computational design and the atomic level characterization of working catalysts for complex molecular mixtures modeled after coal and biomass. Bio-inspired catalysts will be synthesized and evolved for the selective disassociation of oxygen from model mixtures, selective hydrogenation of oxygen functional groups, and controlled carbon-carbon linking. Complex, multifunctional catalysts that behave predictably under reaction conditions at relatively high temperature and in solvents will be developed to uncover detailed structure-reactivity relationships. The IACT plans collaborations with researchers from Argonne National Laboratory, Northwestern University, Purdue University, and University of Wisconsin-Madison. IACT will make use of the Advanced Photon Source at Argonne National Laboratory and several Office of Science computational facilities.

EFRC awards relevant to biomass conversion

Center for Direct Catalytic Conversion of Biomass to Biofuels (C3Bio)
Maureen McCann, Director
Purdue University

Objective: To use fundamental knowledge about the interactions between catalysts and plant cell walls to design improved processes for the conversion of biomass to energy, fuels, or chemicals.

This EFRC will combine expertise in biology, chemistry, and engineering to increase much needed knowledge of catalysis pertaining to plant cell wall chemistry. The EFRC includes planned collaborations with scientists at the University of Tennessee for development of “hybrid” catalysts and catalytic conversion of renewable materials; with National Renewable Energy Laboratory for advanced, high resolution biomass imaging technology and computational modeling; and with researchers at the Argonne National Laboratory for advanced scattering and imaging techniques using the Advanced Photon Source. Additional scattering experiments using the Spallation Neutron Source at Oak Ridge National Laboratory are also planned.

Center for Advanced Biofuels Systems (CABS)
Richard Sayre, Director
Donald Danforth Plant Science Center

Objective: To generate the fundamental knowledge required to increase the efficiency of photosynthesis and production of energy-rich molecules in plants.

CABS will focus its efforts on the model algae Chlamydomonas and the oilseed plant Camellina. Metabolic networks will be modified to increase lipid and thus “bio-oil” synthesis, and new metabolic pathways will be designed for production of hydrocarbons from sunlight. Utilizing the skills of plant biochemists, biophysicists, and computational biologists, this innovative center will integrate all aspects of metabolism, from the early events in photosynthesis to the synthesis and accumulation of oils and biofuel precursors. This EFRC may lead to a transformational channeling of solar energy through carbon metabolism and, ultimately, into biofuels and includes planned collaborations with scientists at University of Nebraska, University of Missouri-St. Louis, University of Arizona, and Michigan State University.

EFRC awards relevant to biomass conversion

Center for Lignocellulose Structure and Function
Daniel Cosgrove, Director
Pennsylvania State University

Objective: To dramatically increase our fundamental knowledge of the physical structure of bio-polymers in plant cell walls to provide a basis for improved methods for converting biomass into fuels.

To achieve its objective, this EFRC will study the physical structure of lignocellulose at the nanoscale level and the rules and principles by which lignocellulose is created. An interdisciplinary team that includes plant and microbial molecular biologists, chemists, physicists, material scientists, engineers and computational modelers will utilize advanced, cutting-edge approaches and methodology to bring about desperately needed advances in the fundamental understanding of the "rules of assembly" of plant cell wall. Specifically, the focus will be placed on understanding the cellulose synthesis, lignocellulose assembly, and the relationship between nanoscale structure and macroscale properties such as porosity and mechanics of the plant cell wall. This EFRC has strong potential for transforming bioenergy and materials sciences through combined molecular, genetic, and nano-materials engineering approaches and includes planned collaborations with scientists at North Carolina State University and Virginia Polytechnic Institute and State University.

FY 2010 Proposed Budget

U.S. DEPARTMENT OF ENERGY

BES FY 2010 Highlights

The FY 2010 BES Budget Request supports President Obama's goals for a clean energy economy, investments in science and technology—including exploratory and high-risk research, and training the next generation of scientists and engineers.

Research:

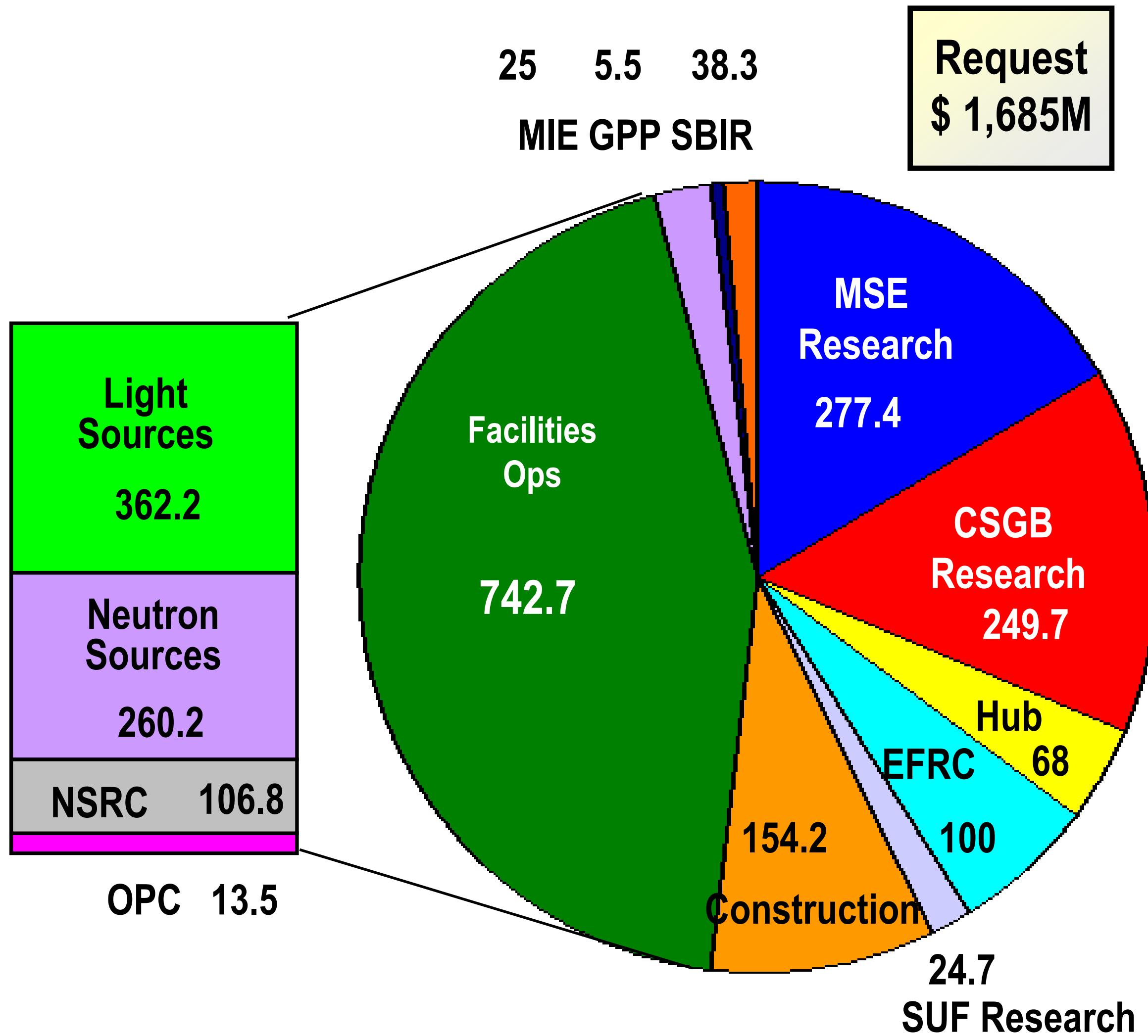
- Two **Energy Innovation Hubs** are initiated in FY 2010 in the topical areas of **Fuels from Sunlight**, and **Batteries and Energy Storage**. Each hub will assemble a multidisciplinary team to address the basic science, technology, economic, and policy issues needed to achieve a secure and sustainable energy future, and will be funded at $25,000,000 per year for an initial period of 5 years. One-time funding of $10,000,000 is provided to each Hub for start-up needs, excluding new construction.
- **Energy Frontier Research Centers (EFRCs)** initiated in FY 2009 continue in FY 2010. EFRCs integrate the talents and expertise of leading scientists across multiple disciplines to conduct fundamental research to establish the scientific foundation for breakthrough energy technologies.
- **Core research**—primarily supporting single principal investigator and small group projects—will be continued and expanded to initiate promising new activities that respond to the five grand challenges identified in the BESAC Grand Challenges report: quantum control of electrons in atoms, molecules, and materials; basic architecture of matter, directed assemblies, structure, and properties; emergence of collective phenomena; energy and information on the nanoscale; and matter far beyond equilibrium.

Facilities:

- The **Linac Coherent Light Source (LCLS)** at SLAC National Accelerator Laboratory, the world's first hard x-ray coherent light source, begins operations in FY 2010. The LCLS provides laser-like x-ray radiation that is 10 billion times more intense than any existing coherent x-ray light source and will open new realms of exploration in the chemical, material, and biological sciences.
- The **National Synchrotron Light Source II** at Brookhaven National Laboratory will continue its construction phase, including the largest component of the project—the building that will house the accelerator ring.
- **Scientific User Facility Operations** are fully funded in FY 2010. The BES user facilities are visited by more than 10,000 scientists and engineers from academia, national laboratories, and industry annually and provide unique capabilities to the scientific community that are critical to maintaining U.S. leadership in the physical sciences.

FY 2010 BES Budget Request

- **Core research programs**
  - 2 Energy Innovation Hubs
  - $100M for Energy Frontier Research Centers
  - Core research increases for grand challenge science, accelerator & detector research
- **Scientific user facilities operations**
  - Synchrotron light sources
  - Neutron scattering facilities
  - Nanoscale Science Research Centers
- **Construction and instrumentation**
  - National Synchrotron Light Source-II
  - Linac Coherent Light Source
  - Spallation Neutron Source instruments
  - SNS Power Upgrade



FY 2010: Energy Innovation Hubs

- **In FY 2010, DOE proposes to launch eight Energy Innovation Hubs to support cross-disciplinary R&D focused on the barriers to transforming energy technologies into commercially deployable materials, devices, and systems.**
- **Total proposed budget is $280M. Each Hub is funded at $25M annually with an initial $10M in FY 2010 for equipment, building modifications, leases, but not construction.**
- **Initial award period is five years, with one additional five-year renewal period possible.**
- **Topical areas and DOE program offices are:**

Solar Electricity (EERE)

Fuels from Sunlight (SC/BES) – Artificial Photosynthesis

Batteries and Electrical Energy Storage (SC/BES)

Carbon Capture and Storage (FE)

Grid Materials, Devices, and Systems (OE)

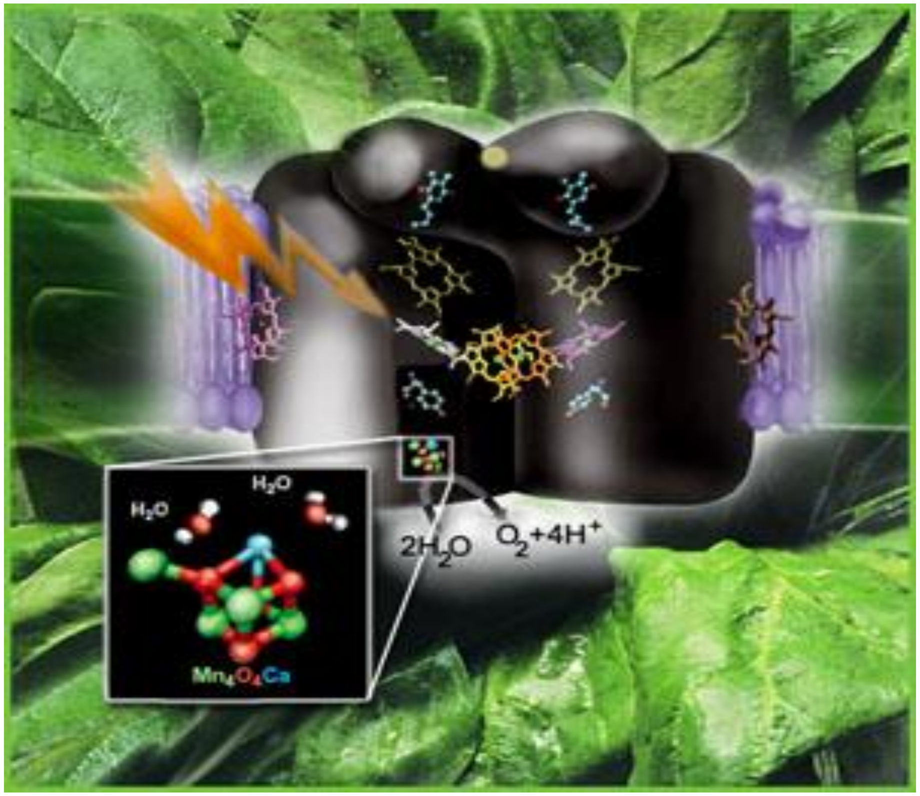
Energy Efficient Building Systems Design (EERE)

Extreme Materials for Nuclear Fuel Cycles and Systems (NE)

Modeling and Simulation for Nuclear Fuel Cycles and Systems (NE)

U.S. DEPARTMENT OF ENERGY

Natural Photosynthesis



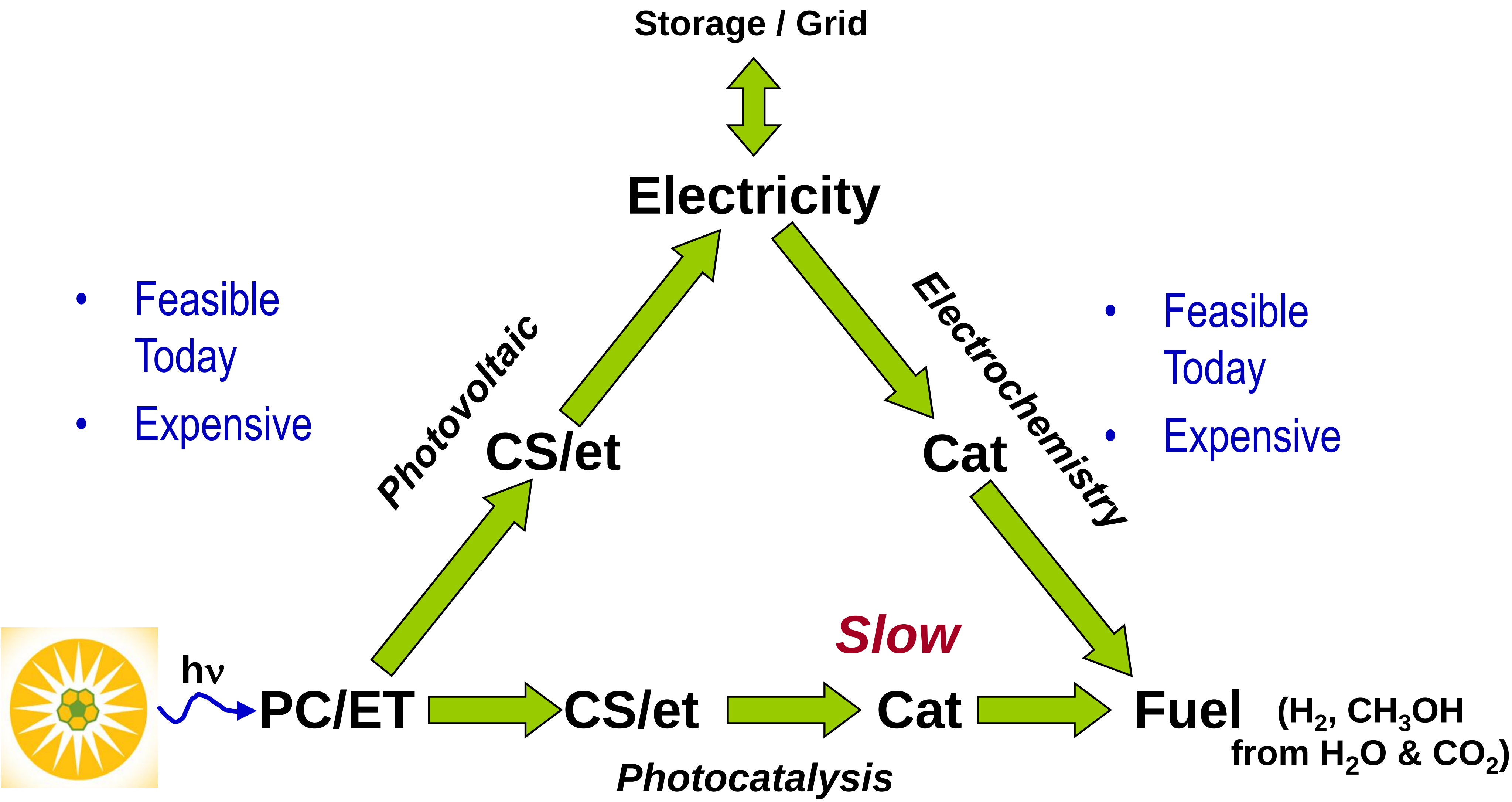
Photosystem II uses solar energy to break two molecules of water into one oxygen molecule plus four hydrogen ions, meanwhile freeing electrons to drive other reactions. At the heart of the water oxidation complex is a cluster of manganese and calcium ions and bridging oxygen atoms. Energized by light, positive charge builds as ions and atoms in the manganese cluster lose electrons in a repeating process; eventually water is split into oxygen and hydrogen.

- The structure, biochemical composition, and physical principals of natural photosynthetic energy conversion remain a grand scientific challenge.
- The photosynthetic machinery, developed over 3 billion years of evolution, drives one of the most energetically demanding reactions in biology, the oxidation of water.

Bottom Line:

The photosynthetic apparatus is an exquisite machine, but is *not designed to meet human energy needs* – the plant must devote much energy to life processes.

Artificial Photosynthesis



- Feasible Today
- Expensive

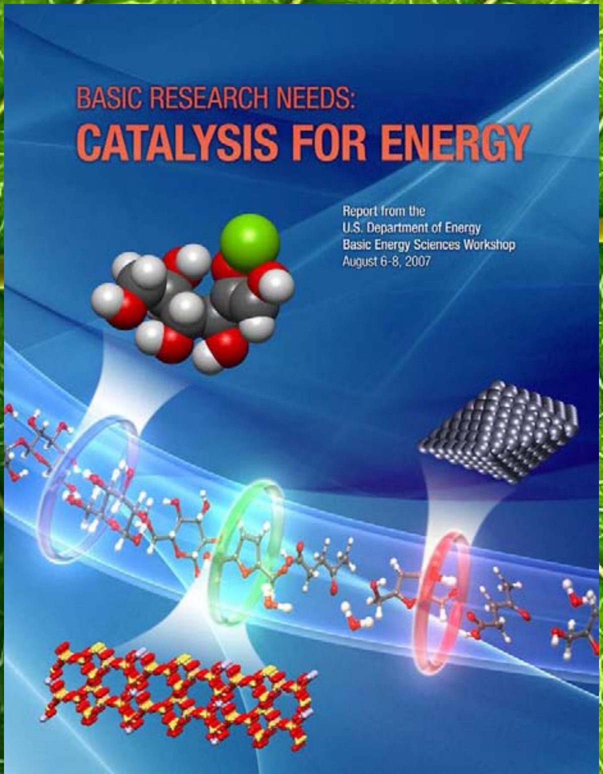
- Feasible Today
- Expensive

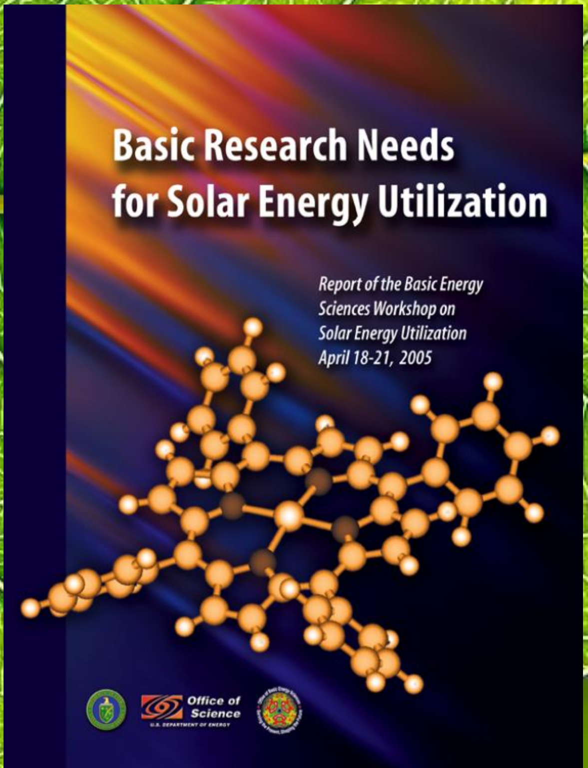
Key	
Photon capture and energy transfer	PC/ET
Charge separation and electron transport	CS/et
Catalysis and fuel formation	Cat

- Work in Progress
- Possibly Transformative?

Artificial Photosynthesis

Take the "Beat-the-Leaf" Challenge





EFRCs, ARPA-E, and Energy Innovation Hubs

Secretary Chu, testifying before the Senate Committee on Appropriations, Subcommittee on Energy and Water Development on May 19 said:

- "EFRCs are small-scale collaborations (predominantly at universities) that focus on overcoming known hurdles in basic science that block energy breakthroughs – not on developing energy technologies themselves.
- ARPA-E is a highly entrepreneurial funding model that explores potentially revolutionary technologies that are too risky for industry to fund.
- The proposed Energy Innovation Hubs will take a very different approach – they will be multi-disciplinary, highly collaborative teams ideally working under one roof to solve priority technology challenges, such as artificial photosynthesis (creating fuels from sunlight)."

Another Program Comparison (Pat Dehmer)

	Investigators and their institutions	Central location for investigators?	Diversity of Disciplines	Period of Award and Management	Award Amount	Core Motivation
Energy Innovation Hubs	Large set of investigators spanning multiple science and engineering disciplines and possibly including other non-science areas such as energy policy, economics, and market analysis. May be led by Labs or universities. The model is the three existing SC Bio-energy Research Centers.	Yes, there is a central location (building) housing many/most of the investigators. A significant aspect of the Hubs is the collocation of researchers. Collaborators at other institutions may partner with the Hub leader. Industries may also be associated with Hubs.	Many	5 years with one 5-year renewal possible. "The bar is significantly higher" for further renewals. Managed by Offices across DOE. A Board of Advisors consisting of senior leadership will coordinate across DOE.	$25M/year with $10M additional in the 1st year for CE or building mods.	Purpose-driven research, spanning fundamental, transformational science to commercialization. The breadth and emphasis of activities will be influenced greatly by the nature of the Hub. For example, the topics of some Hubs are ready for commercialization or improved manufacturing methods (solar photovoltaics). Other Hubs address topics that may require greater emphasis on fundamental research. In general, DOE determines the topical areas of the Hubs, and FOAs are specific.
Energy Frontier Research Centers	Self-assembled group of ~6-12 investigators. May be led by Labs or universities. About 2/3 of EFRCs are led by universities.	Ideally, each EFRC will have a lead institution, home to many/most of the investigators, but there is flexibility.	Several	5 years with 5-year renewals possible. Managed by SC/BES	$2-5M/year	Fundamental, transformational research with a clear link to new energy energy technologies or technology roadblocks. In general, the investigators propose the subject matter from among a large set of general energy-relevant topics, and FOAs are broad.
ARPA-E	Single investigator, small group, or small teams.	No	Few	1-3 years Managed by ARPA-E, which reports to the Secretary of Energy	$0.5 - 10M/year	High risk research driven by the potential for significant commercial impact. In general, DOE determines the area of interest.

EFRCs and Hubs on the Five-Column Chart (Eric's view)

Grand Challenges *How nature works*	Discovery and Use-Inspired Basic Research *Materials properties and functionalities by design*		Applied Research	Technology Maturation & Deployment
▪ Controlling materials processes at the level of quantum behavior of electrons ▪ Atom- and energy-efficient syntheses of new forms of matter with tailored properties ▪ Emergent properties from complex correlations of atomic and electronic constituents ▪ Man-made nanoscale objects with capabilities rivaling those of living things ▪ Controlling matter very far away from equilibrium	▪ Basic research for fundamental new understanding on materials or systems that may revolutionize or transform today's energy technologies ▪ Development of new tools, techniques, and facilities, including those for the scattering sciences and for advanced modeling and computation	▪ Basic research, often with the goal of addressing showstoppers on real-world applications in the energy technologies	▪ Research with the goal of meeting *technical milestones*, with emphasis on the development, performance, cost reduction, and durability of materials and components or on efficient processes ▪ Proof of technology concepts	▪ Scale-up research ▪ At-scale demonstration ▪ Cost reduction ▪ Prototyping ▪ Manufacturing R&D ▪ Deployment support

?? DOE Energy Innovation Hubs ??

SC/BER Bioenergy Research Centers

EFRCs and BES core research

BESAC & BES Basic Research Needs and Grand Challenge Workshops

DOE Technology Office/Industry Roadmaps

Basic Energy Sciences
Goal: new knowledge / understanding
Mandate: open-ended
Focus: phenomena
Metric: knowledge generation

DOE Technology Offices: EERE, NE, FE, EM, RW…
Goal: practical targets
Mandate: restricted to target
Focus: performance
Metric: milestone achievement

Thank you!